ACTION HISTORY OF RTI REQUEST No.WLIOI/R/E/20/00073

Applicant Name Pandit Ajay Gautam

Text of Application May kindly furnish details via email or by Post as deem fit Certified Copy of the Documents u/s 6 and Section 6(1) of the RTI Act 2005 is requested, In case the reply is ready its not necessary to wait for 30 days information disposal to speed up the process of disposal of information 1. List of targeted animals for Radio Collaring relevant documents 2. List of Animals Radio Collared with relevant Documents 3. Whether Purpose of Radio Collaring Animals Reached-Yes /No, If yes kindly furnish years wise research report. 4. Current Status of All Animals Radio Collared and their available current/last/fresh report 5. Periodic fund Utilisation Certificate report for Radio Collar program Last, Fresh, Current 6. Any Other Information related to 7. Cost of one Radio Collar 8. Cost Involved in Installation of One radio collaring on one animal 9. Detailed Sales and Purchase Drug Inventory utilised in Radio Collaring Tiger

Reply of Application kindly see the Annexure-I and supporting documents which are being sent separately by email in part files due to large size of documents

SN.	Action Taken	Date of Action	Action Taken By	Remarks
1	RTI REQUEST RECEIVED	31/12/2020	Nodal Officer	
2	REQUEST FORWARDED TO CPIO	04/01/2021	Nodal Officer	Forwarded to CPIO(s) : (1) P.K.Aggarwal
3	REQUEST DISPOSED OF	29/01/2021	P.K.Aggarwal-(CPIO)	

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Government of India
Wildlife Institute of India, Dehradun
Wildlife Institute of India
P.O.Box-18, Chandrabani, Dehradun, Uttarakhand,

Dated: 29/01/2021

To

Ms. Pandit Ajay Gautam
26/127a Sidhharth Gali No 10
Vishwas Nagar
Delhi
110032

Registration Number : WLIOI/R/E/20/00073

Dear Sir/Madam

I am to refer to your Request for Information under RTI Act 2005, received vide letter dated 31/12/2020 and to say that *kindly see the Annexure-I and supporting documents which are being sent separately by email in part files due to large size of documents.*

In case, you want to go for an appeal in connection with the information provided, you may appeal to the Appellate Authority indicated below within ***thirty days*** from the date of receipt of this letter.

Director, WII
FAA & Director
Address: Wildlife Institute of IndiaChandrabaniDehradun
Phone No.: 01352646101

Yours faithfully

(P.K.Aggarwal)
CPIO & Deputy Registrar
Phone No.: 01352646110
Email : pka@wii.gov.in

ANNEXURE-I

F.No. WII/RTI/CPIO/2020-21 (Qtr-IV)/83

Date: 29 January, 2021

Sub.: RTI Reply of Online RTI No. WLIOI/R/E/20/00073 dated 31.12.2020 of Mr. Pandit Ajay Gautam, New Delhi under RTI Act, 2005–reg.

Sir,

Please refer to application cited above under RTI Act, 2005. In this context, the point-wise response to queries asked by applicant is given below:

Information Sought under RTI	Reply
1. List of targeted animals for Radio Collaring relevant documents	Information is attached at page 1-3, 28, 29 and attached with reports.
2. List of Animals Radio Collared with relevant Documents	Information is attached at page 1-3, 28, 29 and attached with reports.
3. Whether Purpose of Radio Collaring Animals Reached-Yes /No, If yes kindly furnish years wise research report.	Yes, Information is provided in the attached research reports.
4. Current Status of All Animals Radio Collared and their available current/last/fresh report	Information is available in attached reports.
5. Periodic fund Utilisation Certificate report for Radio Collar program Last, Fresh, Current	Please see attached page from 5-26.
6. Any Other Information related to	--
7. Cost of one Radio Collar	Please see attached page 30.
8. Cost Involved in Installation of One radio collaring on one animal	Please see attached page 30.
9. Detailed Sales and Purchase Drug Inventory utilised in Radio Collaring Tiger	Please see attached page 31.

Jhala

Signature of Concerned Authority
(Officer Name & Designation)

To,
NO & CPIO (RTI), Wildlife Institute of India, Chandrabani Dehradun

Details of Animals collared under various project and active collars – Dr. Bilal Habib

State	Species	Collar Type	No. of animals collared	No. of animals from which collar removed	No. of collars functional on animal	Objectives of the study
Maharashtra	Tiger	GPS collar	19	17	2	1. To understand the movement of tigers that drives population connectivity on a landscape scale 2. To validate the modelled corridors and identify new functional corridor and habitats in a highly dynamic landscape 3. Directly aiding effective conservation and management of tigers beyond the Protected Area (PA) system from radio-collars.
Maharashtra	Leopard	GPS collar	4	4	0	1. Space use of leopards using radiotelemetry in TATR
Jammu & Kashmir	Leopard	GPS collar	3	3	0	1. Study movement pattern, home range size and social organization of leopards across different sites.
Maharashtra	Wolf	GPS collar	8	8	0	1. To estimate the home-range/territorial behaviour of dispersing individuals 2. To study the dispersal pattern and habitat use of the existing wolf packs dwelling in the human-dominated landscape of Solapur, Osmanabad, Pune and Ahmednagar districts of Maharashtra, India 3. To study the social structure and dynamics of the selected wolf packs for individual behaviours within the pack and their interaction with other wolf packs in the vicinity. 4. To delineate critical habitat patches and factors governing their utilization in a human-dominated landscape

State	Species	Collar Type	No. of animals collared	No. of animals from which collar removed	No. of collars functional on animal	Objectives of the study
Maharashtra	Dhole	GPS collar	5	5	0	1. To study space-use and movement of wild dog in Tadoba-Andhari Tiger Reserve
Maharashtra	Great Indian Bustard	GPS collar	3	3	0	1. To identify all the habitats across the landscape used by the GIB through satellite telemetry
Himachal Pradesh	Wolf	GPS collar	3	3	0	1. To understand spatial ecology of Himalayan Wolf.

https://www.researchgate.net/publication/237048827_Telemetry_in_Wildlife_Science_ENVIS_Bulletin_Wildlife_Protected_Areas

https://animalbiotelemetry.biomedcentral.com/articles/10.1186/2050-3385-2-4#:~:text=Three%20decades%20of%20wildlife%20radio%20telemetry%20in%20India%3A,%5D.%203%20Results%20and%20discussion%20More%20items...%20

(5)

Studying the Dispersal of Tiger across the Eastern Vidarbha Landscape, Maharashtra

UTILIZATION CERTIFICATE

(To be sent in duplicate)

For the financial year: 2015-2020

1.	Title of the project/Scheme/Programme	**Studying the Dispersal of Tiger across the Eastern Vidarbha Landscape, Maharashtra**
2.	Name of the Principle Investigator & Organization.	**Dr. Bilal Habib**
3.	Amount brought forward from the previous financial year, quoting the Studying the Dispersal of Tiger across the Eastern Vidarbha Landscape, Maharashtra	Nil
4.	Amount received from during the financial year Studying the Dispersal of Tiger across the Eastern Vidarbha Landscape, Maharashtra during the financial year (2015-2020) (Please give number and dates of sanction orders showing the amount paid)	**Rs 1,30,00,000/-**
5.	Total amount that was available for expenditure (Including commitments) incurred during the financial year (2015-2020) (S.No.4+5)	**Rs 1,30,00,000/-**
6.	Actual expenditure (excluding commitments) incurred during the financial year (2015-2020).	**Rs 1,30,00,000/-**
7.	Unspent Balance amount refunded, if any: (Please give details of cheque no. etc.)	**Nil**
8.	Balance amount available at the end of financial year (2015-2020)	**Nil**
9.	Amount allowed to be Carried forward to the next financial year vide Letter No. and dated	**Nil**
10.	Accrued bank Interest (2015-2020)	**Nil**

WILDLIFE INSTITUTE OF INDIA · CHANDRABANI, DEHRADUN ·

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Certified that the expenditure of **Rs. Rs. 1,30, 0000/(Rupees One Crore Thirty Lakh Only)** mentioned against Sr. no.7 was actually incurred on the project/scheme for the purpose it was sanctioned.

Dated: 23.10.2020

(Signature of Principal Investigator)

23.10

डा० बिलाल हबीब Dr. Bilal Habib
विभागाध्यक्ष / वैज्ञानिक Head/Scientist
Deptt. of Animal Ecology & Conservation Biology
भारतीय वन्यजीव संस्थान Wildlife Institute of India
देहरादून Dehradun

(Signature of Finance Officer)

Finance Officer
वित्त अधिकारी
WILDLIFE INSTITUTE OF INDIA
भारतीय वन्यजीव संस्थान
Chandrabani, Dehradun
चन्द्रबनी, देहरादून

(Signature of Head of the Organization)

निदेशक / Director
भारतीय वन्यजीव संस्थान
Wildlife Institute of India
देहरादून / Dehradun

OUR REF. No.

ACCEPTED AND COUNTERSIGNED

WILDLIFE INSTITUTE OF INDIA
CHANDRABANI, DEHRADUN

Date:

COMPETENT AUTHORITY

(132) (7)

भारतीय वन्यजीव संस्थान
Wildlife Institute of India

Dr. Ruchi Badola
Dean, Faculty of Wildlife Sciences

No.: PN/WII/GAUR-2015-2018

Dated: 18th November 2020

To,

The Field Director,
Bandhavgarh Tiger Reserve,
Shahdol – 486 661,
District : Umaria, Madhya Pradesh

Sub: Release of budget of project titled Monitoring of Reintroduced Gaur in Bandhavgarh Tiger Reserve (BTR)-Phase II Extension (2015-18)

Sir,

Finance Section
Diary No. 25590
Date 19-XI-2020

It is informed that the MPFD sponsored project titled **"Monitoring of Reintroduced Gaur in Bandhavgarh Tiger Reserve (BTR)-Phase II Extension (2015-18)"** was initiated on 30th November 2018 with the total approved budget of Rs 49,66,850.00 for three years. The details of the budget are as follows:

Sr. No.	Year	Yearly Budget
1.	Ist	11,67,250.00
	IInd	22,42,500.00
	IIIrd	15,57,100.00

A partial grant of Rs 23,62,395.00 out of total amount of 34,09,750.00 (total of 1st and 2nd year) has been received on 30th March 2020 through NEFT from the Forest Department. It is informed that an amount of Rs. 2,21,845.00 that was unspent in the Phase II (2015-18) was carried forward to run the project activities and the amount has been adjusted as grant received in the project making a total grant received as Rs 25,84,240.00. The utilization certificate of the expenditure incurred and booked under the project is enclosed.

It is requested that the balance of Rs.8,25,510/- towards the 1st two years may kindly be released to meet the expenditure committed in the project. The money may kindly be transferred to following account:

Name of Account Holder: Director, Wildlife Institute of India
Bank & Branch name: Union Bank of India, Chandrabani, Dehradun
Account Type & number: 518502010050629
IFSC Code: UBIN0551856

Yours faithfully,

(Ruchi Badola)

Copy to: Principal Chief Conservator of Forests (Wildlife), Govt. of Madhya Pradesh, Pragati Bhawan, Bhopal Development Authority, 3rd Floor, M.P. Nagar, Zone-1, Bhopal, Madhya Pradesh

(Ruchi Badola)

20.11.2020

S.O. 20/11 FA/134

Shri Madan Lal

पत्रपेटी सं० 18, चन्द्रबनी, देहरादून – 248 001, उत्तराखण्ड, भारत
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EPABX : +91-135-2640114, 2640115, 2646100 Fax : 0135-2640117
ई–मेल/E-mail : wii@wii.gov.in वेब/Website : www.wii.gov.in

(B1) (8)

UTILIZATION CERTIFICATE

Ser No	Letter No & Date	Amount (Rs in Lac)	Remarks
1.	Previous Balance	2,21,845.00	Certified that out of Rs. **23,62,395/-**(Rupees Twenty three lakh sixty two thousand three hundred ninety five only), sanctioned during the financial year **2019-2020** for conducting **"Monitoring Re-introdued Gaur in Bhandavgarh Tiger Reserve, Madhya Pradesh : Phase II** in favour of **WILDLIFE INSTITUTE OF INDIA, DEHRADUN** by the **Field Director Bhandhavgarh Tiger Reserve, Umaria (MP)** ,vide letter given in the margin and **Rs 2,21,845/-** (Rupees Two lakh twenty one thousand eight hundred forty five only) on account of unspent balance of the previous year, a sum of Rs. **25,84,240/-** has been utilized for the purpose for which it was sanctioned and that the balance is **Nil.**
2.	Through RTGS Bandhavgarh National Park dated 30.03.2020	23,62,395.00	
	Total	25,84,240.00	

2. Certified that I have satisfied my self that the conditions on which the fund was sanctioned have been duly fulfilled/are being fulfilled and that I have exercised the checks to see that the money was actually utilized for the purpose for which it was sanctioned.

Finance Officer / वित्त अधिकारी
भारतीय वन्यजीवन संस्थान
Wildlife Institute of India
देहरादून / Dehradun

Signature :
Designation : निदेशक / Director
भारतीय वन्यजीवन संस्थान
Wildlife Institute of India
देहरादून / Dehradun

Dated : 17-11-2020

Dr. V.B. Mathur
Director

भारतीय संस्थान
Wildlife Institute of India

No.: WHM/V[illegible]095/BTR – Gaur Project (Phase II Ext.)

Dated: 13th March, 2019

To,

The Field Director
Bandhavgarh Tiger Reserve
Shahdol – 486 661, Distt. Umaria
Madhya Pradesh

Sub.: **MPFD Sponsored project titled "Monitoring Reintroduced Gaur (*Bos gaurus gaurus*) in Bandhavgarh Tiger Reserve, Madhya Pradesh : Phase II-Extension 2018-21" – Revision of budget reg.**

Sir,

It is informed that the Phase-II of the MPFD sponsored project titled "Monitoring Reintroduced Gaur (*Bos gaurus gaurus*) in Bandhavgarh Tiger Reserve, Madhya Pradesh, Phase II (2015-18) has been completed on 31st May, 2018. Final report has been submitted vide Dean, FWS letter No. PN/WII/Gaur-2015-2018 dt. 13th July, 2018 .

The Phase II extension of the project (2018-21) has been initiated from 30th November, 2018 further to FD, Bandhavgarh Tiger Reserve letter क्रमांक / मा.चि. / 910 / dated 29-11-2018. Accordingly, a Senior Research Fellow has been engaged since 30th November, 2018 and the work initiated at Bandhavgarh from the balance of budget of Phase-II. An amount of Rs. 2,21,845/- was the balance as on 30th November, 2018. The head-wise details are provided below:

S.No.	Budget Head	Total Grant Received (2015-2018)	Total Expenditure (2015-2018)	Balance as on 30.11.2018
1	Purchase of Radio Collars	7,00,000	6,96,277	3,723
2	Manpower	15,90,700	15,02,490	88,210
3	Travel	3,80,000	3,54,171	25,829
4	Insurance liability to researcher & field assistant	18,000	12,997	5,003
5	Vehicle & POL maintenance	7,20,000	5,93,651	1,26,349
6	Laboratory Analysis	18,000	18,000	0
7	Purchase of drugs & accessories	1,00,000	1,00,000	0
8	Contingencies	3,33,835	3,61,104	-27,269
9	Yearly Total	38,60,535	36,38,690	2,21,845
10	5% cost escalation per year	0	0	0
	Total	**38,60,535**	**36,38,690**	**2,21,845**

The Utilization Certificate of Phase II (2015-18) project is enclosed for your perusal and records.

The total budget for Phase II extension (2018-21) has erroneously been mentioned as Rs. 59,11,080/- instead of Rs. 62,22,930/-. The overall budget of the project is **Rs 62,22,930/-** and budget heads are provided below:

Contd....2

पत्रपेटी सं० 18, चन्द्रबनी, देहरादून – 248 001, उत्तराखण्ड, भारत
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EPABX : +91-135-2640114, 2640115, 2646100 Fax : 0135-2640117
ई–मेल/E-mail : wii@wii.gov.in वेब/Website : www.wii.gov.in

(10)
(114)

FORM GFR-19-A

FORM OF UTILIZATION CERTIFICATE

Ser. No.	Letter No. & Date	Amount (Rs in Lac)	Remarks
1	क्रमांक / वि.नि. / 360 उमरिया दिनांक 23.3.15	14,80,500	Certified that out of **Rs. 38,60,535/- (Rupees Thirty Eight Lakh Sixty Thousand Five Hundred Thirty Five)** sanctioned during the **FY 2015-16 to 2017-18** for conducting **"Monitoring Reintroduced Gaur (*Bos gaurus gaurus*) in Bandhavgarh Tiger Reserve, Madhya Pradesh : Phase II,** in favour of WILDLIFE INSTITUTE OF INDIA, DEHRADUN by the **Field Director, Bandhavgarh Tiger Reserve, Umaria (MP),** vide letter given in the margin and a sum of **Rs. 36,38,690/-** has been utilized for the purpose for which it was sanctioned and that the balance of **Rs. 2,21,845/-** on account of unspent balance of the year, remaining unutilized at the end of the year will be adjusted towards the grant-in-aid payable during the next year.
2	Through RTGS Bandhavgarh National Park dt 26.07.2016	8,50,500	
3	Through RTGS Bandhavgarh National Park dt 17.05.2017	3,77,475	
4	Through RTGS Bandhavgarh National Park dt 27.09.2017	11,52,060	
	TOTAL	**38,60,535**	

2. Certified that I have satisfied myself that the conditions on which the funds was sanctioned have been duly fulfilled/are being fulfilled and that I have exercised the checks to see that the money was actually utilized for the purpose for which it was sanctioned.

(Finance Officer)
Wildlife Institute of India

Dated: 13/3/15

Signature:

Designation:

डा. वि.वि. माथुर/Dr. V.B. Mathur
निदेशक/Director
भारतीय वन्यजीव संस्थान
WILDLIFE INSTITUTE OF INDIA
देहरादून/Dehradun

Dr. G.S. Rawat
Dean, Faculty of Wildlife Sciences

भारतीय वन्यजीव संस्थान
Wildlife Institute of India

Dated: 19th May, 2017

To,

The Field Director
Bandhavgarh Tiger Reserve
Shahdol – 486 661
District : Umaria, Madhya Pradesh

Sub.: Annual Progress Report and Utilization Certificate for project titled "Monitoring Reintroduced Gaur (*Bos gaurus gaurus*) in Bandhavgarh Tiger Reserve, Madhya Pradesh Phase II"

Sir,

Please find enclosed the Annual Progress Report for the period of 2016-17 along with the Utilization Certificate of the for an amount of Rs. 10,86,847.35/- allocated to Wildlife Institute of India under the project titled "Monitoring Reintroduced Gaur (*Bos gaurus gaurus*) in Bandhavgarh Tiger Reserve, Madhya Pradesh Phase II".

It is requested that budget for the period 2017-18 of Rs. 11,52,060/- may kindly be released at an early date for facilitating the project activities

The money need to be transferred to following account:

Name of Account Holder:		Director, Wildlife Institute of India
Bank & Branch Name	:	Union Bank of India, Chandrabani, Dehradun
Account Type & Number:		518502010050629
IFSC Code	:	UBIN0551856

Thanking you,

Yours faithfully,

(G.S. Rawat)

Copy to: Principal Chief Conservator of Forests (Wildlife), Govt. of Madhya Pradesh, Pragati Bhawan, Bhopal Development Authority, 3rd Floor, M.P. Nagar, Zone - I, Bhopal, Madhya Pradesh

(G.S. Rawat)

Encl.: As above

पत्रपेटी सं. 18, चन्द्रबनी, देहरादून - 248 001, उत्तराखण्ड, भारत
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EPABX : +91-135-2640111 to 2640115, Fax : 0135-2640117
ई-मेल/Email : wii@wii.gov.in, वेब/website : www.wii.gov.in

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FORM '

FORM OF UTILIZATION CERTIFICATE

Ser No	Letter No & Date	Amount (Rs in Lac)	Remarks
1	**Previous balance**	**2,36,347.35**	Certified that out of Rs **10,86,847.35 (Rupees Ten Lakh Eighty six thousand eight hundred forty seven and paisa thirty five only),** sanctioned during the financial year **2016-17** for conducting **"Monitoring Re-introdued Gaur in Bhandavgarh Tiger Reserve, (M.P),** in favour of **WILDLIFE INSTITUTE OF INDIA, DEHRADUN** by the **Field Director Bhandhavgarh Tiger Reserve, Umaria (MP),** vide letter given in the margin and a sum of **10,86,847.35** has been utilized for the purpose for which it was sanctioned and that the balance of **Rs. NIL,** on account of unspent balance of the year, remaining unutilized at the end of the year will be adjusted towards the grant in aid payable during the next year.
2	**RTGS Bandhavgarh National Park dated 26.07.2016.**	**8,50,500.00**	
	Total	**10,86,847.35**	

2. Certified that I have satisfied my self that the conditions on which the fund was sanctioned have been duly fulfilled/are being fulfilled and that I have exercised the checks to see that the money was actually utilized for the purpose for which it was sanctioned.

PK Aggarwal
Finance Officer
Wildlife Institute of India

Date: 12.5.2017

Signature :

Designation: डा. वि.बि. माथुर/Dr. V.B. Mathur
निदेशक/Director
भारतीय वन्यजीव संस्थान
WILDLIFE INSTITUTE OF INDIA
देहरादून/Dehradun

Date: 12/5/2017

Dr. G.S. Rawat
Dean, Faculty of Wildlife Sciences

भारतीय वन्यजीव संस्थान
Wildlife Institute of India

13/167

No: A/6-13/2008/A/C

Dated: 16 February, 2017

To,

Sh. B.S. Bonal, IFS
ADG (Project Tiger) & Member Secretary (NTCA)
Ministry of Environment, Forests and Climate Change, Govt. of India
B -1 Wing, Parayavaran Bhawan, CGO Complex,
Lodhi Road, New Delhi – 110003.

Sub.: **Utilization Certificate for project titled "Monitoring of Reintroduced Tigers in Sariska Tiger Reserve, Rajasthan Phase II"**

Sir,

Please find enclosed the Utilization Certificate of the fund received from National Tiger Conservation Authority (vide NTCA order no. F.No. 2(3)/2005-PT(Vol. I) dated 16th January, 2017) for Rs. 10.71 lakhs as 1st installment (40% of total cost) for the period 2016-17 under the project titled "Monitoring of Reintroduced Tigers in Sariska Tiger Reserve, Rajasthan Phase II".

It is requested that remaining fund for the year 2016-17 may kindly be released at an early date for facilitating the project activities.

The money need to be transferred to following account:

Name of Account Holder:		Director, Wildlife Institute of India
Bank & Branch Name	:	Union Bank of India, Chandrabani, Dehradun
Account Type & Number:		518502010050545
IFSC Code	:	UBIN0551856

Thanking you,

Yours faithfully,

(G.S. Rawat)

Copy to: Sh. Nishant Verma, IFS, DIG (NTCA)

(G.S. Rawat)

पत्रपेटी सं. 18, चन्द्रबनी, देहरादून - 248001, उत्तराखण्ड, भारत
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(14) (166)

FORM GFR-19-A

FORM OF UTILIZATION CERTIFICATE

Ser No	Letter No & Date	Amount (Rs in Lakhs)	Remarks
1	F.No. 2 (3)/2005 – PT (Vol.I) dated 16st January 2017.	10,71,000.00	Certified that out of Rs 10,71,000/- (Rupees Ten lakhs seventy one thousand only), sanctioned during the financial year 2016-17 for conducting "Monitoring Re-introduced Tiger in Sariska Tiger Reserve, Rajasthan Phase-II in favour of WILDLIFE INSTITUTE OF INDIA, DEHRADUN by the Government of Inida, Ministry of Environment Forests & Climate Change (NTCA), New Delhi vide letter No given in the margin and Rs Nil on account of unspent balance of the previous year, a sum of Rs 10,71,000/- has been utilized for the purpose for which it was sanctioned and that the balance of Rs Nil remaining unutilized at the end of the year has been surrendred to Government (vide letter No -- Nil – dated – Nil --)/ will be adjusted towards the grant in aid payable during the next year.
	Total	10,71,000.00	NIL

2. Certified that I have satisfied my self that the conditions on which the fund was sanctioned have been duly fulfilled/are being fulfilled and that I have exercised the checks to see that the money was actually utilized for the purpose it was sanctioned.

Signature :

Designation : संकाय अध्यक्ष /Dean
भारतीय वन्यजीव संस्थान
Wildlife Institute of India
देहरादून / Dehradun

Dated : 16 February 2017

Dr. G.S. Rawat
Dean, Faculty of Wildlife Sciences

15 164

वन्यजीव संस्थान
Wildlife Institute of India

Dated: 11th January, 2017

To,

Sh. B.S. Bonal, IFS
ADG (Project Tiger) & Member Secretary (NTCA)
Ministry of Environment, Forests and Climate Change, Govt. of India
B -1 Wing, Parayavaran Bhawan, CGO Complex,
Lodhi Road, New Delhi – 110003.

Sub.: **Utilization Certificate for project titled "Monitoring of Reintroduced Tigers in Sariska Tiger Reserve, Rajasthan Phase II"**

P/160

Sir,

Please find enclosed the Utilization Certificate of the fund received from National Tiger Conservation Authority (vide NTCA order no. F.No. 2(3)/2005-PT(Vol. I) dated 21st December, 2016) for Rs. 6.8208 lakhs as 2nd and final installment for the period 2015-16 under the project titled "Monitoring of Reintroduced Tigers in Sariska Tiger Reserve, Rajasthan Phase II".

It is requested that fund for the year 2016-17 may kindly be released at an early date for facilitating the project activities.

The money need to be transferred to following account:

Name of Account Holder:		Director, Wildlife Institute of India
Bank & Branch Name	:	Union Bank of India, Chandrabani, Dehradun
Account Type & Number:		518502010050545
IFSC Code	:	UBIN0551856

Thanking you,

Yours faithfully,

(G.S. Rawat)

Copy to: Sh. Nishant Verma, IFS, DIG (NTCA)

(G.S. Rawat)

पत्रपेटी सं. 18, चन्द्रबनी, देहरादून - 248001, उत्तराखण्ड, भारत
Post Box No. 18, Chandrabani, Dehradun- 248001, Uttarakhand, INDIA
ई.पी.ए.बी.एक्स : +91-135-2640111 से 2640115, फैक्स : 0135-2640117
EPABX : +91-135-2640111 to 2640115; Fax : 0135-2640117
ई-मेल/Email : wii@wii.gov.in; वेब/website : www.wii.gov.in

(16)

FORM GFR-19-A

FORM OF UTILIZATION CERTIFICATE

	Letter No & Date	Amount (Rs in Lakhs)	Remarks
	F.No. 2(3)/2005 – PT (Vol.I) dated 21st December 2016.	6,82,080.00	Certified that out of Rs 6,82,080/- (Rupees Six lakhs eighty two thousand eighty only), sanctioned during the financial year 2015-16 for conducting "Monitoring Re-introduced Tiger in Sariska Tiger Reserve (Raj) in favour of WILDLIFE INSTITUTE OF INDIA, DEHRADUN by the Government of Inida, Ministry of Environment Forests & Climate Change (NTCA), New Delhi vide letter No given in the margin and Rs Nil on account of unspent balance of the previous year, a sum of Rs 6,82,080/- has been utilized for the purpose for which it was sanctioned and that the balance of Rs Nil remaining unutilized at the end of the year has been surrendred to Government (vide letter No -- Nil – dated – Nil --)/ will be adjusted towards the grant in aid payable during the next year.
	Total	6,82,080.00	NIL

2. Certified that I have satisfied my self that the conditions on which the fund was sanctioned have been duly fulfilled/are being fulfilled and that I have exercised the checks to see that the money was actually utilized for the purpose it was sanctioned.

Signature :

Designation :

भारतीय वन्यजीव संस्थान
Wildlife Institute of India
देहरादून / Dehradun

Dated : 11 January 2017

17 182

Dr. V.B. Mathur
Director

भारतीय वन्यजीव संस्थ
Wildlife Institute of India

No.: WII/RES/STR/C.62

Dated: 12th March, 2018

To,

The Member Secretary (NTCA)
Ministry of Environment, Forests and Climate Change, Govt. of India
B -1 Wing, Parayavaran Bhawan, CGO Complex,
Lodhi Road, New Delhi – 110003.

Sub.: NTCA funded project on "Monitoring of Reintroduced Tigers in Sariska Tiger Reserve, Rajasthan Phase II" – reg

Ref.: Letter no. WII/Rest/STR/C.62 dated 1st March, 2018

Sir,

With reference to above, please find following documents to support release of funds under the project titled "Monitoring of Reintroduced Tigers in Sariska Tiger Reserve, Rajasthan Phase II".

1. Utilization Certificate
2. Statement of Expenditure
3. Physical Progress Report

As informed vide aforesaid letter, the project is due for completion on 31st March, 2018. It is however requested to grant 3-month no cost extension for the project for data assimilation and analysis and reporting writing.

The 3rd year installment for the year 2017-18 may kindly be released at an early date for facilitating the project activities.

The bank details for transfer of funds are as follows:

Name of Account Holder:		Director, Wildlife Institute of India
Bank & Branch Name	:	Union Bank of India, Chandrabani, Dehradun
Account Type & Number:		518502010050545
IFSC Code	:	UBIN0551856

Thanking you,

Yours faithfully,

(V.B. Mathur)

Copy to: Dr. Vaibhav C. Mathur, IFS, AIG (NTCA)

(V.B.Mathur)

पत्रपेटी सं. 18, चन्द्रबनी, देहरादून - 248 001, उत्तराखण्ड, भारत
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ई-मेल/Email : wii@wii.gov.in, वेब/website : www.wii.gov.in

(18) (181)

FORM GFR-19-A

FORM OF UTILIZATION CERTIFICATE

Ser No	Letter No & Date	Amount (Rs in Lac)	Remarks
1	F.No.2(3)/2005-PT(Vol.I) dated 3.11.2017	**12,33,640.00**	Certified that out of **Rs 12,33,640.00** sanctioned for conducting "Monitoring Re-introduced Tiger in Sariska Tiger Reserve, Phase-II during the financial year 2017-18 in favour of **WILDLIFE INSTITUTE OF INDIA, DEHRADUN** by the Government of India, Ministry of Environment Forests & Climate Change (NTCA), New Delhi vide letter No given in the margin and Rs Nil on account of unspent balance of the previous year, a sum of **Rs 12,33,640/- (Rupees Twelve Lakh thirty three thousand six hundred forty only)**, has been utilized for the purpose for which it was sanctioned and that the balance of Rs Nil ,remaining unutilized at the end of the year has been surrendered to Government (vide letter No. Nil.dated.Nil.)/will be adjusted towards the grant in aid payable during the next year.
	Total	**12,33,640.00**	NIL

2. Certified that I have satisfied my self that the conditions on which the fund was sanctioned have been duly fulfilled/are being fulfilled and that I have exercised the following checks to see that the money was actually utilized for the purpose for which it was sanctioned.

Kinds of Checks exercised
Cash Book
Bill Register
Cheque issue Register
Internal Review Committee Meetings

Finance Officer
WILDLIFE INSTITUTE OF INDIA
Chandrabani, Dehradun

Dated :

Signature: डा. वि.वि. माथुर/Dr. V.B. Mathur
निदेशक/Director
Designation: भारतीय वन्यजीव संस्थान
WILDLIFE INSTITUTE OF INDIA
Dated : देहरादून/Dehradun

Dr. G.S. Rawat
Dean, Faculty of Wildlife Sciences

(19) (175)

भारतीय वन्यजीव संस्थान
Wildlife Institute of India

No.: WII/RES/STR/C.62

Dated: 10th October, 2017

To,

Dr. Debabrata Swain, IFS
ADG (Project Tiger) & Member Secretary (NTCA)
Ministry of Environment, Forests and Climate Change, Govt. of India
B -1 Wing, Parayavaran Bhawan, CGO Complex,
Lodhi Road, New Delhi – 110003.

Sub.: Utilization Certificate for project titled "Monitoring of Reintroduced Tigers in Sariska Tiger Reserve, Rajasthan Phase II"

Sir,

Please find enclosed the Utilization Certificate of the fund received from National Tiger Conservation Authority (vide NTCA order no. F.No. 2(3)/2005-PT(Vol. I) dated 26th May, 2017 for Rs. 08.00 lakhs under the project titled "Monitoring of Reintroduced Tigers in Sariska Tiger Reserve, Rajasthan Phase II".

It is requested that remaining 3rd year installment for the year 2017-18 may kindly be released at an early date for facilitating the project activities. B/- 22,32,400) =

The money need to be transferred to following account:

Name of Account Holder:		Director, Wildlife Institute of India
Bank & Branch Name	:	Union Bank of India, Chandrabani, Dehradun
Account Type & Number:		518502010050545
IFSC Code	:	UBIN0551856

Balance Due - 22,32,400 — (-) 12,33,640 — = 9,98,760 — Balance Grant

Thanking you,

Yours faithfully,

(G.S. Rawat)

Copy to: Sh. Nishant Verma, IFS, DIG (NTCA)

(G.S. Rawat)

पत्रपेटी सं. 18, चन्द्रबनी, देहरादून-248001, उत्तराखण्ड, भारत
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ई–मेल/E-mail : wii@wii.gov.in, वेब/website : www.wii.gov.in

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FORM GFR-19-A

FORM OF UTILIZATION CERTIFICATE

Ser No	Letter No & Date	Amount (Rs in Lakhs)	Remarks
1	F.No.2(3)/2005-PT (Vol.I) dated 26th May 2017.	8,00,000.00	Certified that out of Rs 8,00,000/- (Rupee Eight lakh only), sanctioned during the financia year 2016-17 & 2017-18 for conductin "Monitoring Re-introduced Tiger in Sariska Tige Reserve, Rajasthan Phase-II in favour o WILDLIFE INSTITUTE OF INDIA, DEHRADUN by the Government of Inida, Ministry o Environment Forests & Climate Change (NTCA), New Delhi vide letter No given in the margin and Rs Nil on account of unspent balance of the previous year, a sum of Rs 8,00,000/- has been utilized for the purpose for which it was sanctioned and that the balance of Rs Nil remaining unutilized at the end of the year has been surrendred to Government (vide letter No -- Nil – dated – Nil --)/ will be adjusted towards the grant in aid payable during the next year.
	Total	8,00,000.00	NIL

2. Certified that I have satisfied my self that the conditions on which the fund was sanctioned have been duly fulfilled/are being fulfilled and that I have exercised the following checks to see that the money was actually utilized for the purpose for which it was sanctioned.

Kinds of Checks exercised

Cash Book
Bill Register
Cheque issue Register
Internal Review Committee Meetings

(PK Aggarwal)
(Finance Officer
Wildlife Institute of India

Signature :
Designation :

डा. वि.बि. माथुर/Dr. V.B. Mathur
निदेशक/Director
भारतीय वन्यजीव संस्थान
WILDLIFE INSTITUTE OF INDIA
देहरादून/Dehradun

Date: 10th October 2017

Date 10 : October 2017

Dr. G.S. Rawat
Dean, Faculty of Wildlife Sciences

भारतीय वन्यजीव संस्थान
Wildlife Institute of India

No.: WII/RES/STR/C.62

Dated:24th May, 2017

To,

Dr. Debabrata Swain, IFS
ADG (Project Tiger) & Member Secretary (NTCA)
Ministry of Environment, Forests and Climate Change, Govt. of India
B -1 Wing, Parayavaran Bhawan, CGO Complex,
Lodhi Road, New Delhi – 110003.

Sub.: Utilization Certificate for project titled "Monitoring of Reintroduced Tigers in Sariska Tiger Reserve, Rajasthan Phase II"

Sir,

Please find enclosed the Utilization Certificate of the fund received from National Tiger Conservation Authority (vide NTCA order no. F.No. 2(3)/2005-PT(Vol. I) dated 6th March, 2017 for Rs. 10.71 lakhs as 2nd installment (40% of total cost) for the period 2016-17 under the project titled "Monitoring of Reintroduced Tigers in Sariska Tiger Reserve, Rajasthan Phase II".

It is requested that 20% remaining fund for the year 2016-17 and allocated funds for the period 2017-18 (Rs. 24,96,900/-) may kindly be released at an early date for facilitating the project activities.

The money need to be transferred to following account:

Name of Account Holder:		Director, Wildlife Institute of India
Bank & Branch Name	:	Union Bank of India, Chandrabani, Dehradun
Account Type & Number:		518502010050545
IFSC Code	:	UBIN0551856

The Annual Progress Report for the period 2016-17 has been communicated separately vide WII letter no. WII/RES/STR/C.62 dated 22nd May, 2017.

Thanking you,

Yours faithfully,

(G.S. Rawat)

Copy to: Sh. Nishant Verma, IFS, DIG (NTCA)

(G.S. Rawat)

पत्रपेटी सं. 18, चन्द्रबनी, देहरादून - 248 001, उत्तराखण्ड, भारत
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ई-मेल/Email : wii@wii.gov.in, वेब/website : www.wii.gov.in

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FORM GFR-19-A

FORM OF UTILIZATION CERTIFICATE

Ser No	Letter No & Date	Amount (Rs in Lakhs)	Remarks
1	Through RTGS dated 15th March 2017.	10,71,000.00	Certified that out of Rs 10,71,000/- (Rupees Ten lakhs seventy one thousand only), sanctioned during the financial year 2016-17 for conducting "Monitoring Re-introduced Tiger in Sariska Tiger Reserve, Rajasthan Phase-II in favour of WILDLIFE INSTITUTE OF INDIA, DEHRADUN by the Government of Inida, Ministry of Environment Forests & Climate Change (NTCA), New Delhi vide letter No given in the margin and Rs Nil on account of unspent balance of the previous year, a sum of Rs 10,71,000/- has been utilized for the purpose for which it was sanctioned and that the balance of Rs Nil remaining unutilized at the end of the year has been surrendred to Government (vide letter No -- Nil – dated – Nil --)/ will be adjusted towards the grant in aid payable during the next year.
	Total	10,71,000.00	NIL

2. Certified that I have satisfied my self that the conditions on which the fund was sanctioned have been duly fulfilled/are being fulfilled and that I have exercised the checks to see that the money was actually utilized for the purpose it was sanctioned.

(PK Aggarwal)
(Finance Officer
Wildlife Institute of India

Date: 22.4 May 2017

Signature :
Designation :

डा. वि.बि. माथुर/Dr. V.B. Mathur
निदेशक/Director
भारतीय वन्यजीव संस्थान
WILDLIFE INSTITUTE OF INDIA
देहरादून/Dehradun

Date 22.4 May 2017

Dr. V.B.Mathur
Director

भारतीय वन्य
Wildlife Ins ___dia

No.: WII/RES/STR/C.62 Dated: 15th December, 2016

To,

Sh. B.S. Bonal, IFS
ADG (Project Tiger) & Member Secretary (NTCA)
Ministry of Environment, Forests and Climate Change, Govt. of India
B -1 Wing, Parayavaran Bhawan, CGO Complex,
Lodhi Road, New Delhi – 110003.

Sub.: Utilization Certificate for project titled "Monitoring of Reintroduced Tigers in Sariska Tiger Reserve, Rajasthan Phase II"

Sir,

Please find enclosed the Utilization Certificate of the fund received from National Tiger Conservation Authority (vide NTCA order no. F.No. 2(3)/2005-P dated 6th August, 2015) for Rs. 27,28,320/- (80% of 1st installment) for the period 2015-16 under the project titled "Monitoring of Reintroduced Tigers in Sariska Tiger Reserve, Rajasthan Phase II".

It is requested that balance 20% amount of 1st year (Rs. 6,82,080/-) and fund for the year 2016-17 (Rs. 17,30,400/-) may kindly be released at an early date for facilitating the project activities.

The money need to be transferred to following account:

Name of Account Holder	:	Director, Wildlife Institute of India
Bank & Branch Name	:	Union Bank of India, Chandrabani, Dehradun
Account Type & Number	:	518502010050545
IFSC Code	:	UBIN0551856

Thanking you,

Yours faithfully,

(V.B. Mathur)

Copy to: Dr. Vaibhav C. Mathur, IFS, AIG (NTCA)

(V.B. Mathur)

Soft copy also sent

पत्रपेटी सं0 18, चन्द्रबनी, देहरादून – 248001, उत्तराखण्ड, भारत
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EPABX : +91-135-2640111 to 2640115; Fax : 0135-2640117;
ई–मेल / E-mail: wii@wii.gov.in, वेब / website: www.wii.gov.in

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FORM GFR-19-A

FORM OF UTILIZATION CERTIFICATE

Ser No	Letter No & Date	Amount (Rs in Lac)	Remarks
1	F.No. 2(3)/2005 – PT dated 6st August 2015.	27,28,320.00	Certified that out of Rs 27,28,320/- (Rupees Twenty seven lakhs twenty eight thousand three hundred twenty only), sanctioned during the financial year 2015-16 for conducting "Monitoring Re-introduced Tiger in Sariska Tiger Reserve (Raj) in favour of WILDLIFE INSTITUTE OF INDIA, DEHRADUN by the Government of Inida, Ministry of Environment Forests & Climate Change (NTCA), New Delhi vide letter No given in the margin and the utilization certificate of Rs 20,61,477/- has been submitted vide dated 30th June 2016 and the unspent balance of Rs 6,66,843/- as reflected in the UC has also been expended under the project. The total amount of Rs 27,28,320/- has been utilized for the purpose for which it was sanctioned and that the balance of Rs Nil at the end of the year.
	Total	27,28,320.00	

- NIL

2. **Certified that I have satisfied my self that the conditions on which the fund was sanctioned have been duly fulfilled/are being fulfilled and that I have exercised the checks to see that the money was actually utilized for the purpose it was sanctioned.**

निदेशक
Director
भारतीय वन्यजीव संस्थान
Wildlife Institute of India
देहरादून
Dehradun

Signatur :

Designation :

Dated : December 2016

15

156

(25)

सूचना का अधिकार
RIGHT TO INFORMATION

RTI –URGENT

From Office of the
Central Public Information Officer (CPIO)
Wildlife Institute of India, Dehradun

No. WII/RTI/CPIO/2020-21 (Qtr-IV)/83

Date: 4 January, 2021

Sub.: Information under RTI Act, 2005–reg.

Kindly arrange to provide the point-wise information **in two copies duly certified by the concerned authority** of the Institute **WITHIN 7 DAYS** receipt of this note, so that the information can be furnished to the applicant u/s 7(1) of RTI Act, 2005.

The details of RTI application (**Annexure-I**) are given below:

Applicant Name	Pandit Ajay Gautam
RTI No.	WLIOI/R/E/20/00073
Application Date	31.12.2020
Application Receipt Date and No.	App. S.No. 83 31 Dec, 2020
Information pertains to Section/ Department	Research/ Academics

Dispatch No. 1535
Date 08/01/2021

NO & CPIO (RTI)

Dean, FWS

Please see the RTI queries and provide responses. Question 5 relates to Utilization of Funds and Q.9 to drugs and their inventory.

Dr. B. Habib, Dr. Parag Nigam, Finance officer, Dr. K. Ramesh, Dr. Samrat Mondol may please provide details based on available documents.

6/1/21

(contd. on next page)

(26) (Contd. from prepage)

We have not any project of radio calling by project name. Also there is no dedicated budget for radio calling programmes.

(B) 8.1.2021

Registrar

कुल सचिव / Registrar
प्रेषण सं. / Despatch No 3726
दिनांक / Date 08/1/21

Reply may be given "Information not available.".

11/1

CPIO

12.1.2021

Information Dean F.O as above has been read. Please provide the information with reference to other points as per RTI Applications, so that information may be furnished.

12.01.2021
DY R

Dean, FWS

(27)

RTI REQUEST DETAILS

Registration No. :	WLIOI/R/E/20/00073	**Date of Receipt :**	31/12/2020
Type of Receipt :	Online Receipt	**Language of Request :**	English
Name :	Pandit Ajay Gautam	**Gender :**	Female
Address :	26/127a Sidhharth Gali No 10, Vishwas Nagar, Delhi, Pin:110032		
State :	Delhi	**Country :**	India
Phone No. :	Details not provided	**Mobile No. :**	+91-9811128861
Email :	panditajaygautam@gmail.com		
Status(Rural/Urban) :	Urban	**Education Status :**	Graduate
Is Requester Below Poverty Line ? :	No	**Citizenship Status**	Indian
Amount Paid :	10)	**Mode of Payment**	Payment Gateway
Does it concern the life or Liberty of a Person ? :	No(Normal)	**Request Pertains to :**	P.K.Aggarwal

Information Sought :

May kindly furnish details via email or by Post as deem fit Certified Copy of the Documents u/s 6 and Section 6(1) of the RTI Act 2005 is requested, In case the reply is ready its not necessary to wait for 30 days information disposal to speed up the process of disposal of information

1. List of targeted animals for Radio Collaring relevant documents
2. List of Animals Radio Collared with relevant Documents
3. Whether Purpose of Radio Collaring Animals Reached-Yes /No, If yes kindly furnish years wise research report.
4. Current Status of All Animals Radio Collared and their available current/last/fresh report
5. Periodic fund Utilisation Certificate report for Radio Collar program Last, Fresh, Current
6. Any Other Information related to
7. Cost of one Radio Collar
8. Cost Involved in Installation of One radio collaring on one animal
9. Detailed Sales and Purchase Drug Inventory utilised in Radio Collaring Tiger

Print Save Close

WILDLIFE INSTITUTE OF INDIA
Right to Information Act, 2005
Apl. No. 83 Qtr. IV Year 2020-21
Fee — Inward Date 31/12/2020

28

Response to RTI

Date: 18 January, 2021

Reference to the RTI application by Pandit Ajay Gautam, dated 04.01.2021 (WLIOI/R/E/20/00073), seeking information on (1) List of targeted animals for Radio Collaring with relevant documents, (2) List of Animals Radio Collared with relevant documents, (3) Whether purpose of Radio Collaring Animals Reached-Yes/No, If yes to furnish year wise research report, (4) Current Status of All Animals Radio Collared and their available current/last/fresh report, (5) Periodic fund Utilisation Certificate report for Radio Collar program last fresh, (6) current, Any other Information related to Cost of one Radio Collar, (7) Cost Involved in Installation of One radio collaring on one animal and (8) Detailed sale and Purchase Drug Inventory utilized in Radio Collaring Tiger, the following information are furnished below as per the listed questions:

<table>
<tr><td colspan="4">Q.No. 1</td></tr>
<tr><td colspan="4">Tiger, Leopard and Vulture</td></tr>
<tr><td colspan="4">Q.No.2</td></tr>
<tr><td colspan="4">18 tigers, 5 leopards and 3 vultures. No specific documents for collaring.</td></tr>
<tr><td colspan="4">Q.No. 3</td></tr>
<tr><td colspan="4">It is under the continuous process. Radio-collaring was a part of larger project and conservation objectives. There is no year wise research report for radio-collaring only.</td></tr>
<tr><td colspan="4">Q.No.4</td></tr>
<tr><td>1</td><td>Alive with functioning collar</td><td colspan="2">7 tiger, 5 leopards and 3 vultures (radio tags)</td></tr>
<tr><td>2</td><td>Alive with non-functioning collar</td><td colspan="2">2 tigers</td></tr>
<tr><td>3</td><td>Alive without Collar</td><td colspan="2">2 tigers</td></tr>
<tr><td>4</td><td>Dispersed/dead</td><td colspan="2">9 tigers</td></tr>
<tr><td colspan="4">Q.No.5</td></tr>
<tr><td colspan="4">There is no specific radio-collaring program, and it is a small part of larger projects. Therefor No UC specifically for radio-collaring program.</td></tr>
<tr><td colspan="4">Q.No.6</td></tr>
<tr><td>1</td><td>Vertex plus collar</td><td>1,98,313</td><td rowspan="3">As per recent procurement rate and other import costs will be extra.</td></tr>
<tr><td>2</td><td>E-obs GPS Tag</td><td>2,37,583</td></tr>
<tr><td>3</td><td>Telonics VHF MOD 500</td><td>32,556</td></tr>
<tr><td colspan="4">Q.No.7</td></tr>
<tr><td colspan="4">Not available</td></tr>
<tr><td colspan="4">Q.No.8</td></tr>
<tr><td colspan="4">Not available</td></tr>
</table>

Sd/-
(Dr. K. Ramesh)
Scientist-E

Dr Sonia' [illegible] 29.

Report will be sent through [illegible]

RTI No: WLIOI/R/E/20/00073

State	Species	Collar type	No. of animals collared	No of active collars
Uttarakhand	Swamp Deer	GPS collar	2	0

Radio collaring purpose was to understand their movement pattern. The report related to this goal is attached.

(30)

VECTRONIC Aerospace

ive technology for science and research

GPS Collars made in Germany since 2000

VERTEX PLUS - datasheet

Oval-round shaped VERTEX PLUS collar with 3D battery and Drop Off

battery type	Globalstar 1 position send per message	IRIDUM 12 positions send per message	GSM 8 positions send per message	UHF position download in field	weight (without Drop Off)
1C	not available for this communication type			188 - 504 days	starting with 312 g**
1D	266 - 412 days	323 - 568 days	376 - 753 days	449 - 1113 days	starting with 470 g**
2D	559 - 865 days	680 - 1193 days	791 - 1582 days	943 - 2337 days	starting with 630 g**
3D	879 - 1360 days	1068 - 1875 days	1243 - 2486 days	> 4years	starting with 830 g**
4D	1225 - 1896 days	1489 - 2613 days	> 4 years	> 5 years	starting with 1030 g**
5D	1598 - 2473 days	> 5 years	> 6 years	> 7 years	starting with 1200 g**
7D	> 6 years	> 7 years	> 8 years	> 8 years	starting with 1500 g**

*example calculation for following settings: GPS schedule with one GPS position every 2 hours, the VHF beacon active for 12 hours per day with Pulse Length 20ms, Period Length 1500ms, Output Power +10 dBm and no additional features running in 0°C ambient temperature

**weight varies depending on belt configuration and communication type
add 70 gram for collar with Drop Off

डा० बिलाल हबीब Dr. Bilal Habib
विभागाध्यक्ष / वैज्ञानिक Head/Scientist
Dept. of Animal Ecology & Conservation Biology
भारतीय वन्यजीव संस्थान Wildlife Institute of India
देहरादून Dehradun

Please contact our customer support for individual calculation in battery lifetime and weight.

contact us

wildlife@vectronic-aerospace.com • www.vectronic-aerospace.com

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VECTRONIC Aerospace CA, Ontario, Canada, Phone: +1 905 535 1514, Fax: +1 289 803 2539

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Tsavran Pharmaceuticals Limited

Jacovides Tower, Georgiou Griva Digeni 81-83, 1st Floor, Nicosia, 1090
Reg Nr: 319856
VAT Nr: 10319856E

Tel: 0035722503049
Fax: 0035722503001
Email: admin@tsavran.com
Web:

Proforma Invoice

OUR CONTRACT MANUFACTURER AND SUPPLIER IS

Wildlife Pharmaceuticals (Pty) Ltd

www.wildpharm.net
vetsupplies@wildpharm.co.za
38 Wilken Street, Rocky Drift, White River 1240, South Africa

Reg: 1997/017062/07
Customs Code: 0186887
VAT No: 4910188434

To:
WIL005
Wildlife Institute of India
Chandrabani, Dehradun
Uttarakhand 248001
India

Account	Date	Order No	Delivery Note	Our Reference
WIL005	30/03/2019	Quote		SOQ0075

Item Code	Item Description	Quantity Unit	Price (Ex)	Disc %	Tax	Total (Incl)
CAP001	Captivon 98	2.00	0.00			
THI002	Thianil Singles	2.00	0.00			
TRE001	Trexonil	5.00	0.00			
ACT001	Activon	2.00	0.00			
KET001	Ketanil	5.00	0.00			
BAM001	Bamanil	1.00	0.00			
MET001	Metonil	2.00	0.00			
DAZ001	Dazonil	1.00	0.00			
PER001	Perinil	1.00	0.00			
ZAP001	Zapnil	1.00	0.00			
ALP001	Alphanil	5.00	0.00			

Kindly note that all medicines will be provided as "Free Samples"

Total (Excl)	$	0.00
Tax	$	0.00
Total (Incl)	**$**	**0.00**
Discount	$	0.00
Rounding	$	0.00
Total (Incl)	**$**	**0.00**

Received by _____
Date _____
Signed _____

Banking Details:

Acc Name:	Tsavran Pharmaceuticals Limited
Bank:	AfrAsia Bank Ltd USD
Account Nr:	055392000000018
IBAN:	MU90AFBL2501055392000000018USD
Swift Code	AFBLMUMU
Bank Transfer	**All charges to be borne by principal**

Reference: **WIL005** **Please use your Account Number as Reference**

Capture, collaring and monitoring of swamp deer at Jhilmil Jheel Conservation Reserve

by

भारतीय वन्यजीव संस्थान
Wildlife Institute of India

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Introduction

The Jhilmil Jheel swamp deer population in Uttarakhand has been observed to move out of the reserve during monsoons (June-July). Observations from January 2016 to July 2018 revealed that the numbers start building up post December and peak around May. Once the monsoon arrives, the animals start moving out of the area and the numbers of swamp deer begin to diminish (Figure.1). This leads to speculations about probable presence of swamp deer and their habitat outside Jhilmil. The initial survey and later genetic analysis have revealed that small fragmented grassland patches along Ganges still harbour swamp deer (Paul et al., 2018) with genetic connectivity between them. Relatedness analysis indicates recent movement between the fragmented grassland patches. So, to know the movement routes and the usage of grassland patches along Ganges, the study necessitated capture, collaring and monitoring of swamp deer. Field capture and collaring operation was initiated from May 2017 onwards and this section is an attempt to document the procedures followed for successful operation and insights into movement ecology along with habitat use of swamp deer.

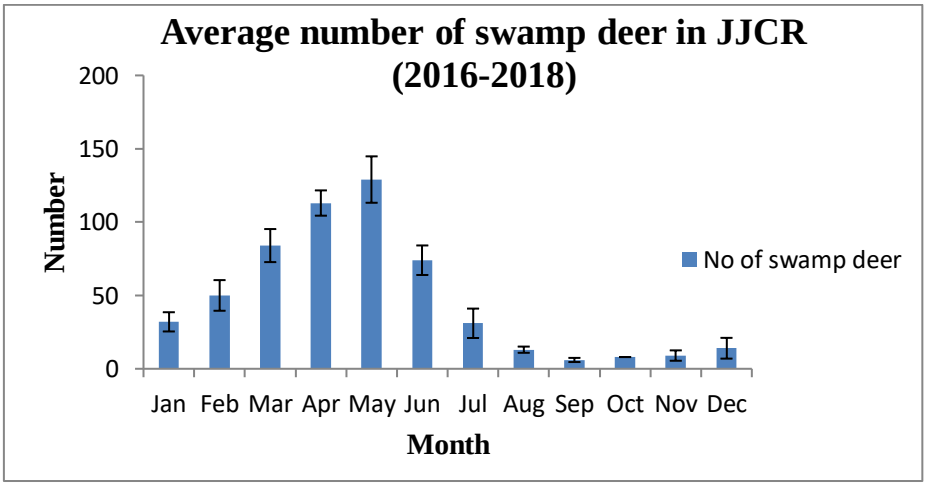

Figure.1: The average number of swamp deer in JJCR (2016-2018)

Study area

Jhilmil Jheel Conservation Reserve (JJCR) is a saucer shaped wetland located between Haridwar–Najibabad along the Ganges River, in Rasiabad range of Haridwar Division, Uttarakhand (Area of 37.83 km^2 of Reserve Forest with elevation ranging from 200 to 250 m above Mean Sea Level (Tewari et al., 2013a) (Figure.2 & 3).

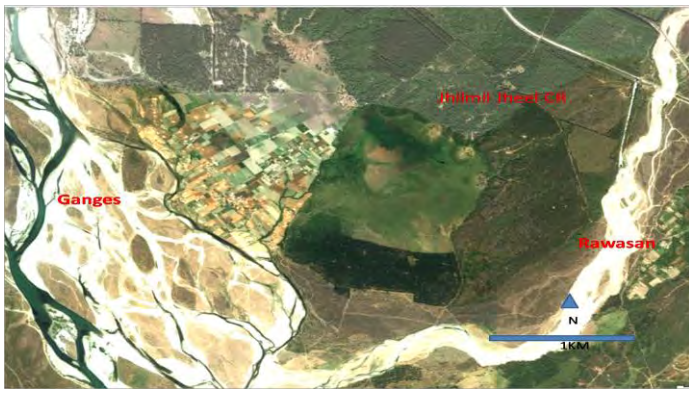

Figure.2: Google Earth Im agery of JJCR

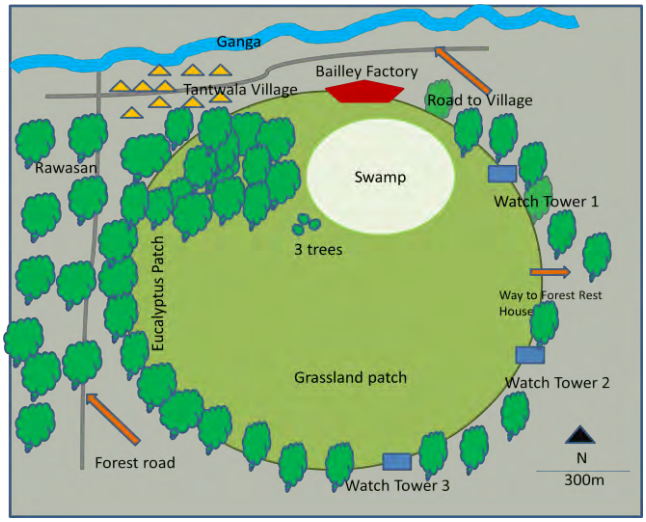

Figure.3: Schematic representation of Jhilmil

The landscape of the study area is a mosaic of short and tall grasslands, tropical mixed moist deciduous forests, and secondary scrub. The area experiences sub-tropical climate with annual rainfall averaging 1300 mm (recorded between 1997 and 2007) and peaking during June-September (monsoon). Temperature ranges from 44°C during May to 2°C during January. The soil quality varies from fine sand to clayey loam. The area is rich in faunal diversity including spotted deer, elephant, nilgai, wild boar, monkey, langur, mongoose, hare, common leopard and occasionally tiger, jungle cat, otter, porcupine, sambar, barking deer and hog deer. Avifauna includes a large number of resident and winter migratory birds. Out of the total area of JJCR only 1.2 km^2 of core habitat is available for swamp deer.

Methods

Capture

The options chosen for capturing included following methods

- Chemical capture through remote darting
- Employing physical restraint procedure viz. Drive-netting

a) Efforts towards chemical capture

Chemical capture involves use of immobilization drugs delivered remotely through long range syringe projectors though essentially require closer approach (Morris, 2001). Habituating the animals to use specified areas close to darting area forms basis for effective darting. It requires placing of the darting team in a hide and luring the animals to use the area using lures, salt, mineral mixture blocks etc.

Habituation effort

The field effort carried out during the reporting period included construction of multiple hides in the swampy patches inhabited by swamp deer with the deer lure placed at distances of 10 m, 20 m and 30 m (Figure.4) from the hide with pair of camera traps deployed to monitor animal activity. This effort was continued for almost 90 days starting from February 2018. Since swamp deer is an extremely shy species and sensitive to human presence and smell, the animals avoided an unnatural structure in their natural environment though the lure was sporadically visited. Based on the camera trap images, we found that the buffaloes mostly fed on the lures (Figure.5). The hides were destroyed by elephants and buffaloes many a times.

Figure.4 & 5: Construction of hide and buffalo feeding on the lure

Efforts to capture swamp deer in the adjacent crop fields

Based on questionnaire survey administered to local community, it was speculated that the swamp deer capture could be attempted in the crop fields adjacent to Jhilmil Jheel on the northern border. These agricultural fields had single access route and had indirect evidences of animal use. Three camera traps were deployed at the entry points to the crop fields from 17th March 2018 to 31st March 2018 (Figure.6) and the night surveys were conducted between 2200h to 0400h for potential swamp deer sighting.

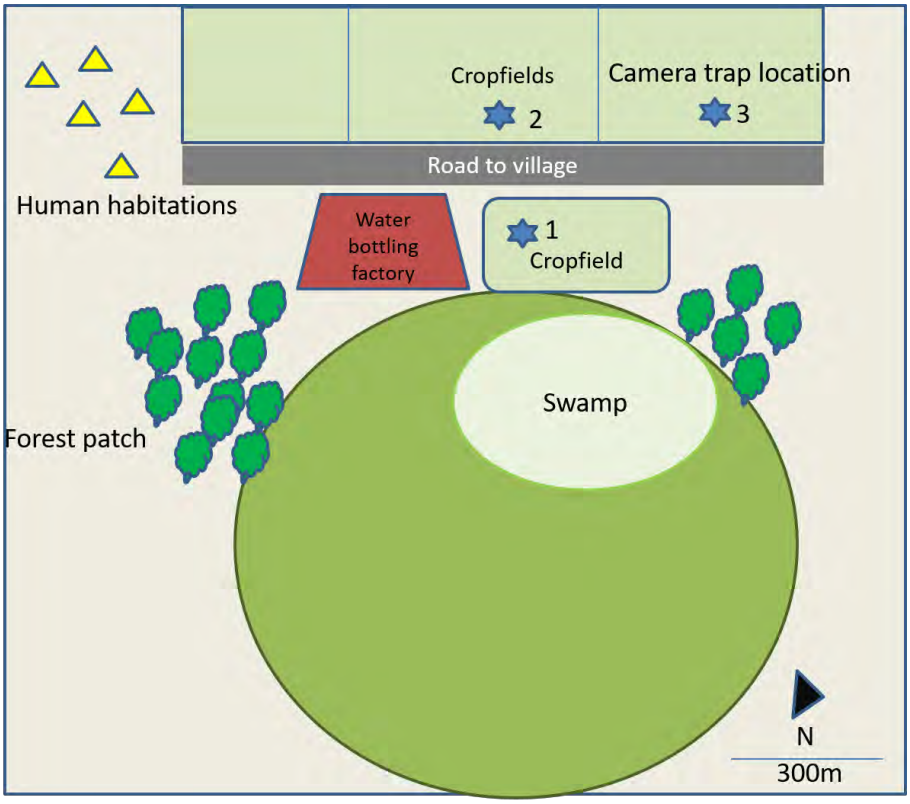

Figure.6: Camera trap locations to monitor swamp deer movement

Swamp deer visited the crop fields but the number and frequency were low as obtained from camera trap images (Figure.7). The capture rate per trap night (Cr/Tn) for swamp deer was 0.04 while that of sambar was 0.55. This conclusively proved that people mistakenly identified sambar as swamp deer. The capture rate per trap night for leopard and buffaloes was (0.04Cr/Tn) and (0.33Cr/Tn) respectively.

Figure.7: Animals captured by camera trapping (17.03.2018 to 31.03.2018)

Gentle drive for darting

As the animal habituation efforts did not bear positive results, a plan was put in place to drive the animals gently towards the hide where the darting team was positioned. This exercise was carried out on 5th April 2018. The schematic representation of the drive effort is presented at Figure.8.

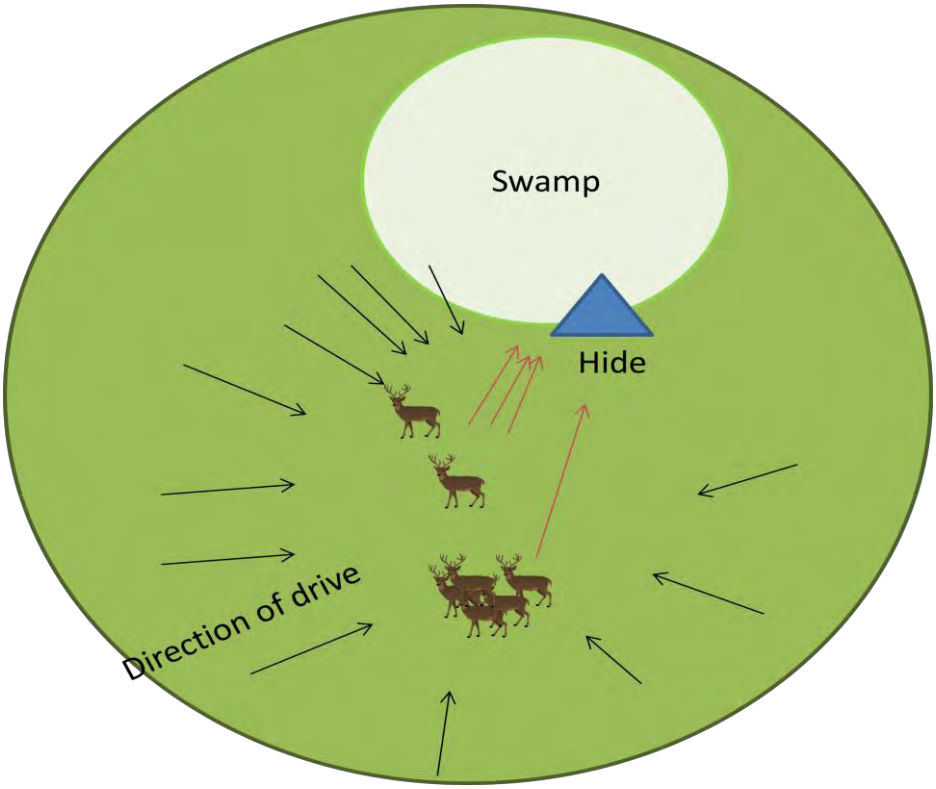

Figure.8: Representation of technique for driving animals towards the hide

Though the drive team was successful in cornering and pushing the animals gently towards the darting team, the swamp deer maintained a distance of about 80-90 m from the hide and did not provide opportunity for darting. The animals managed to escape into the nearby Phragmites/ Typha swamp patch.

b) Efforts towards physical capture (Drive-net Method):

As the efforts towards capturing the animals using above mentioned techniques did not bear positive results, the second option of physically capturing the animal was attempted. The project team discussed various methods for physical capture (Drop-netting, Drive-netting, Pop-up netting, Cannon-nets, Box traps, Clover traps etc.) (Schemnitz et al., 2009) and its associated procedures and risks. Capture methods that are conspicuous (e.g., Drop-nets, Box traps, Clover traps) are susceptible to vandalism, specifically in disturbed areas. Other problems with some of these established capture techniques include difficulty in setting or moving traps in swamps (e.g., Drop-nets, Box traps), potential for the trap to damage multiple animals (e.g., Drop-nets, Net guns, Cannon-nets, Rocket-nets) and high risk of capture myopathy (e.g., Clover traps, Box traps) (Haulton et al., 2001; Peterson et al., 2003).

Finally, some of these capture methods can be expensive (e.g., Cannon-nets, Net guns, Clover traps) and lack the selectivity in animal capture.

> **Drive-net method:** Drive-net method is a technique for capturing and restraining free-ranging herding ungulates. In this method, camouflaged nets are put up at strategic positions covering a considerable distance. Then the animals are cornered and driven towards the net by drive team. A restraining team remains hidden in the vegetation near the nets who starts restraining the animal once it hits the nets and gets entangled. Drive-net has been reported to be a safe and efficient method to capture wild ungulate animals with good success rates.

The efficacy of each method was discussed and drive-net method was selected based on its versatility, ease of deployment, manageable logistical requirements. Drive-net method for capturing of swamp deer was narrowed down based on its successful and effective use in similar species elsewhere. Drive-nets had been effectively used in capturing swamp deer in Nepal (Youtube, 2016, *https://***www.youtube.com/***watch?v=gXwjemTw-Ng*), Saiga antelope in Mongolia (Berger et al., 2010), urban white tailed deer in Florida (Locke et al., 2004) and mountain sheep (Kock et al., 1987). The previous attempts of drive-netting in India used for black bucks and nilgai were not successful (personal communication). The shortcomings of these operations were discussed and necessary preparedness to deal with emergencies and possible failures were deliberated.

Drive-netting was chosen, as the nets could be effectively hoisted in the swamp, would keep the animals away from swamp thereby limiting associated emergencies and provide opportunity for the team to reach and react quickly. It was however decided to keep the procedures as short as possible to subject the animals to minimal stress. The concern with drive-nets for a herding animal is the probability of multiple animals getting trapped and injured. From field observation it was found that once an individual takes the lead, the others follow. It was speculated that once the first animal collides with the net, the other animals can leap over the dropped net.

Necessary components of a physical capture operation (Drive-nets, physical deterrents, drugs and other equipment)

Drive-nets

Three drive-nets of 30 m length each with mesh size of 4 inch by 4 inch and height of 10 ft were setup in the Phragmites patch used by the swamp deer. The nets were hoisted on bamboo poles (Figure.9 & 10) that were positioned at 6 m distance. Around 3 ft of the net length was kept lying on the ground and remaining 7 ft of net was hoisted on the poles. The nets were anchored on nail head on top of the pole. The efficacy of net to drop on impact was tested again and again. Five poles were used to hoist a single net (Figure.12).

Figure.9: Drive-net

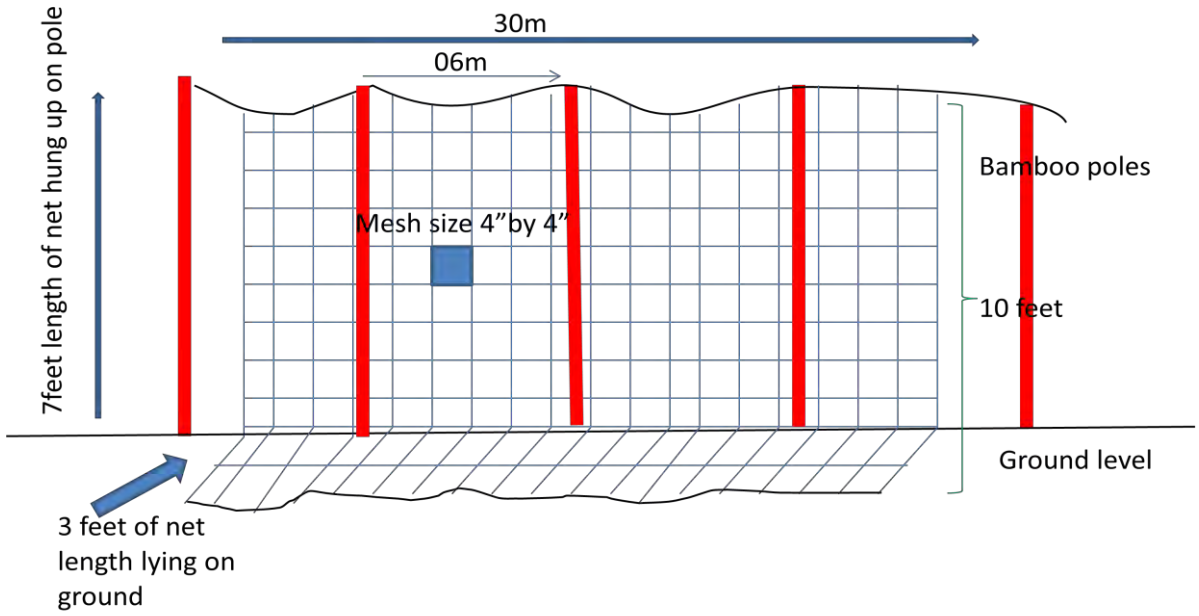

Figure.10: Graphical representation of drive-net system

Cost-effective physical deterrents

As a physical deterrent to stop animals running haywire, a cost-effective locally made barrier was setup. The periphery of the entire ground (length 3.2 km) starting from the two sides of the nets was covered using the cost-effective barriers. The barriers were comprised of torn pieces of gunny bags (700) attached to the rope of length 3.2 km (Figure.11).

Figure.11: Cost-effective barriers to act as physical deterrent

Emergency preparedness

During the entire operation, the safety of the animal would be given priority over other procedures. If the animal was in stress condition during capture, the operation would be aborted. Clippers would be used to free the animals cut the net open if multiple animals get entangled. Selected people were trained for a week who would deal with the emergency situation. Oxygen canisters were kept for emergency. Processing of tranquilizers, sedatives and supplementary drugs was ensured to manage any veterinary emergencies.

Preparatory phase

i) Observations

The preparatory phase of the field operation for capturing swamp deer using drive-net was initiated on 16th May 2018. The procedure involved initial observation of animal activity and assessment of area use. To understand the use of area by the animals and for selecting the time for capture, the animals were monitored throughout the day for initial period. Subsequently the monitoring was limited to observations from 0600-1000h and 1500-1900h with a break during mid-day. The mid-day breaks were given, as the ambient temperatures and humidity were high. The capturing attempts during these times would have subjected the animals to additional stress. Ungulates in general are prone to hyperthermia during physical capture (Sawicka, 2015) and this was one of the important concerns prior to capture attempts.

ii) Net setup and trials

The nets were setup and dislodged numerable times to ensure its stability under all circumstances (Figure.12)

Figure.12: Erecting a net

Prior to collaring exercise, dry drives using human and goats were attempted in the nearby village to see the efficacy of the nets (Figure.13).

Figure.13: Drive trials on goat

Collars

a) Radio-tracking and its role in wildlife research

Wildlife radio-telemetry may be defined as the transmission of information from a transmitter on a free-ranging wild animal to a receiver. Wildlife related telemetry is also known as radio-tagging, radio-tracking or simply 'tagging' or 'tracking'. Studying the behavior of wild animal has supplied important information to wildlife management and conservation (Habib

et al., 2014). For many years, the only way researchers were using to track wildlife was to simply follow and observe the movement and habits of an animal. Advances in the field of wildlife telemetry have made it possible to acquire detailed data on many aspects of wildlife biology, including habitat use, home range size, mortality and survivorship, migration timing and routes (Cochran & Lord, 1963; Kernohan et al., 2001; Murray, 2006; Borkowski & Pudelko, 2007; Martin et al., 2010). Since many wildlife species are secretive and difficult to observe, radio-telemetry has provided a valuable tool to learn more about their respective life histories. As a result, radio-telemetry studies are very common throughout the current wildlife literature. For instance; the study by Miller (2005) identified critical stopover sites for the northern pintails, which are the most important sites for conservation and the authors used this information to urge for protection of these sites to ensure the continuation of pintail migration. In addition, wildlife radio-telemetry can be of great use when studying the migration of land mammals. Scientists fitted mountain elk (*Cervus elaphus nelsoni*) with GPS collars and monitored elk's ability to cross roads to assess direct and indirect impacts of highways. Highways are among the most common forces altering ecosystems in the United States, killing an estimated 500,000–700,000 deer on U.S. highways annually. The study showed that using GPS telemetry can provide solutions to physical barriers to elk migration, as data generated were used to develop fencing and re-routing strategies to promote barrier permeability and reduce fatal collisions with vehicles (Dodd et al., 2007)

b) Brief description of Vertex collars used in this study

The Vertex Plus collars have been widely used in wildlife telemetry in the past. It is highly flexible, comes with customisable options and the ultimate tool for wildlife scientists. The basic setup consists of a standard GPS with various communications, sensor and drop-off options. It can also be coupled with External Sensors and UHF ID Tags. The Vertex Plus can be used as a simple 'Store Onboard' version with limited features and abilites (www.vetronicaerospace.com). All GPS, activity, temperature, proximity and external sensor data measured by the collar are stored in the non-volatile on-board memory. Even after the battery is exhausted, the data is always preserved. One can choose from several wireless communication interfaces to communicate with the collar depending on the structure of study area, field work and budget. These collars have an option of Iridium two-way communication through which activity, mortality and temperature data are stored with every GPS fix.

c) Types of collars and their uses

Features	**VHF Collars**	**GPS / GSM Collars**	**GPS Satellite Collars**
Method of locating the collar	VHF transmitters attached to a study animal emit a pulsed radio signal allowing a person to physically locate and observe the animal by homing into the signal using a receiver and directional antenna. More time consuming in field work.	Collar sends GPS locations to researcher via GSM mobile phone signal. Data can be downloaded with a handheld UHF device when the collar is within a certain distance from the researcher. Visual mapping data, available via Google Earth.	Collar sends its location data to researcher through e-mail. Visual mapping data available via Google Earth. Less field time required.
Added features	Only ground tracking possible	Activity, temperature, mortality and ground tracking possible.	Activity, temperature, mortality and ground tracking possible.
Data Acquired	As a visual sighting, data is collected on home range, habitat usage, animal behaviour, population demographics and diet.	Position of animal is recorded at certain intervals to determine home range and fine-scale habitat use. However no behavioural data is recorded, unless it has VHF attachment.	Position of animal is recorded to determine home range and habitat use. Ideal to use in inaccessible areas.
Battery life	Good	Moderate/poor	Poor

Age of Technology	Over 20 years	Over 10 years	Less than 3 years
Cost	Low	Moderate	High

Field operation

a) Episode I: First capture attempt and subsequent learnings

First attempt of driving animals was carried out on 18th May 2018 between 0400h to 1000h. A team of 12 people was used to drive the swamp deer towards the nets. The plan of driving the animals towards the net was successful in the first attempt itself.

Two of the swamp deer from the herd of around nine individuals jumped onto the net but escaped within 10 seconds before the animal restraint team could reach. The animals escaped from the lower end of the net into the Phragmites patch while other individuals of the herd jumped over the half fallen net. Subsequent efforts to again drive the animals did not bear desired results. The procedure was repeated on 19th May 2018 again between 0400h to 1000h but the animals did not come out of the Phragmites patch making capture attempts not possible.

Slight modifications in hoisting of the nets on the bamboo poles for easy and complete dropping were made for subsequent capture attempts. In this regard, the nets were hoisted on the pointed side of the nails instead on the head side.

b) Episode II

The capture operation on 22nd May was initiated at 0400h. The swamp deer finally came out of the swamp by 1600h. A team of 12 people was used to drive the swamp deer towards the nets. The animals responded to the push but were quite alert. Swamp deer escaped and further attempts were not made due to paucity of time and to avoid stress to the animals.

The respective teams again positioned in the morning at 0700h on 23rd May 2018 and waited for the animals to come out. A group of 20 individuals was located in the open patch in front of the nets. As the driving team failed to reach the spot on time, the animals could not be driven towards the net. The animal drive exercise was stopped for the coming days to let the

animals settle and exhibit normal behaviour. Additionally, efforts were made to increase the netting area by adding three more nets that were provisioned from Wildlife Institute of India. The effective netting length was 160 m.

Lessons learnt from the first round of unsuccessful collaring attempts

1) The exit routes of swamp deer require sealing off before the drive is conducted.
2) Need for proper communication among the drive and net deploying teams.
3) Adequate length of the net has to be lying on ground to ensure that the animal is entangled completely within the net.
4) The length of the nail attached to the bamboo pole need to be adjusted so that the net only slides off when the animal hits and not by itself.
5) After one unsuccessful attempt, sufficient time has to be given to the swamp deer for exhibiting normal activities.
6) The physical deterrent has to be lifted only after the nets have been hoisted.

c) Episode III: Successful capture on 30th May 2018 (1400 to 1800h)

A herd of around 50 animals was seen grazing in open in the evening along with a chital herd, near the swamp on 30th May 2018 and provided opportunity for capture. A team of 51 people was used to successfully drive the swamp deer towards the net. When the drive started, the chital started moving towards the forest patch while the swamp deer moved towards the swamp. Four motorbikes were stationed strategically to block off the exit routes of swamp deer. One adult female got into the net while the other animals of the herd reverted back. The animal was immediately approached and restrained. The physiological parameters were monitored and found within normal limits. The individual was blindfolded and administered mild doses of tranquilizer to minimise the stress. The animal was immediately collared with Vectronics GPS satellite collar (Figure.14a-b). Biological samples (blood and hair) were collected and stored for further analysis. The animal was released from the entanglements of the net and administered with reversal drugs. The animal was left undisturbed and sprayed water from distance to support cooling and recovery. The animal got up and rushed back into the thicket. The radio-signals of the deployed collar were checked which indicated proper functioning.

Figure.14a-b: Collaring of swamp deer

d) Episode IV: Subsequent capture attempts

Captures were attempted again on 6th and 21st June but were unsuccessful. The animal numbers in the meadow were low on 6th June and the animals escaped even before the nets

could be set. On 21st June, the animals escaped even prior to initiation of exercise, due to disturbances caused by dogs.

Another attempt was made on 22nd June between 0800h to 1100h. About fifteen individuals were seen in the meadow. As the team was already prepared and positioned, same technique used for driving the animal into the nets. The team was successful in capturing and collaring another adult hind.

Post collaring data analysis

a) Home range estimation

The Brownian Bridge Movement Model (BBMM) is based on the properties of a conditional random walk between successive pairs of locations dependent on the time between locations, the distance between locations and the Brownian motion variance that is related to the animal's mobility (Horne, 2007). A BBMM assumes that locations are not independent, whereas the 'classical' Kernel Density Estimator (KDE) assumes they are. Using the BBMM, we estimated home ranges of two collared swamp deer during the entire period of GPS data records (June 2018-June 2019). The BBMM requires (1) sequential location data (2) estimated error associated with location data and (3) grid cell size assigned for the output utilization distribution. We selected a grid cell size of 30 m for the analysis. Using the BBMM package (http://cran.opensourceresources.org), we calculated BBMM in the R language for statistical computing (R Foundation for Statistical Computing, Vienna, Austria). We prepared 50% BBMM and 95% BBMM to represent the core area of use and the standard home range size, respectively (Fischer et al., 2013).

b) Group dynamics study

There was difficulty in sighting swamp deer inside the tall wet grasslands as accessibility to these areas during monsoon was limited. Based on the core area usage of the two collared swamp deer (Figure.25- only Jhilmil's core area shown), five cameras were deployed in each of the two locations and activity and group dynamics were monitored for 10 days (100 trap nights). We placed the camera traps in certain trails in the grasslands for clear visibility. We calculated the temporal activity overlap analysis with CamTrap package implemented in R software (Niedballa et al., 2016). The time activity of humans and swamp deer was analysed by Oriana software 2.0 (Kovach Computing Services).

Results

Radio-tracking of animals post collaring

The 1st collared swamp deer was named as 'Jhilmil' (Figure.15) and the individual stayed in JJCR from 30th May to 6th June. Detailed movement path of Jhilmil is given in Figure 19. On 6th evening it left Jhilmil Jheel and moved along Ganges and reached Nangal grasslands. Constant data was generated at an interval of 2 hours via satellite tracking and adequate ground tracking was also done (Figure.16). On 9th June it moved further south and settled in a river island grassland patch four km upstream of Balawali Rail Bridge (Figure.17 right panel). Detailed movement path (May 2018-May 2019) from Jhilmil Jheel to Balawali river island with stopover sites is given in Figure 18(a-f). Ground tracking revealed that the habitat in the river island where it spent considerable time is mainly comprised of *Saccharum* spp. It was also accompanied by two more individuals at the time of sighting. During the course of one year monitoring, it had mainly resided within the grassland of Nangal and associated river islands.

Figure.15: Collared swamp deer grazing with the herd on 5th June 2018 at Jhilmil Jheel

The 2nd collared swamp deer was named as 'Gori'. The detailed movement path of the individual is given in Figure 21. Gori stayed in Jhilmil Jheel till 25th June 2018. On 26th June, Gori crossed Ganges and ventured into a cropfield / grassland complex for one day. The

animal moved further south and remained in Ranjeetpur Jheel in Laksar Range, Haridwar Forest Division till it moved downstream on 30th June, crossed the river and reached a small wetland near Sukhapur village in Uttar Pradesh (Figure.17 left panel). Detailed movement path (June 2018-May 2019) from Jhilmil Jheel to Sukhapur and back to Jhilmil with stopover sites is given in Figure.20 (a-f). The habitat is mainly comprised of Typha and Phragmites and it has been sighted twice but alone. It left Sukhapur on 15th January 2019 and stayed near the Balawali bridge area till 14th February 2019. On 15th February, Gori changed bank and moved upstream to Ranjeetpur Jheel where it stayed for about a month. On 15th March it again crossed Ganges and stopped at Nangal grassland for six days before finally reaching Jhilmil on 21st March. Till May 2019, Gori stayed in Jhilmil.

Figure.16: Radio-tracking of collared swamp deer

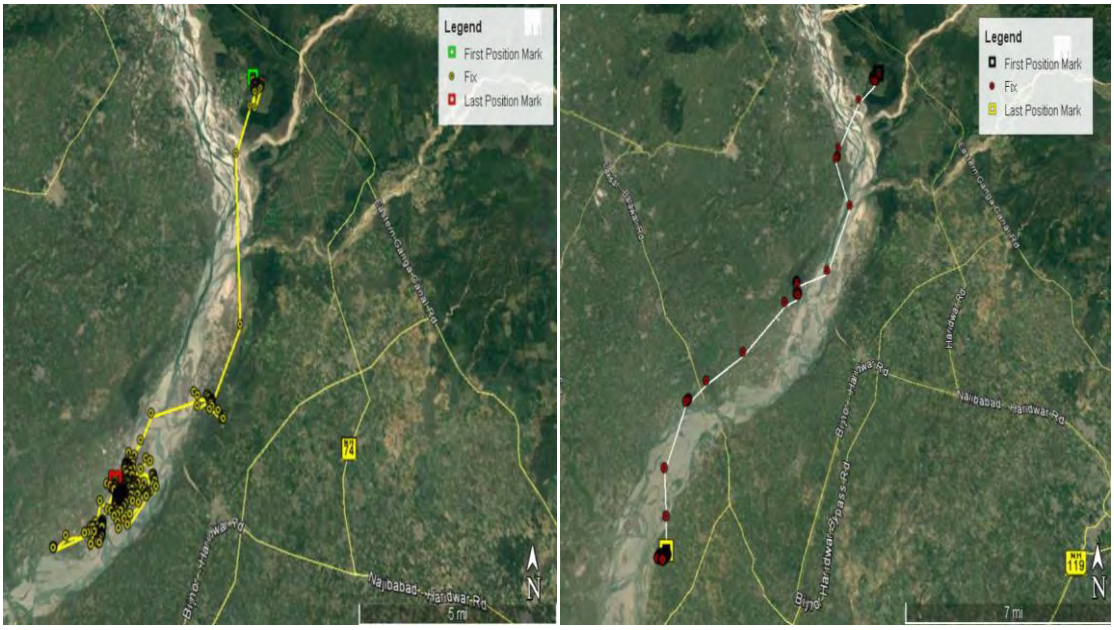

Figure.17: Movement pattern of Jhilmil (Right panel 30-5-18 to 12-7-18) and Gori (Left panel 22-6-18 to 12-7-18) (green/black squares= start point, red/yellow squares= end point)

Figure.18a: Tracklog of Jhilmil; 30-5-18 to 22-7-18

Figure.18b: Tracklog of Jhilmil; 22-7-18 to 19-9-18

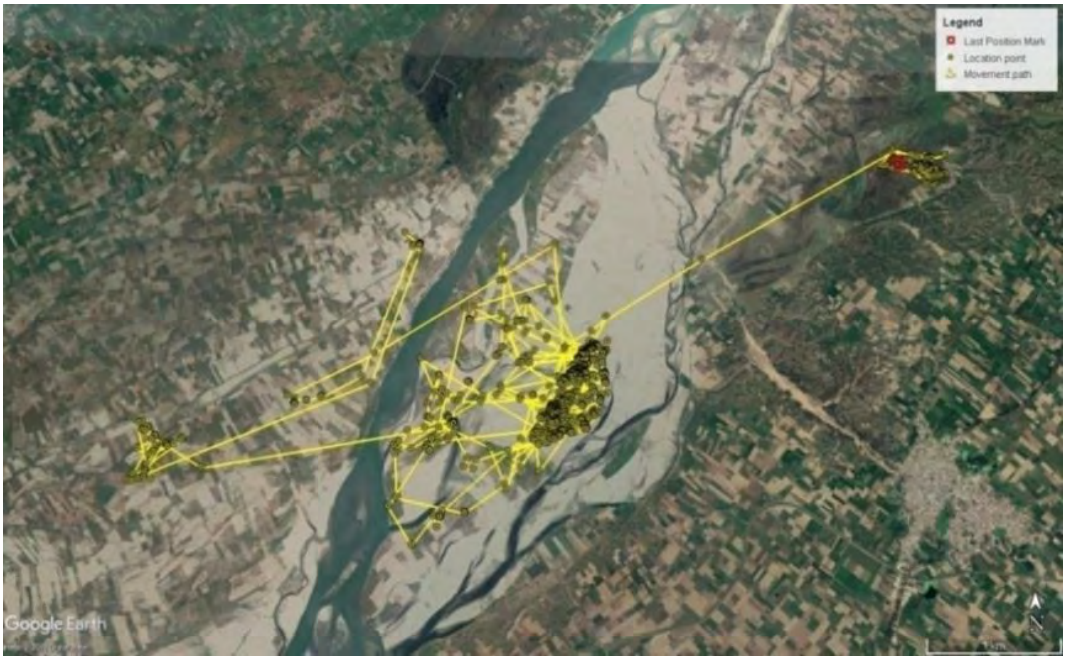

Figure.18c: Tracklog of Jhilmil; 19-9-18 to 17-11-18

Figure.18d: Tracklog of Jhilmil; 17-11-18 to 18-1-19

Figure.18e: Tracklog of Jhilmil; 18-1-19 to 17-3-19

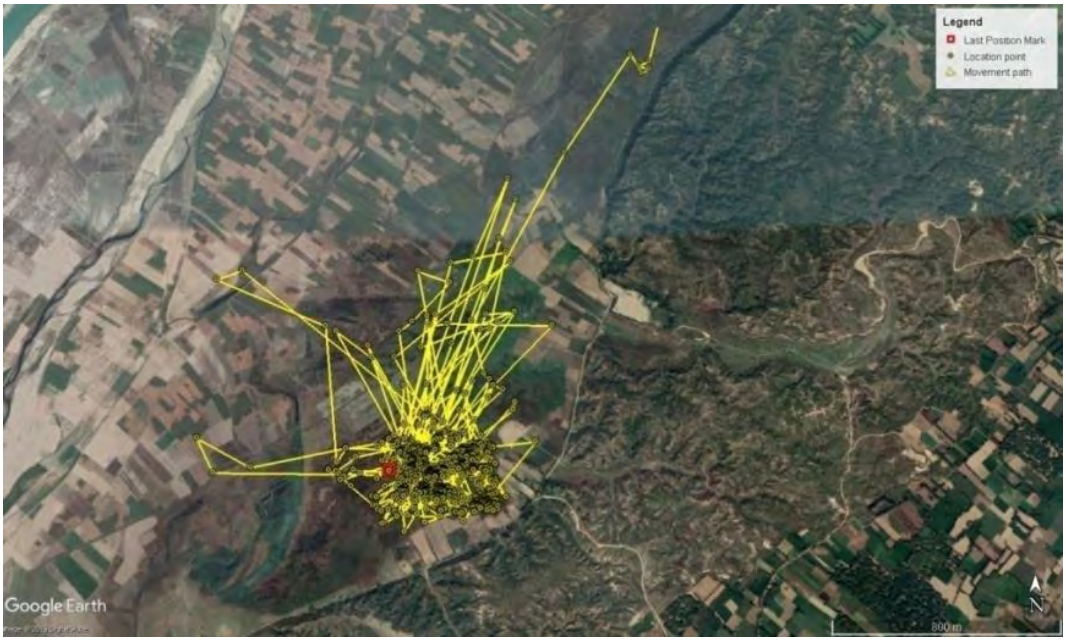

Figure.18f: Tracklog of Jhilmil; 17-3-19 to 28-5-19

Figure.18 (a-f): Swamp deer (Jhilmil) movement from Jhilmil Jheel to Balawali river island with stopovers

Figure.19: Overall tracklog of Jhilmil; 30-5-2018 to 28-5-2019

Figure.20a: Tracklog of Gori; 28-6-18 to 27-7-18

Figure.20b: Tracklog of Gori; 27-7-18 to 12-9-18

Figure.20c: Tracklog of Gori; 12-9-18 to 18-11-18

Figure.20d: Tracklog of Gori; 18-11-18 to 19-1-19

Figure.20e: Tracklog of Gori; 19-1-19 to 12-3-19

Figure.20f: Tracklog of Gori; 12-3-19 to 28-5-19

Figure.20 (a-f): Swamp deer (Gori) movement from Jhilmil Jheel to Sukhapur and back to Jhilmil with stopovers

Figure.21: Overall tracklog of Gori; 28-6-18 to 28-5-2019

Home range estimation

For the 1st collared swamp deer (Jhilmil), BBMM analysis revealed a 95% usage area of 8.22 km^2 and 50% usage area of 0.58 km^2 (Figure.22). The overall displacement was 224 km and the linear distance between initial and final points was 17 km. The 2nd collared swamp deer showed a 95% and 50% usage area of 11.97 and 1.47 km^2 respectively (Figure.23). Overall it moved 81 km and a maximum of 26 km linearly along Ganges from its initial location. The results suggest that very minimal habitat is available for the swamp deer outside the realms of protected areas.

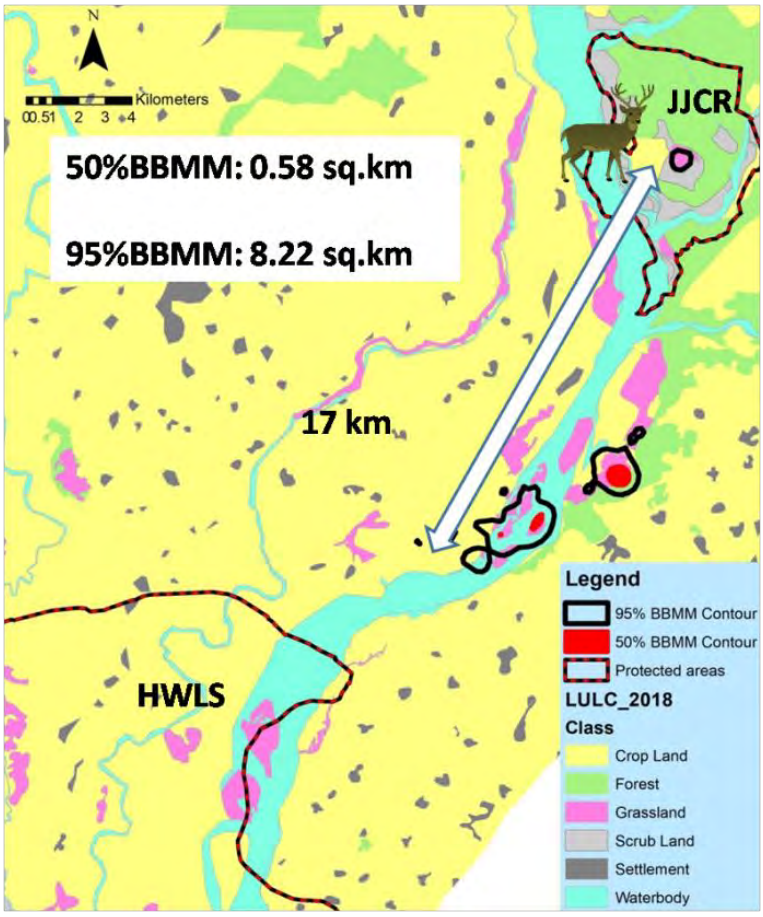

Figure.22: BBMM Home range of 1st collared individual (Jhilmil)

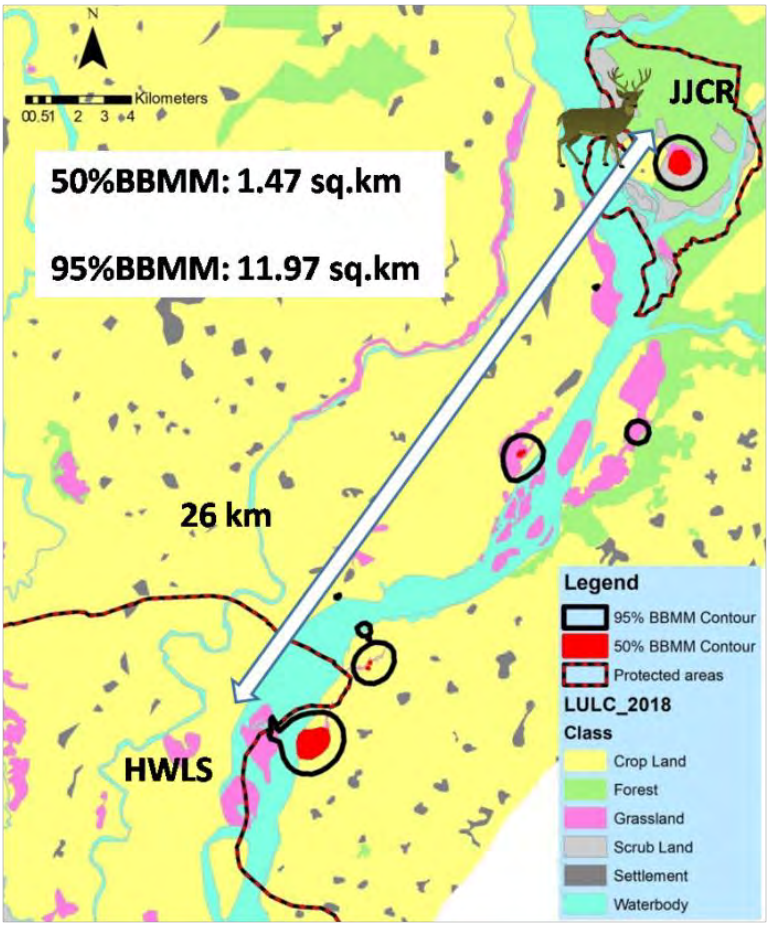

Figure.23: BBMM Home range of 2nd collared individual (Gori)

To see the habitat selection by the two individual swamp deer, we collated all the GPS points and plotted it on the different classes, categorized in Land Use and Land Cover map 2018. We observed that 80% of the GPS points fell on grasslands (Figure.24).

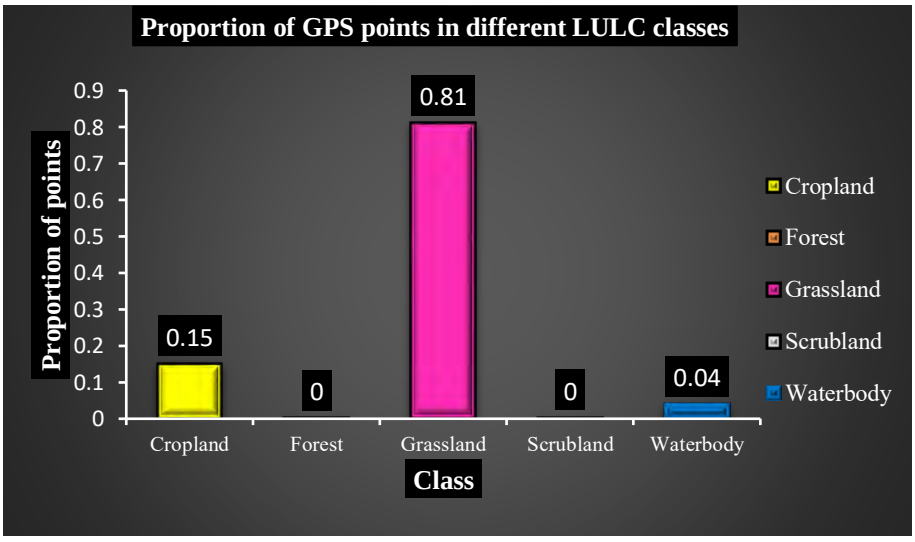

Figure.24: Proportion of GPS points in different LULC classes

Camera trapping to study group dynamics and activity pattern

Based on the core area usage of the two collared swamp deer (Figure.25- only Jhilmil's core area shown), we deployed five cameras in each of the two locations which revealed amazing data on swamp deer group dynamics and temporal segregation with humans.

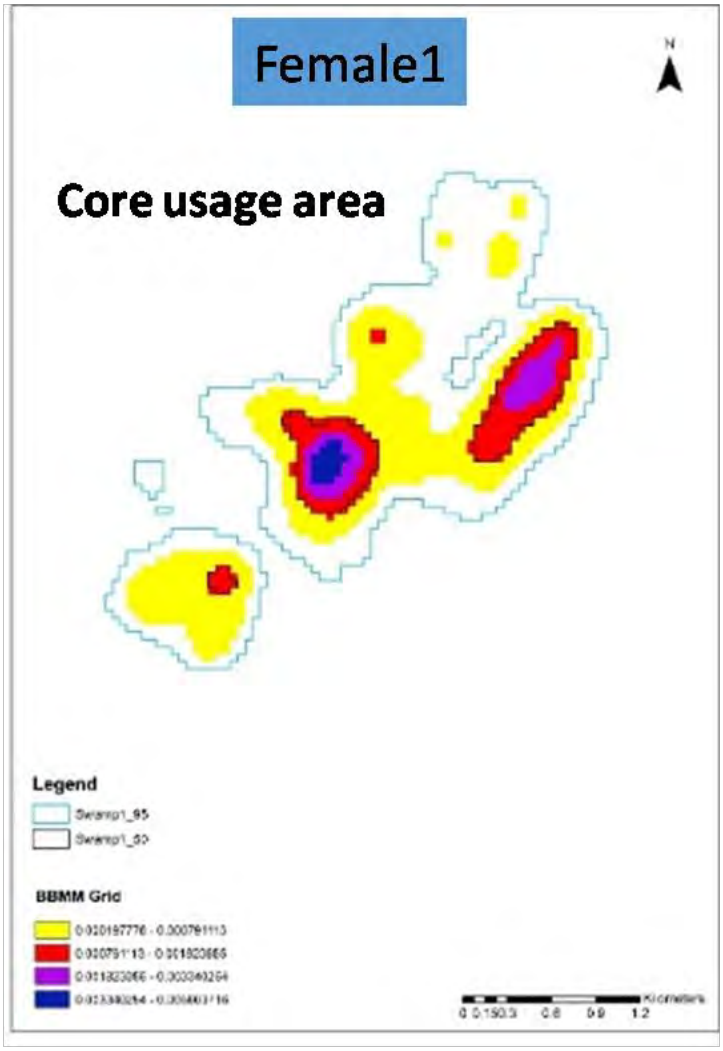

Figure.25: Camera traps deployed based on core area usage (only Jhilmil shown)

Camera trap data suggests that the swamp deer are operating in small groups (Figure.26) with presence of stags (Figure.27) and other hinds (Figure.28) besides collared females (Figure.29). From the camera trap images, it was understood that these fragmented grasslands are critical fawning and rutting grounds (Figure.30 & 31). Most of the captures of swamp deer were during the night between 6:00pm to 6:00am (Figure.34). During day, human activities are rampant, especially between 7:00am and 4:00pm (Figure.32, 33 & 35). An

activity overlap analysis shows only a mere 16% overlap between the activities of swamp deer and human (Figure.36) ($U2= 4.69$ $p<0.001$).

Figure.26: A group of swamp deer in Sukhapur

Figure.27: A stag in Sukhapur

Figure.28: A hind and a stag near Balawali river island

Figure.29: 2nd collared individual (Gori) in Sukhapur

Figure.30: Swamp deer stag in rut

Figure.31: Swamp deer hind with fawn

Figure.32: Human activity in Sukhapur

Figure.33: Human activity in Balawali river island

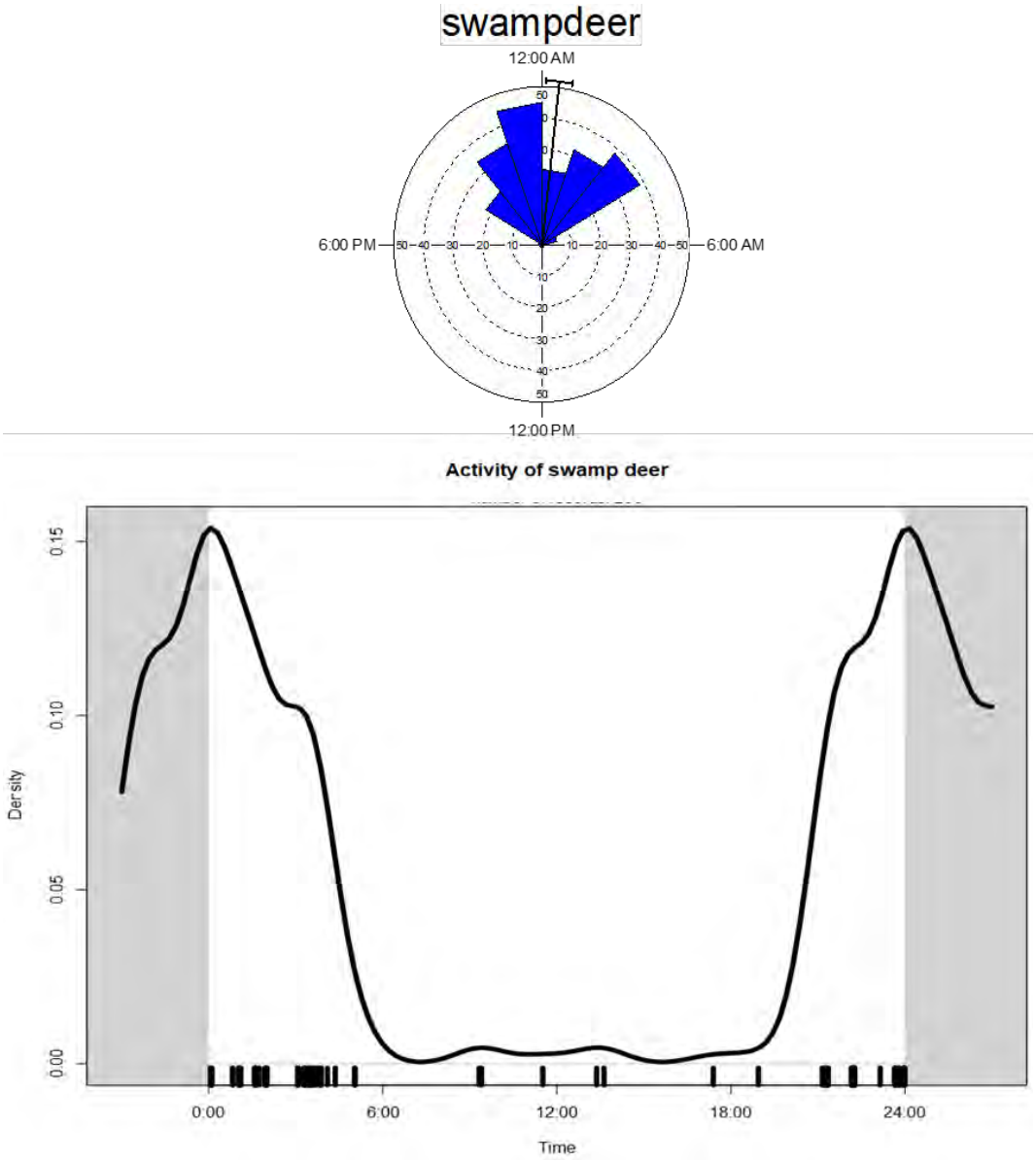

Figure.34: Temporal activity pattern of swamp deer (Trapnight=100)

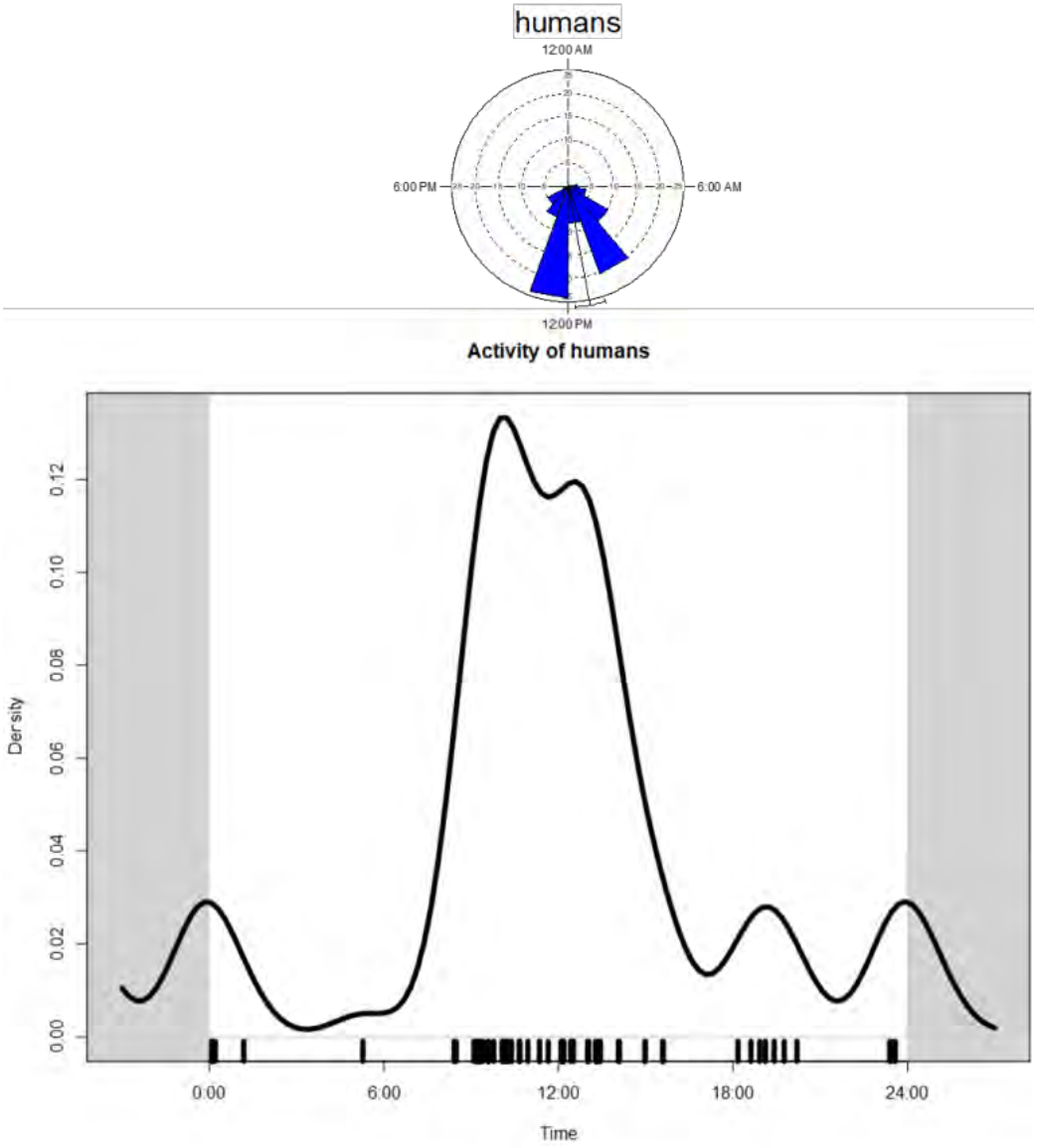

Figure.35: Temporal activity pattern of human (Trapnight=100)

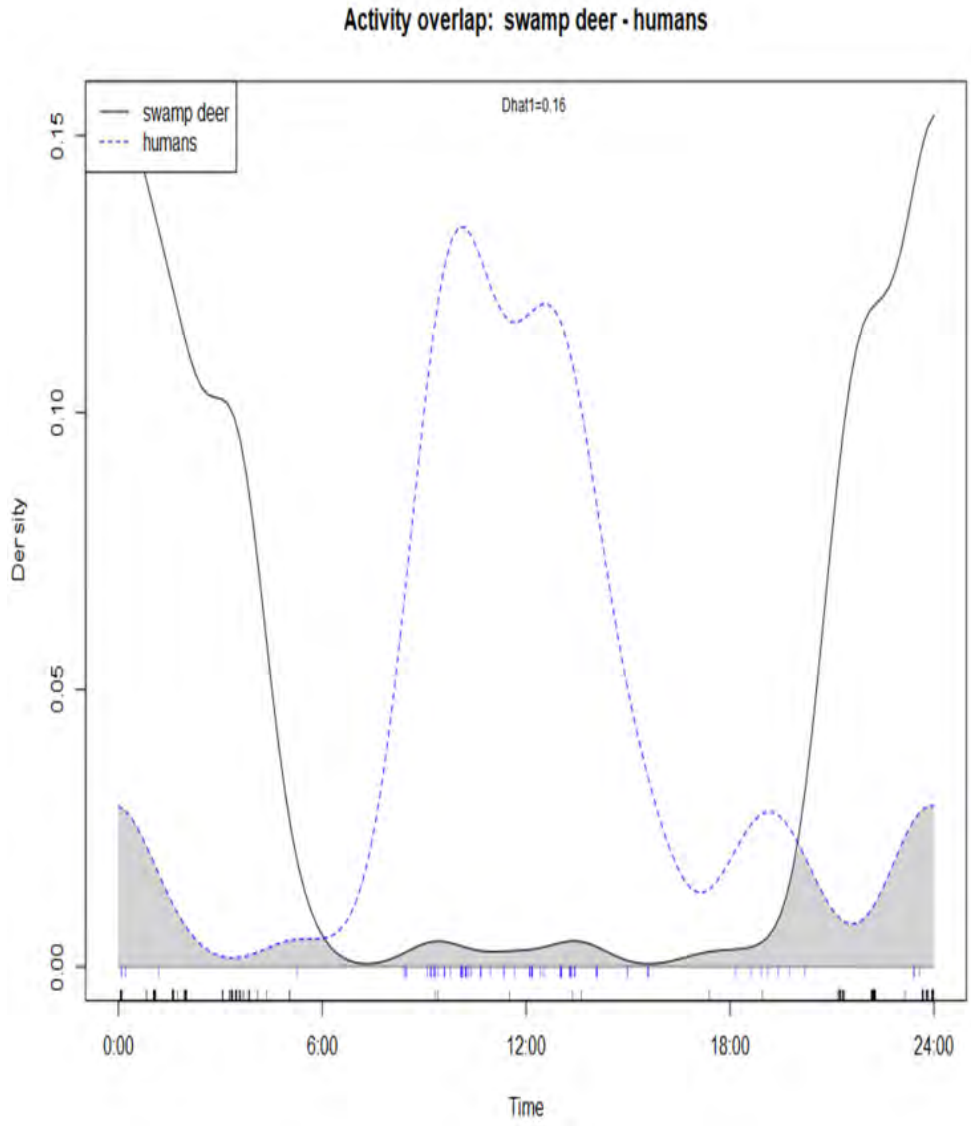

Figure.36 : Activity overlap pattern between human and swamp deer (Trapnight=100)

Discussion

The collaring of swamp deer is a critical step in the conservation of this species in this fragmented non-protected landscape. Fluctuating swamp deer numbers throughout the year raised questions about their unknown whereabouts. Surveys revealed presence of grassland patches outside Jhilmil Jheel which could be used by swamp deer moving from Jhilmil Jheel Conservation Reserve. Drive-net technique was successfully implemented to collar two swamp deer. The movement pattern displayed by the two collared individuals validated the previously generated genetic data which showed connectivity between different swamp deer harbouring areas. The movement data identified critical stopover sites (Nangal grassland, Ranjeetpur Jheel, river islands) between Jhilmil and Bijnor which both swamp deer actively

used. Some of the habitats are still suitable for swamp deer (Nangal grassland) while Sukhapur is highly degraded and requires immediate attention. If the intermediate habitats perish, it can have catastrophic effect on swamp deer population. Also we found that the core area usage for swamp deer was limited (0.58 and 1.47 km^2) which indicates minimal habitat left for swamp deer in this human-dominated landscape. The swamp deer are operating in small groups in these non-protected grasslands and they showed an overlap coefficient of 0.16 with humans. Presence of fawns and rutting males in the fragmented grassland patches indicate that these grasslands are integral part of their life-cycle. Some croplands were also used by the collared swamp deer but the croplands were in close vicinity of the grasslands. In our current study we have been able to radio-collar only two females from 2016-2018. Further efforts with radiocollaring some stags would shed some light on the sex-specific movement and habitat usage pattern in this landscape. A long-term radiocollaring study with significant number of animals would help us priortize conservation measures for swamp deer of the Gangetic plains in future. As of now, all analysis and findings indicate that these grassland patches continue to be critical in supporting a viable population of swamp deer. It is essential to devise management plans involving local communites around Ganges for these fragmented patches to support swamp deer conservation.

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Conservation management of elephants in Chhattisgarh: A study on dispersal, ranging patterns and human–elephant conflict

Annual report for the period July 2017 to June 2018

Submitted to

Chhattisgarh Forest Department

भारतीय वन्यजीव संस्थान
Wildlife Institute of India

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Extended Executive Summary

Preamble

Chhattisgarh human-elephant conflict situation is a conservation conundrum: There are just over two to three hundred elephants in the state and they currently occur in vast swathes of forests spanning several districts in Surguja, Bilaspur and Raipur forest circles and yet, there is intense conflict between people and elephants culminating in to a major social, economic, political and conservation problem. In response to prevailing conflict situation, the state forest department has been trying a suite of site-specific mitigation measures. Additionally, Wildlife Institute of India and Chhattisgarh forest department has embarked a long-term study in response to repeated calls for better understanding of elephant conflict situation by focusing on patterns of dispersal and ranging behavior of elephants among other objectives. Fieldwork for our study began a year ago, during July 2017, and we have completed the first year of the study. In this report, we discuss the activities that were carried out during the period, preliminary findings of some of the objectives and the way forward.

A year that was…

We commenced our study by carrying out reconnaissance surveys in elephant ranging divisions across the state. These surveys provided the much-required insights on the spatial distribution of elephants, schema of the landscape, management aspects and the local socio-political and cultural settings. During these reconnaissance surveys, we could also garner the extent of conflict in different areas through field visits and informal discussions with the staff. Our reconnaissance surveys hinted at the fact that elephants in Chhattisgarh operate in a vast mosaic of forests and human-use shared areas.

Chhattisgarh forest department has a fairly robust system of daily monitoring of elephant groups and division-level details of elephant occurrence are maintained real-time. Nevertheless, elephants are not confined to forests and have been moving extensively within the landscape over time. Therefore, assessing the spatial extent of elephant occurrence in the landscape is far from easy. To comprehend this, we have used elephant-caused crop and property damage records maintained at the division level. Crop and property damage records not only provide the intensity of conflict, but also serve as surrogate for elephant occurrence. We collated over 25000 records pertaining to a three-year period from 2015 to 2017, from division offices in elephant ranging divisions in Surguja circle and plotted them in GIS. The map provided insights on the spatial extent

of conflict, which is vast spanning in several districts. In Surguja circle, over 520 villages have had suffered crop damage by elephants during the period 2015 to 2017. This number is best considered minimum, as numerous farmers who suffer minimal damage to crops may not file for compensation. Although the spatial extent of crop damage is widespread, there are conflict hotspots – villages that repeatedly suffer high conflict. Such hotspots are shown in the form of heat map. These are the villages where suite of conflict mitigation strategies can be experimented by engaging with local communities. Moreover, from the conflict heat map, it further transpires that elephants move about significantly in the landscape and have emerged in lot of areas just for a few weeks. These 'erratic' movements indicate that some of the herd's home ranges could be temporary (unlike well-set home ranges of herds in intact habitats) and analogous to "streaking behavior", which are exploratory in nature. Thus, understanding how elephants traverse in this landscape is important to know. In particular, how their seasonal habitat use is influenced by environmental and anthropogenic factors is crucial to understand both for conflict management and also for developing/managing habitats for the purpose of conservation of elephants.

Telemetry collars provide the much-needed insights on movement and suite of other behaviors. Therefore, after obtaining due permits from the state and central governments, we have procured six iridium-based satellite collars from 'Savannah Tracking', Kenya. During the 2nd week of May 2018, a large bull makhna (around 40 years) was collared in Rajpur range of Balrampur division. For sedating the elephant for collaring purpose, a combination of Xylazine and Ketamine drugs were used. Post collaring, a team of researchers and field staff of the respective ranges have been closely monitoring the movement patterns of the bull. During the 2nd week of June 2018, an adult cow (around 25 years) from a family herd of elephants was collared in Mainpat range of Surguja division. The elephant was immobilized using Etorphine (M99), a narcotic. The collared bull's home range for the last few months after collaring has been over 350 km^2 (based on Minimum Convex Polygon estimates). The bull has been solitary during the study period. Our day-wise rigorous monitoring shows that the bull has been raiding crops everyday. The bull has been regularly breaking houses (mud-walled huts) as well to access stored grains. Based on our ad-libitum observations, behaviorally, the bull is mild-tempered and has not exhibited any antagonistic behaviors towards people both inside the forest and in human use areas. The cow elephant, which is part of a larger family group, has had a comparatively small home range of 20 km^2 for the two months, June and July

2018, whence we deployed the collar. Although the collared cow raided crops, it was just for a few days. Interestingly, even though some of the herd members got in to conflict during a few nights (particularly house breaking), the collared cow did not come out of the forests on those days. Lest it be misinterpreted that the collared cow does not raid crops or get in to conflict. The point we submit here is there could be significant individual-level behavioral differences influenced by the behavioral idiosyncrasies, dominance ranks, association patterns, physical, physiological and reproductive states that could conflict behaviors as well. Only long-term engagement with a variety of individuals can we understand these elephants better. Our technique of tracking and following elephants with iridium collars would reveal key travel routes, crucial habitats that can be developed in to elephant habitats.

While telemetry data shall provide fine-scale details on how elephants use the mosaic landscape, due to cost and logistics considerations, only a few individuals can be collared. On the other hand, re-sighting and continuous monitoring of identified individual elephants can provide a wealth of information on ranging, group dynamics and conflict patterns. Since the inception of our fieldwork, we have been developing a repository of elephant photos and videos. From this repository, we have started identifying individual elephants based on their unique morphological characteristics. A total of around 50 elephants have been identified individually. Re-sighting data (location information, group composition and association patterns constitute the re-sighting data) of identified individuals is providing interesting insights. For example, an identified adult cow, CFG001, along with a group of elephants, was sighted in different areas across Surguja circle. By using Minimum Convex Polygon estimator, the home range size of this female's group was estimated to be over 3950 km^2 for the given period. Another group of identified elephants exhibited exploratory behavior and moved across many divisions spreading conflict in new areas. Repository of identified elephant is also crucial for management interventions such as translocation, collaring and others.

Whilst telemetry, spatial mapping of conflict and continuous monitoring of elephant groups have started providing important insights on managing conflict, the overarching need for the management is to reduce human deaths due to elephants. Understanding fine-scale details of how human deaths due to elephants take place may be a first step in that regard. Therefore, we have collected circumstances that led to human death and other details directly from the field for 27 cases from across the state and collated 52 secondary records of

deaths from Surguja circle. We used simple descriptive statistics to understand the patterns and circumstances of human deaths due to elephants.

From our basic analysis, we can broadly bin human deaths in to three categories – deaths that occur in crop fields; deaths that occur in and around houses; and deaths that occur inside the forests. The first two are outside the elephant habitat while the third one is inside the habitat. Most of the deaths have occurred in the crop fields. The proportion of human deaths due to elephants was high during the months of November, December and January, coinciding with crop harvest season. This is the time when elephants intensify crop raiding (to optimize their foraging strategy) and being a single crop; marginal farmers risk their lives while guarding crops. A fairly high proportion of deaths have occurred in and around the hutments as well. This is because, when standing crops are not available, elephants sometimes break houses to access stored grains (mostly) and also come close to houses for fruits like jackfruit and banana grown in the backyard and in some cases, for accessing stored fermented local brew as well. There were also human deaths inside the forests when people go in for collecting fuel wood and other minor forest commodities. Human deaths have sometimes happened when villagers went to forests for relieving themselves and even while moving through the forests to their homes after the day's work. Reducing human deaths in the landscape where elephants extensively range in human use areas in an unpredictable manner and exhibit behaviors such as breaking houses and at the same time dealing with people that show high dependence on forests is seldom easy. It requires multi-pronged efforts. Nevertheless, attempts to safeguard hutments might be one of the mitigation strategies that could help in reducing human deaths as many human deaths have occurred near houses. Further, elephants coming close to houses wreak fear and pandemonium to villagers. As a consequence, they sometimes resort to unplanned driving, which has led to many deaths.

For effectiveness and sustenance of conflict mitigation strategies, particularly in shared landscapes where conflict is widespread, it is crucial to engage with local communities. A prerequisite for such an engagement is developing an understanding of the local communities' lifestyle, socio-economic aspirations, perceptions about conflict and willingness to participate in conflict management. As a small step towards achieving this, with help from committed local volunteers who are well versed with Surgujia, a dialect that local populace use, we carried out structured interview surveys in 50 villages across Surguja and Surajpur divisions. For interviews we selected villages that are highly affected by

human–elephant conflict. A total of 180 respondents participated in our interview surveys. We are in the process of analyzing the data.

Whether or not we like, elephant conflict management in Chhattisgarh may entail interventions like drives and translocation of elephants. Developing a basic understanding of the population structure and first order relatedness of elephants shall help in better planning of adaptive management interventions. Just to illustrate, in the case of translocation of a young male, the prospects of it settling down in the release site could be better if it is far from the animal's natal range. As first step in this regard, we have collected over 200 fresh fecal samples of elephants from nine divisions to assess genetic structure of the elephant groups with in the state. Since elephants do not appreciate state boundaries, which are porous, it is important to assess landscape and population-level genetic structure and connectivity of elephants in the large central Indian regional population. At the population level, it shall be vital to find out from where more elephants are getting displaced. Simply put, from where the elephants operating in Chhattisgarh have come? We are in the process of extracting the DNA from the samples at our laboratory facility in Dehradun.

Whilst the aforementioned activities were part of our standard work plan, elephant conflict management involves site- and time-specific issues – some of which are emergency in nature, where timely advisory role is crucial. WII is fortunate to work closely with Chhattisgarh FD on a wide range of conflict management issues, playing an advisory role. It shall be prohibitive to list them down in this succinct summary. Therefore, we have listed some of them in the core of the report.

Way forward…

Going forward, we shall continue our core activities such as collaring more elephants, monitoring elephants and conflict and others. We shall be testing lion-shield based early warning systems as well. Alongside, we shall ramp up the training programs intended to frontline staff and continue our advisory role with active participation in a suite of real-time elephant conflict management issues.

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We express our sincere gratitude to Principal Chief Conservator of Forests (Wildlife), Chhattisgarh, Dr. R.K. Singh for initiating the study, providing financial and logistic support and overall guidance.

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Conservation management of elephants in Chhattisgarh: A study on dispersal, ranging patterns and conflict

Introduction

Chhattisgarh Forest Department and the Wildlife Institute of India initiated a long-term study on dispersal, ranging behavior and human–elephant conflict in the state in 2017. Conflict between people and elephants in Chhattisgarh has attained serious proportions with over 50 human lives being lost annually, culminating in to a major political problem. Chhattisgarh elephant problem is unique in many ways: Firstly, elephants have resurfaced in to Chhattisgarh during late 1980s after becoming locally extinct during 1920s. This re-colonization was mostly due to rapid loss and degradation of elephants' home ranges in the neighboring states of Jharkhand and Odisha. Thus, the state is dealing with displaced elephants. Secondly, the habitats in which elephants currently occur are highly fragmented and speckled with human use areas, and the distinction between the forest and human use areas are fuzzy (in-discernable). Lastly, the local populace is predominantly tribal and highly marginal and shows high dependence on the forests for livelihood rendering the remnant habitats highly degraded.

It is in this background that this collaborative long-term project has started. The overarching objective of this project is to gain good understanding on the patterns of home range and movement behavior and use the insights, thus gained, to try and address critical issues facing elephant conflict management in the state. Furthermore, the state is relatively new in elephant management as elephants' re-colonization was quite recent. Therefore, there is an urgent need to enhance the capacity of the frontline staff of the forest department and village-level volunteers on the tenets of elephant management. Thus, training programs to selected staff are integral to the project.

Our fieldwork for the project began during the first week of July 2017. In this first interim report, we present the details on the work-in-progress, the activities carried out for the first year and the future directions. The analyses we have carried out so far are quite basic and the findings are preliminary.

1. Collating thematic and spatial layers for the study area

We have collated vector layers of protected areas and reserved forests from the state forest department's GIS cell at Raipur. Additionally, from other sources we have also collated remotely sensed vegetation layers, landscape-level forest cover map of neighboring states and vector layers of linear intrusion in the landscape. These layers shall be useful in mapping and predicting conflict, developing heat rasters of elephant distribution and movement, potential corridors and identifying areas for habitat improvement.

2. Reconnaissance surveys in elephant range divisions and narrowing down an intensive study area

Although the population size of elephants is small, their spatial distribution in Chhattisgarh is widespread spanning many divisions and protected areas. Our objective of carrying out reconnaissance surveys was to order to gain a basic understanding on the spatial distribution of elephants, scheme of the landscape, the local socio-political and cultural settings. Furthermore, the state forest department has already been implementing a suite of elephant conflict mitigation strategies, which are important for us to understand so that duplication and redundancy in management recommendations can be avoided.

Our reconnaissance surveys were started during the first week of July 2017. Our surveys involved visiting the forest divisions, holding discussions with the top management of the divisions and the field formations, and visiting areas with the field staff where elephants generally occur. When field conditions did permit, we have tried to locate the elephants to build an identification file (discussed in later sections) and record *ad libitum* observations. Such "recce surveys" were carried out in Surguja, Surajpur, Jashpur and Balrampur forest divisions in Surguja circle; Korba and Dharamjaigarh forest divisions in Bilaspur circle and Mahasamund forest division in Raipur circle. Additionally, we have also surveyed the four protected areas in Surguja: Guru Ghasidas NP, Badhalkol WLS, Semarsot WLS and Tamor Pingla WLS. The first two months of the project period was largely devoted to recce surveys. These recce surveys helped us in narrowing down Surguja forest circle as our main focal area. Bilaspur and Raipur forest circles continue to be our peripheral area where we shall ramp up the activities at the later stage of the project.

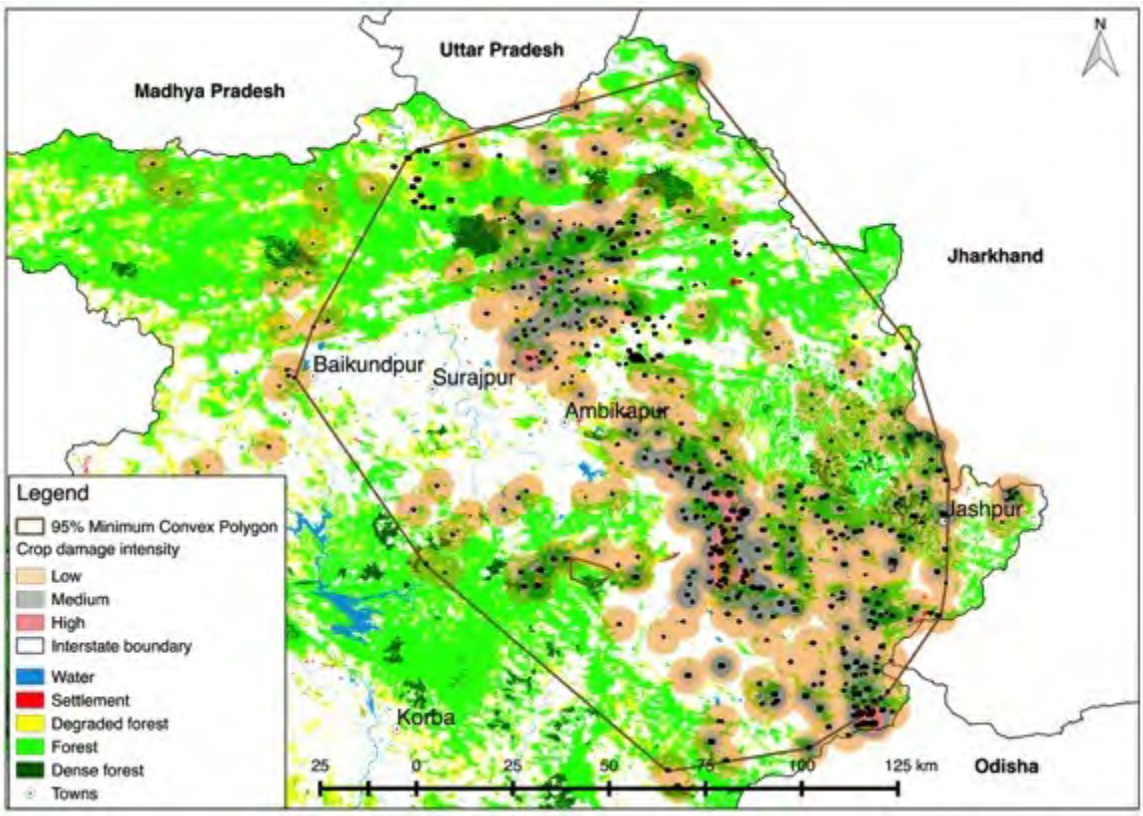
3. Procurement of collars

In the first indent, we placed order for 6 iridium-based satellite collars from Savannah Tracking, Kenya (http://www.savannahtracking.com). We have briefed the collar manufacturer about our specific field requirements (taking in to account the dense vegetation, hilly terrain etc) that predispose effective functioning of the collars. All the six collars and the ancillary gadgets were manufactured and shipped in two consignments. Of the six collars that we have received, two collars have already been deployed (section 5) and the other four collars are ready for deployment. We have also received lion-shied based early warning systems that can be integrated with the collar to alert villages. The lion-shields are yet to be tested in the field. An engineer from Savannah Tracking shall be visiting India soon to field-test the lion-shields.

4. Assessing the spatio-temporal patterns of human–elephant occurrence and conflict in Surguja

Conventional methods of assessing elephant distribution based on sign-based field surveys or interview surveys are prohibitive of efforts and logistics as elephants operate in a vast area spanning several divisions in an “unpredictable manner”. Given that crop and property damage by elephants is widespread, an easy way to understand spatial and temporal distribution of elephants is by delving in to forest department records as such records serve as a good surrogate for elephant occurrence as well in addition to providing insights on the intensity of conflict. Chhattisgarh FD is maintaining division level crop and property damage records, primarily to pay ex-gratia to affected villagers. We collated the damage records for all the elephant ranging divisions in Surguja circle and also from the protected areas in the circle for the last three years (to get a good temporal perspective as well).

Each and every crop damage points have been plotted in the GIS platform to random locations within respective villages, as GPS locations of the damage are not available. A total of 25000 records pertaining to a three-year period from 2015, 2016 and 2017 were used. We used Heat Map tool in QGIS, which uses Kernel Density Estimate function to assess conflict “hotspots” in the landscape (Map-1).



Map 1: Heat map of crop damage locations in Surguja circle. Crop damage records maintained in the division offices were used to generate the map.

Map-1 shows the spatial extent of crop damage in Surguja. Although there is not more than 100 to 150 elephants that use Surguja landscape, the spatial extent of their distribution is vast (~18000-km^2). Elephants have damaged crops in more than 520 villages between the years 2015 and 2017. As shown in the map, elephants are not confined to forests, but are operating extensively in areas outside the forest as well for movement and foraging. Lest it should be misinterpreted from the graph that elephants occur in all the shaded areas through the year. That is not the case. Rather, the elephant movement within the region is highly seasonal and there are pockets of high conflict zones in which elephants occur relatively more frequently. There are also numerous areas that elephants range infrequently and that's the reason why the crop damage is spread out over a very large area.

The spatial clusters of high crop damage areas include Tapkara and Bagicha ranges in Jashpur FD, Sitapur and Udaipur ranges in Surguja FD, Pratappur and Surajpur ranges in Surajpur FD and Rajpur and Wadrafnagar ranges in Balrampur FD. We are planning to select a subset of these high conflict villages and work on experimenting various conflict mitigation strategies like lion-shield based early warning systems, participatory physical barriers and others.

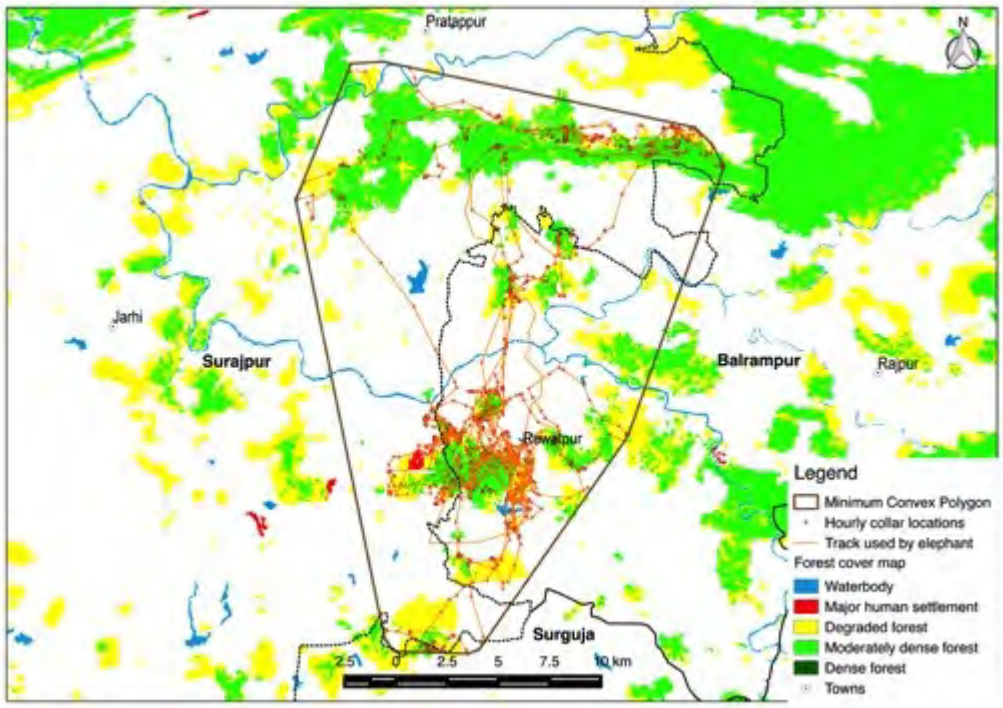
5. Deployment of two satellite collars in Surguja to understand the landscape from elephants' point of view – some preliminary insights

During 2nd week of May 2018 we have collared a large bull makhna in Rajpur range of Balrampur FD. For the purpose of collaring, the animal was sedated using a combination of Xylazine-Ketamine. The bull was estimated to be about 40 years old. The bull was christened Behradev. During the 2nd week of June 2018, an adult cow, estimated to be around 25 years of age was collared in Mainpat range of Surguja FD. The cow was immobilized using Etorphine (M99). The cow was christened Gautami. Both the elephants were fitted with Iridium-based satellite collars manufactured by Savannah Tracking. Detailed collaring reports are provided in Annexure-2 and Annexure-3. Across this vast landscape, our iridium-based satellite collars are providing GPS fixes at every one-hour interval. We have set the collars to communicate with the satellite once in every six hours. Thus, we can download location details and the tracks four times a day. We also generate maps to see how elephants traverse the landscape. Till date both the collars are working fine and the collar data has already started providing interesting insights on ranging behavior of elephants.

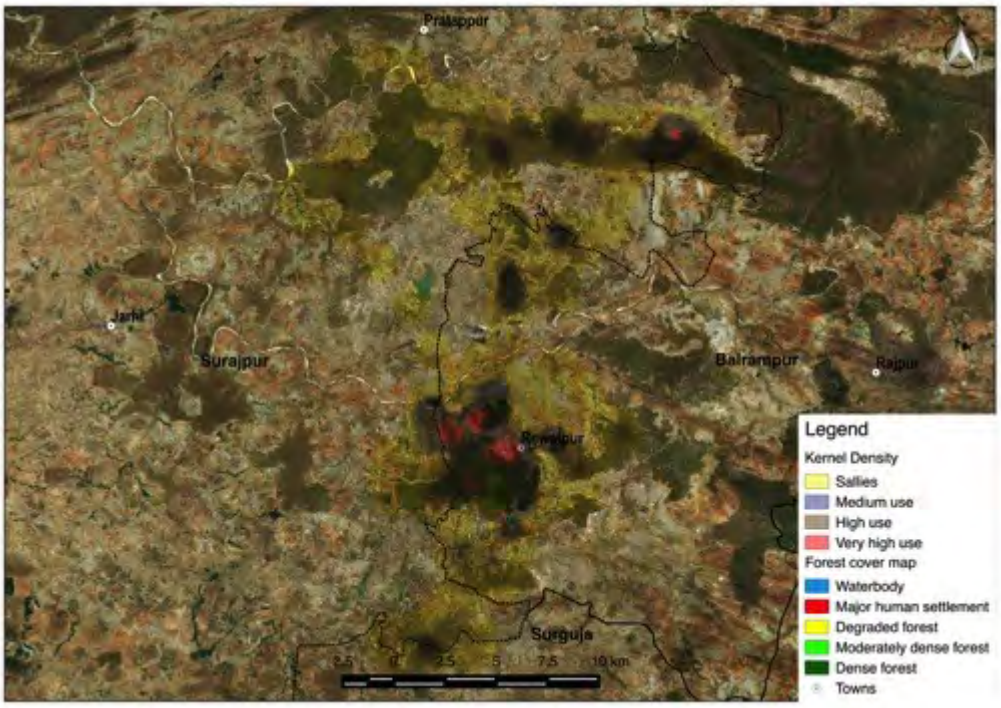
Picture 1: Chemical immobilization of cow elephant for collar deployment in Mainpat range, Surguja

5.1 Ranging behavior of the collared bull elephant

The home range estimate as per Minimum Convex Polygon (MCP) estimator for the bull for the last few months after collaring has been over 350 km^2 (Map-2). We have created Kernel Density Estimates (KDE) to show the hot spots or intensive use areas and the peripheral areas (Map-3). Interestingly, the bull has been traversing extensively in intensive human-use areas. It has been a habitual crop raider and has emerged out of forests almost every night to raid crops and move between forest patches. The bull has also been breaking houses to access stored grains. Notwithstanding the crop raiding and house breaking behaviors, based on our many hours of ad-libitum observations, behaviorally, the bull is mild-tempered and has not exhibited antagonistic behaviors towards people. Although our KDE estimates show forests as hot spots, the bull has spent considerable time outside the forests for foraging and movement needs. Most of the forest patches that the bull currently uses are predominantly dense secondary Sal. Sal and associates are poor habitats for elephants as most of the plants are inedible. In fact, our direct ad-lib observations show that the bull is using dense patches of Sal forests as refugia during the day for shelter, cover and water.



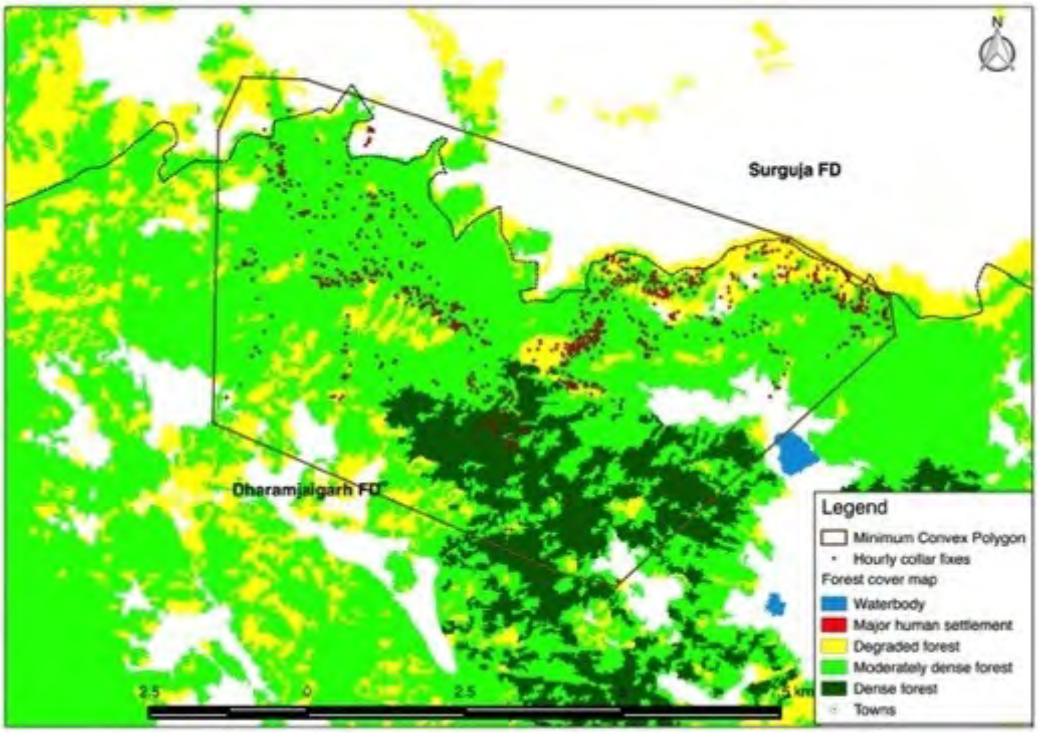
Map 2: Home range of adult bull Makhna, Behradev, for the period May to July 2018, based on Minimum Convex Polygon. Each point is an hourly GPS fix.



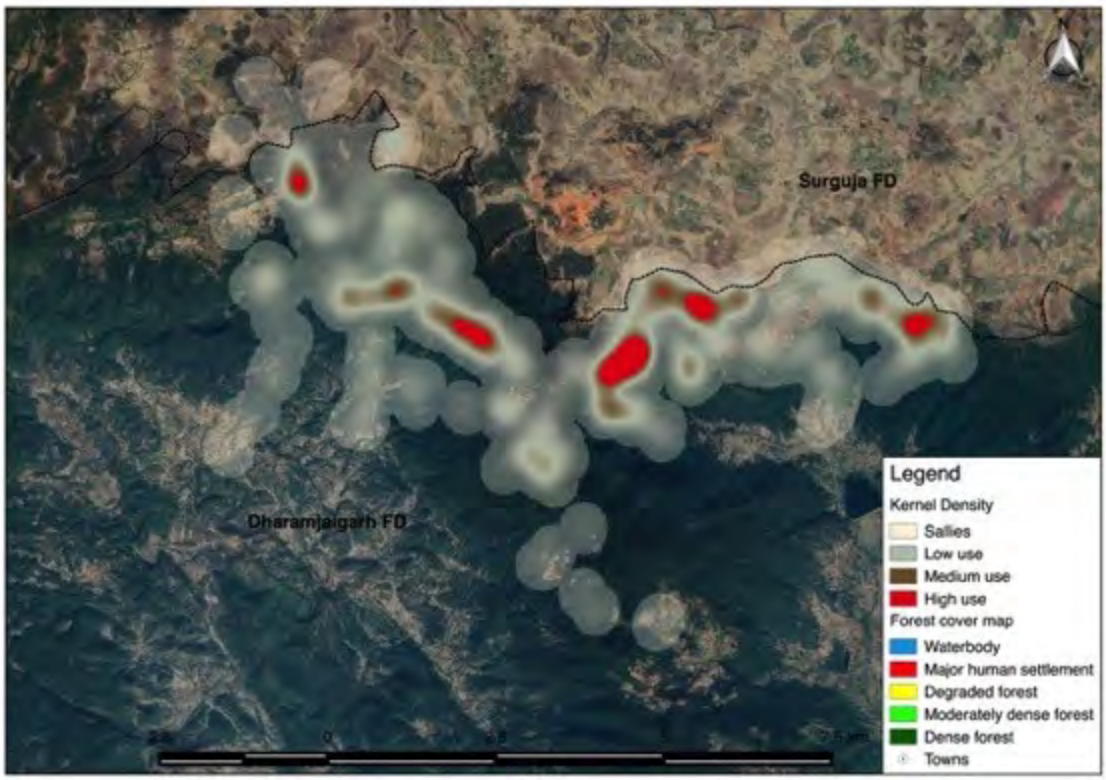
Map 3: Kernel Density Estimate for the period May to July 2018, of adult bull makhna, Behradev showing intensively used areas and peripheral areas

5.2 Ranging behavior of the collared cow elephant

The cow elephant is part of a larger group of elephants. During the time of collaring, there were over 12 elephants in the group. The number of elephants increased subsequently after a week. The group size was reduced to six, when we last observed the cow directly. This shows that the group is having very frequent fission and fusion – all too common in elephants. The home range estimate as per Minimum Convex Polygon (MCP) estimator for the cow for the last few months after collaring has been over 20 km^2 (MAP-4). The Kernel Density Estimates (KDE) show that core use areas fall within the forests and the cow has very rarely come out of forests to raid crops and break houses (MAP-5). Interestingly, although some of the elephants of the collared cow's group ventured out to break houses and raid crops, the cow did not. We urge caution it should not be misinterpreted that collared cow does not raid crops or break houses. Rather, we submit that there could be significant individual-level behavioral differences influenced by the behavioral idiosyncrasies, dominance ranks, physical, physiological and reproductive states.



Map 4: Home range of adult cow elephant, Gautami, for the period June to July 2018 based on Minimum Convex Polygon



Map 5: Kernel Density Estimate of adult cow elephant, Gautami, for the period June and July 2018 showing intensively used areas

6. Identification profile of individual elephants and tracking individuals over time and space

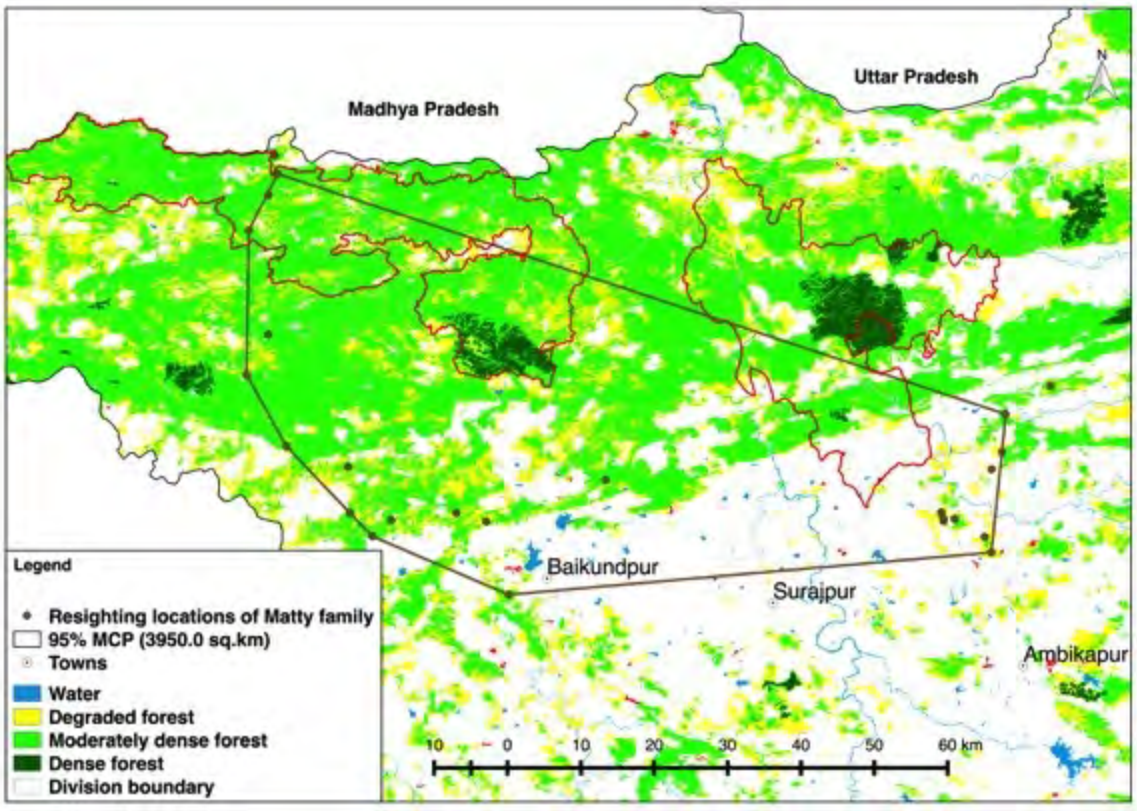
Developing identikit of elephants shall be useful in many ways: The herds' movement can be tracked and plotted, individuals that are suitable for collar deployment can be identified, and in conflict situations that warrant adaptive management (such as capture and translocation), individual identification shall be indispensible. Cursorily, elephants appear strikingly similar to each other. However, closer and careful examination shall bring forth the differences between individuals. Individual elephants can identified using morphological features like the size of the ear pinnae, cuts, tear and holes; size and shape of the tusks (for tuskers); tail features like brush and kinks; warts, injuries, deformities and others (Moss, 1988; De Silva et al., 2013). An elephant identikit template based on the aforementioned morphological features was prepared (Annexure-4). Better quality photographs and video graphs that best depict the morphological features sharply were used to identify individual elephants.

During the last one-year, we have built a usable collection of photographs and videos of elephants, directly photographed in the field from across the state. A total of 50 elephants have been individually identified from the photo repository we have created. Going forward we shall also be using photos from other sources as well (field staffs' personal collection, divisions' collections etc) to increase the number of identified elephants in the region. In the next three months, we hope to print an identification manual of elephants in Chhattisgarh – the first of its kind.

Box-1: Tracking identified individuals in space and time – utility of having a repository of identified elephant individuals

One of the identified elephants (CGF001) along with a group of elephants has been re-sighted in a number of locations across the landscape. These observations were systematically recorded. Using the re-sighting location points, we estimated the home range of CGF001 (and its group) using an MCP approach in GIS. The range spanned 3950 km^2 showing that the home ranges of elephants in this landscape are vast (MAP 6). In addition to using the identified elephants to decipher broad scale patterns of ranging, the data is being used for understanding association patterns and some aspects of elephant social organization as well.

Picture 2: Adult female CGF001. This female is part of a larger family group that was sighted in a number of locations providing a 're-sighting' data



Map 6: Home range of identified elephant, CGF001, representing a family group based on Minimum Convex Polygon estimate. The points are re-sighting locations

Panel 1: An example of photographic profiles of some of the elephants individually identified using morphological features.

Ranging patterns of elephants in Chhattisgarh state: A synthesis

In intact natural habitats, elephants exhibit profound site fidelity to their home ranges and therefore, their movement patterns may be predictable (Moss, 1988). In such intact habitats, their home ranges also tend to be relatively small (home range of elephants in the intact habitats of the Nilgiris was estimated to be around 400 km^2) (Desai, 1991). On the other hand, in fragmented habitats, elephant home ranges tend to be comparatively very large (in the fragmented forests of north West Bengal it was estimated to be over 3500 km^2) (Sukumar, 2003). In Chhattisgarh, where elephants have started recolonizing the habitats after a gap of several decades, not only their home ranges appear to be large, they appear to be in constant flux as well. Chhattisgarh elephant conflict situation in a way exemplify the problems facing management in dealing with elephants with large and ostensibly fluid home ranges in a very complex landscape mosaic with high level of fragmentation and degradation to natural

habitats. The convoluted landscape mosaic in Chhattisgarh that elephants currently operate precludes direct application of conventional fence-based conflict management approach and there is a pressing need to be innovative, taking cognizance of the local situation. A step in the right direction is gaining a better understanding of how elephants use the landscape. Here, we make an effort to piece together the insights gained from different approaches to decipher the general patterns of elephant occupancy and movement in Northern Chhattisgarh. Different approaches include direct field observations, discussions with the frontline staff and others, mapping conflict from secondary data, systematic re-sighting records of identified elephants and the telemetry data provided by the collared elephants. This narrative is more descriptive and qualitative and the idea is to provide a broader perspective of elephant movement in the state rather than finer details of it.

Distribution of elephants

Notwithstanding the fact that there are less than an estimated 300 elephants in Chhattisgarh, ironically, they operate in a number of multiple use forest divisions and a few protected areas as well, encompassing a very large area. To illustrate, during the three-year period between 2015 and 2017, the elephants have operated in an area close to an estimated 18000 km^2 in Surguja circle. This was estimated using minimum convex polygon estimator with crop damage records (MAP-1). Although minimum convex polygon estimator assumes home range shapes to be convex and thus has a tendency to overestimate the home range sizes (Anderson, 1982), nonetheless, for a comparatively small population size, the elephants' spatial range in Surguja is vast.

Elephants presently occur in three major forest circles in the state – Raipur, Bilaspur and Surguja in the central and northern Chhattisgarh. The forest divisions include: Surguja, Surajpur, Balrampur, Koriya, Jashpur and Manendragarh in Surguja circle; Dharamjaigarh, Raigarh, Korba and Katghora in Bilaspur circle; and Mahasamund, Baloda Bazar and Ghariyaband in Raipur circle. The protected areas include Gurughasidas NP, Tamor Pingla WLS, Badalkhol WLS, and Semarsot WLS in Surguja circle and Barnawapara WLS in Raipur circle. Elephant use of Katghora, Ghariyaband, Manendragarh and Koriya has been reported very recently indicating that there is lot of flux in their ranges.

Exploratory behavior and range expansion

The elephant herds that do not have well-established home ranges (due to displacement, dispersal and other factors) tend to exhibit exploratory behavior – whereby the herds keep expanding their ranges in search of a favorable range to "settle down". There is a good reason to believe that at least some of the elephant groups are exploring the landscape intensively and as a consequence, the overall range of elephants in Chhattisgarh is increasing.

To illustrate this point; a few elephants that we have photographed in Dharamjaigarh division during September 2017 and identified systematically were photographed later in Katghora division as well. Hitherto, elephants did not regularly use Katghora. However, after initial sauntering for a short period of a few weeks, the herds have started staying put for longer durations making Katghora too an elephant ranging division. Interestingly, quite recently, during the month of October 2018, a few identified elephants from the same group of elephants that operated in Katghora division were re-sighted in Koriya division. They further moved into the neighboring state of Madhya Pradesh as well. Comprehensibly, the group is exhibiting 'streaking behavior' by moving large distances into 'new' areas in order to settle down and establish a home range.

Picture 3: Identified young male elephant that was photographed in different areas. Google map shows long-distance linear movement of elephants in the landscape

Interstate movement of elephants

During the month of October 2018, one of our collared elephants, Gautami (a young adult cow) and its group has moved into the neighboring state of Odisha by crossing River Ib in Jashpur district. It is noteworthy that this group has spent considerable time in Chhattisgarh (in Jashpur, Dharamjaigarh and Surguja forest divisions) before moving into Odisha. Chhattisgarh's interstate boundaries with Odisha, Jharkhand and Madhya Pradesh are highly permeable for elephants and the collared elephant moving into Odisha is not a one-off event. There is considerable back and forth movement of elephants between Guru Ghasidas National Park in Chhattisgarh and Sanjay Tiger Reserve in Madhya Pradesh. Similarly, there is frequent movement of elephants between Balrampur division in Chhattisgarh and Palamau tiger reserve in Jharkhand. We have also recorded direct movement of elephants between Chhattisgarh and Jharkhand through Tapkara and Duldula ranges of Jashpur forest division. Between Chhattisgarh and Odisha elephant movement is frequent in Jashpur, Raigarh and Mahasamund divisions.

Elephants and other wild animals do not recognize political boundaries and their frequent interstate movement clearly point to the fact that landscape approach is critical for both conflict and conservation management of elephants. The manner in which each of these states manages elephant conflict in their respective states has potential ramifications for the neighboring states as well. The states may be hard pressed to manage elephants in isolation without smooth interstate coordination.

Intrastate movement of elephants

Within Chhattisgarh, elephants move unhindered between various forest divisions. The collared bull elephant operated in three divisions namely Balrampur, Surguja and Surajpur. The collared cow elephant used Jashpur, Dharamjaigarh and Surguja forest divisions. A group whose movement we are able to follow closely has operated in Surguja, Surajpur, Balrampur and Koriya divisions. Elephants also move freely between Korba, Surguja, Dharamjaigarh, Katghora, Koriya and Manendragarh. Through molecular analyses we are trying to find out landscape-level genetic exchange. There is clear spatial overlap of elephants between Surguja and Bilaspur forest circles. However, it is not clear whether there is exchange between elephants operating in Raipur circle with that of elephants operating in Bilaspur and Surguja. Our molecular analysis should provide some details regarding that. As is the case with managing

elephants between states, managing elephants within the state also requires landscape approach.

7. Assessing the field circumstances leading to human deaths due to elephants

Human death due to elephants is the acute form of human–elephant conflict. More often, human deaths lead to local antagonism towards conservation as a whole and turn in to flashpoint of political discussions. Therefore, for the state forest department, containing human deaths due to conflict situations assumes greater priority. A step in the right direction towards achieving this is to thoroughly assess the circumstances that have led to human deaths due to elephants. Often, the information regarding the human death dies with the victim. However, by visiting the site immediately and collecting basic data besides interacting with eyewitnesses, it may be possible to put pieces of information together cohesively. Information thus collected, shall be invaluable in educating local populace.

We have collected such fine-scale details on 27 cases of elephant-caused human mortality from across the state. Additionally, we have collected secondary details from forest department records for 52 cases from Surguja. Pooling the data together, we used basic descriptive statistics to understand the patterns and possible correlates.

7.1 Seasonality of human deaths

Human deaths due to elephants were recorded all through the year. However, a spurt in number of human deaths was observed during the months of November, December and January. Maximum cases of human deaths due to elephants were recorded during November (21% (n=17)). This coincides with harvesting season of paddy and sugarcane (Figure 1)

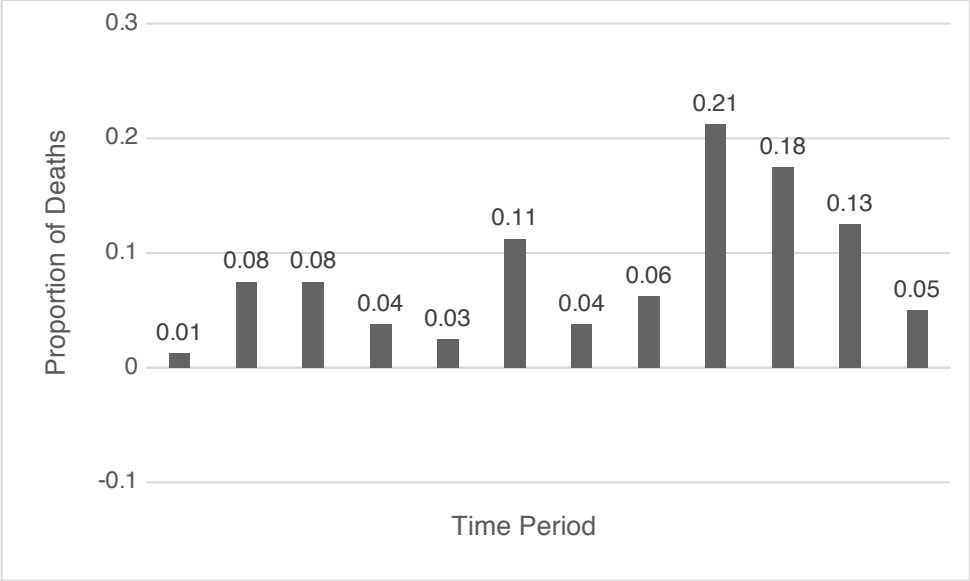


Figure 1: Season-wise proportion of human deaths due to elephants. Note that in figure, from left, months begin from March. Maximum cases of human deaths due to elephants were recorded during the month of November.

7.2 Location of human deaths

A high proportion of human deaths occurred in agricultural fields 42% (n=12). It is noteworthy that human deaths have occurred both in harvested fields and when there were standing crops (Figure-2). Elephants are known to raid cultivars during the grain setting stage to optimize their foraging. This is when farmers intensify guarding risking their lives. Our field observations show that unlike well-established elephant range areas where farmers guard crops from the safety of tree machans, farmers in Chhattisgarh guard their crops from flimsy thatched huts or from ground exposing themselves to serious risk. Thus, engaging with farmers through well-designed outreach materials appears critical.

Around 21% of deaths occurred in the reserved forests as well. The deaths in reserved forests have occurred when local communities went in for collecting forest produce, fuel wood and grazing their cattle. Because local communities show high dependence on forests, it is far from easy to prevent encounters between elephants and people. It shall require long-term engagement with the communities and robust and timely sharing of information regarding elephant occurrence.

A fairly high proportion of deaths have occurred in and around the hutments as well. This is because elephants break houses to access stored grains (mostly), fruits like jackfruit and banana grown in the backyard and in some cases stored fermented local brew as well. House breaking by elephants is a serious problem,

which is rife in the Central Indian regional population. We envision engaging with local communities in some of the selected high conflict villages to develop a model of participatory fences around hutments that could restrain elephants from entering the village premises.

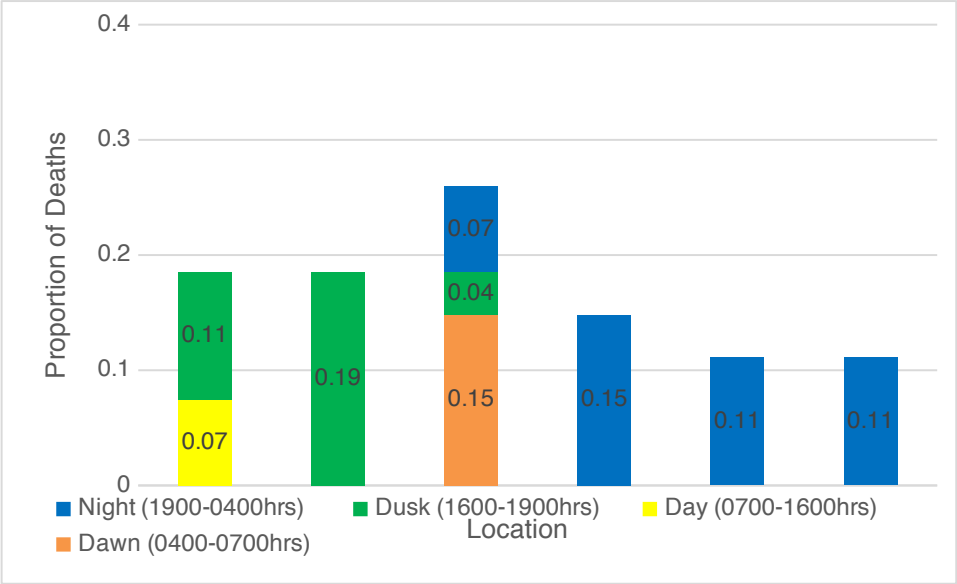


Figure 2: Location of human deaths due to elephants. More deaths occurred in crop fields. The deaths in forests were mostly during dusk while deaths near houses occurred during the night hours

7.3 Age of victims

About 43% (n=32) of the victims were elderly and 28% (n=21) were middle aged. Youth were 19% (n=14) of the victims. Teens formed 4% (n=3). Children 1% (n=1) and infants 4% (n=3) (Figure 3).

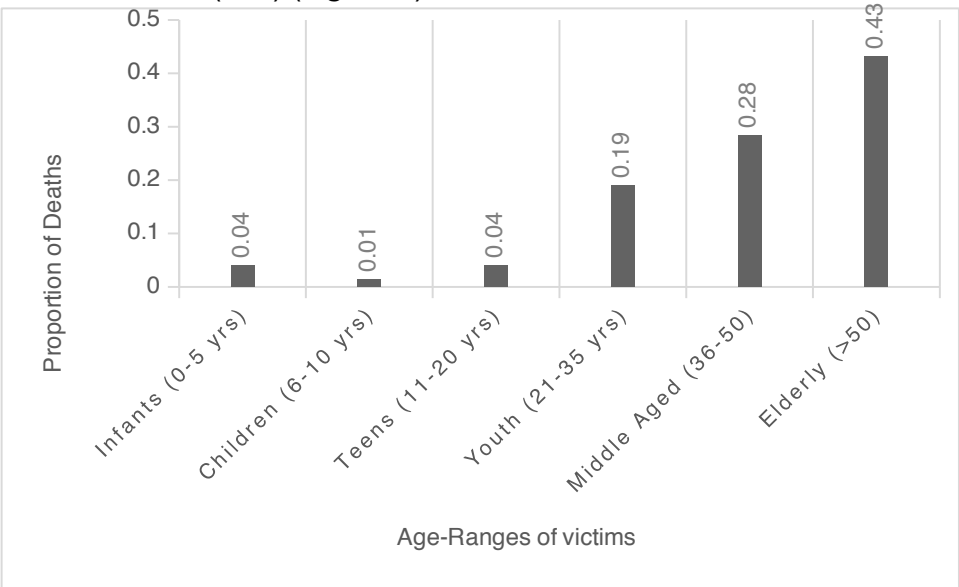


Figure 3: Proportion of deaths due to elephants in different age classes

7.4 Activities that victim were engaged when attacked by elephants

A significant 60% of casualties happened during elephant drives (away from the crop fields and long-distance drives as well). The case of elephant drives is perplexing. Based on our casual discussions with the villagers, we surmise that of the myriad reasons, elephants coming close to hutments is foremost that triggers elephant drives. Local people are terrified of elephants approaching their houses during night. Many villages in the landscape are poorly lit and people live in mud-walled huts. In the darkness of the night safely evacuating elderly and the children when elephants siege huts is difficult. Thus, villagers resort to driving elephants, exposing themselves to serious risk of injury and death.

About 40% of deaths occurred during minor forest produce collection. There were deaths when victims were relieving themselves in the bush, travelling though forests and even while fetching water closer to their houses (Figure 4). Around 14% of the victims were in their homes when elephants attacked them.

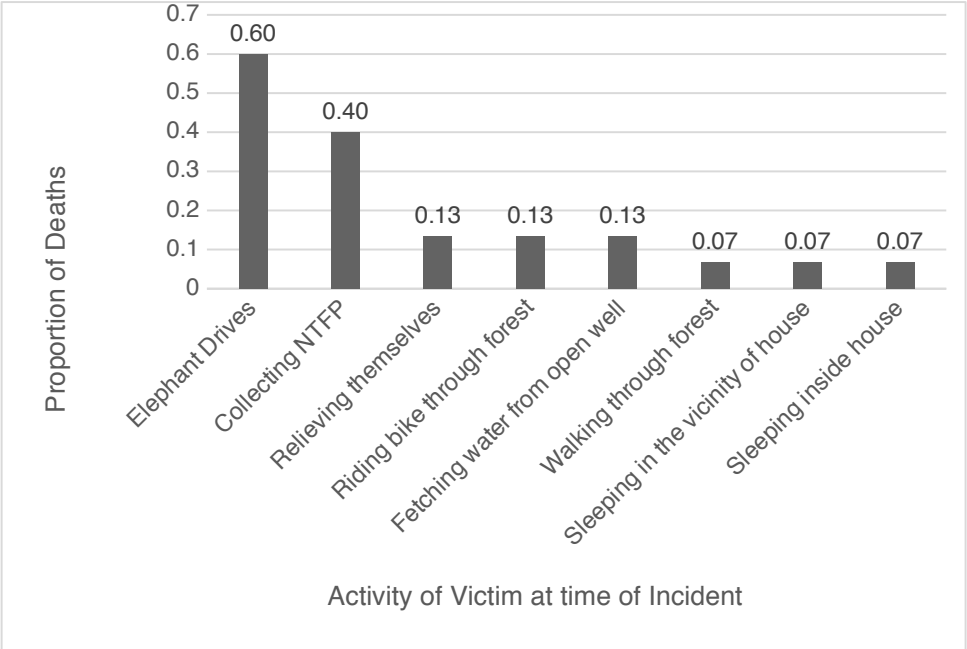


Figure 4: Activities that victims of elephant attack were doing at the time of incident. The figures are not mutually exclusive and thus, the cumulative value in the graph exceeds 100%

8. Assessing the socio-economic factors of affected villages in Surguja through interview surveys

In shared landscapes where conflict is widespread, engaging with local communities is crucial for sustaining conflict mitigation strategies. In order to engage with local communities, it shall be crucial to develop a basic understanding of the lifestyle, socio-economic aspirations, perceptions about conflict and willingness to participate in conflict management. Keeping this in mind, with help from committed local volunteers who were well-versed with Surgujia, a dialect that local populace use, we carried out structured interview surveys in 50 villages across Surguja and Surajpur divisions in villages that are highly affected by human–elephant conflict. A total of 180 respondents participated in our interview surveys, thus providing interesting insights. We have just started processing the interview data.

Picture 4: Interview survey with local villagers at Surguja

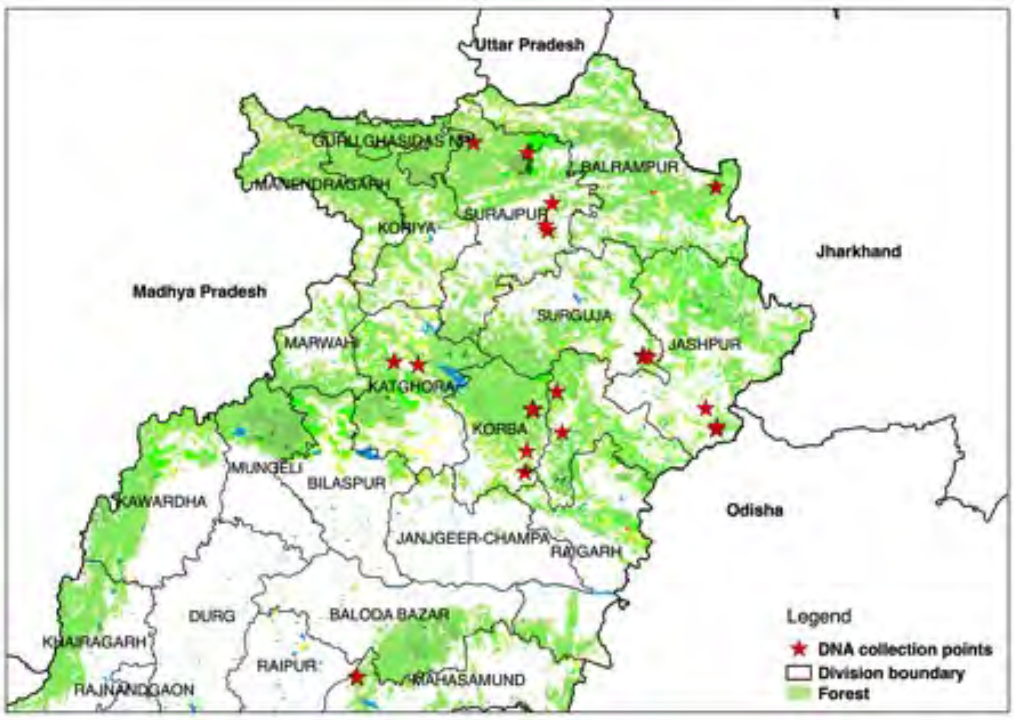
Picture 5: Local populace in elephant ranging areas are predominantly tribal, highly marginal and show high dependence on forests for livelihood

9. Assessment of the population structure and genetic relatedness of elephants

Across Chhattisgarh, elephants occur in nine divisions with varying group sizes. Our observations show that these groups break up and re-group frequently. Indeed, elephant society is profoundly characterized by *fission-fusion* social organization, whereby; the groups break-up and re-group frequently in response to environmental and societal factors. Thus, the group sizes (number of individuals in the group) are not rigid. Based of spatial sorting, many elephant groups operate in different areas and there could be a temptation to consider them discrete. However, to understand if these groups are inter-related or otherwise, it is important to assess the population structure through genetic

relatedness. Such an assessment can throw light on how many genetically distinct clans occur in Chhattisgarh. If we ramp up sampling in the neighboring states of Odisha and Jharkhand, it could be possible to understand the "source site" of the elephant groups that have re-colonized Chhattisgarh. Further, understanding the relatedness – especially the first order relatives shall be helpful during adaptive management as well. To illustrate, in the case of translocation of problem causing individuals such as young males, it is better moving them far from the natal range considering the genetic reasons. In such situations, having an understanding of genetic details shall be invaluable.

In order to establish genetic relatedness between different spatially discrete groups, we have collected elephant fecal deposits. Our samples have been collected only from fresh dung (<24 hours old) piles. In total, we have collected over 200 genetic samples from eight forest divisions across the state (Map-7). All the samples have been dispatched to the laboratory facility at the Wildlife Institute of India, Dehradun for processing and extraction of DNA. A research fellow has been engaged specifically for processing the samples and extracting DNA. We expect to complete this aspect of the study in the next three months.



Map 7: Elephant dung sampling collection sites. In these sites fresh dung samples were collected

10. Training and awareness programs and outreach activities

An important component of our project is capacity enhancement of the frontline staff of forest department in elephant conflict and conservation management. The field researchers of the project (a senior Project Associate and a Research Fellow) have been actively working with the frontline staff of the forest department on a daily basis on range of activities that include observing elephants, ageing and sexing elephants, GPS usage, genetic data collection and others. The project has envisages structured training programs to the staff and village-level volunteers.

Training modules (power-points and videos) for the workshops were developed and shared with PCCF (Wildlife) and CCFs (Surguja and Bilaspur). The modules straddled across themes such as natural history, basic ecology and behavior, drivers of conflict and solutions widely used. There were also discussion sessions with participants. So far, two training programs have been carried out – one in Surguja forest division and the other in Mahasamund forest division. The delivery and reach of the two programs were thoroughly assessed for continuous improvement.

Picture 6: Training frontline staff on elephant management in Surguja division

Picture 7: Training frontline staff on elephant management in Mahasamund division

10.1 Miscellaneous outreach activities

Outreach activities to local communities and other stakeholders are integral to this project. Such need-based activities are being regularly carried out. During wildlife week, the project personnel addressed the higher secondary students of Holy Cross School in Ambikapur. This was organised by the DFO, Surguja and ACF, Sitapur, Surguja.

Picture 8: Addressing villagers during heightened conflict situation in Mainpat

Picture 9: Imparting awareness on elephant natural history to school children, Ambikapur

Further, when conflict levels escalated in Mainpat area during the month of August, the project personnel along with Shri. Prabat Dubey addressed a gathering of villagers on elephant conflict. This program was organised by DFO, Surguja and SDM, Sitapur.

11. Advisory role on elephant conflict management

Although this is *ad hoc*, this is an important on going activity whereby our researchers actively participate on range of elephant management issues across the state. Most of the ad hoc activities are of priority in nature and case-specific reports pertaining to such activities have been submitted to the officials concerned then and there.

11.1 Technical support during transit of trained elephants from Karnataka

Chhattisgarh government received five captive elephants from Karnataka for using them in elephant conflict mitigation activities. We were part of the technical team that went to Karnataka to receive the elephants. The activities we carried out include monitoring elephants during transportation by coordinating with the staff vets and post-arrival monitoring of elephants' behavior during the one-month quarantine period

11.2 Monitoring emergency conflict situations

Conflict situations at times get acute with back-to-back human deaths, continuous damage to property and others culminating in to a crisis situation

that warrants intensive monitoring and technical assistance. Such situations arose in Surajpur, Surguja and Korba divisions where we closely worked with the division staff in handling the situation. Activities broadly include tracking elephants, identifying problem individual elephants, advising management on appropriate conflict management strategies and training personnel. Such intensive engagement with site-specific problems usually span many days.

11.3 Technical support during rescue, rehabilitation, and necropsy of elephants

During the one-year period, we have attended a few cases of elephant necropsy by coordinating with local veterinarians in assessing the causes of death and other details. We have also participated in a few cases of elephant rescues, a case of re-union of a stranded elephant neonate with the putative family and a case of medical assistance to an elephant in distress. These *ad-hoc* cases provide opportunity for engaging with local staff on real-time issues facing elephant management.

11.4 Assistance in radio-collaring operations in Mahasamund FD

During the year, we rendered our assistance to the department and WildlifeSOS during collaring operations in Mahasamund forest division. The activities included being part of the collaring team and pre-collar intensive monitoring of elephants identified for collaring.

Interim recommendations to the management

1) In Chhattisgarh elephants have included human use areas in their range. This has implications in alteration of elephants' normal ranging behavior. There is evidence to show that elephants' range is expanding and in fact, some of the groups are exhibiting exploratory behavior. If elephants range more extensively in the forested tracts (where forest to human-use area ratio is high) of northwest Surguja comprising of Surajpur, Koriya and Balrampur along with contiguous forests of the neighboring Madhya Pradesh state, it is a good sign. In contrast, if their range expands in areas where forest to human-use area ratio is low, then there is a serious concern and it is important to restrain such expansion in to non-habitats. Therefore, we have to closely monitor how elephants range in this landscape, especially their ranging in "new habitats". Deployment of a telemetry collar on a few groups, especially the one that is operating in Chhattisgarh – Madhya Pradesh border will be particularly useful.

2) Managing elephant conflict in known range is better as people are better informed and thus, probability of human deaths is low. Thus, it is important to control unplanned drives that sometimes locals resort to; as such drives could spill or shift the conflict to new areas. When conflict spills in to new areas, the probability of human deaths is often high

3) Habitat enrichment for elephants is a very crucial long-term conflict management strategy in Chhattisgarh. However, a pre-requisite to this is defining and identifying habitats in the first place. A combination of telemetry data and GIS-remote sensing exercise shall help in identifying such crucial habitats for development. Habitat enrichment in sub-optimal habitats such as small patch of forests, for the purpose of conserving elephants, can be counterproductive for conflict management.

4) Elephants operate in a vast area comprising of many forest patches in an unpredictable manner. Thus, physical barriers may not be useful in all the areas. Since the elephants are highly mobile, it shall be prudent to keep the barriers mobile as well. We note that this idea has already taken precedence in the state and use of mobile power fences are being tested by the forest department. Using such simple fences to safeguard crop fields and blocking the elephants in the forests itself may be difficult. On the other hand, elephants entering human settlements are a huge challenge. Moreover, a few human deaths by elephants have occurred directly in the vicinity of the houses. Considering this, these simple mobile barriers are best used in safeguarding *bastis* (settlements) using a participatory approach involving local communities. To start with, we can experiment use of simple fences in a few villages where house breaking by elephants is a big problem.

Activities planned for the next six months

1) Collaring more elephants in Surguja and Bilaspur circles: We shall be deploying telemetry collars on a number of elephants in Surguja and Bilaspur circles. This includes intensive pre- and post collaring monitoring of elephants.

2) Developing lion-shied based early warning systems: Along with the telemetry collars, we have received lion-shield early warning equipment. The units are based on UHF (ultra high frequency). The collar maker has committed to send

their authorized engineer to experiment early warning gadgets in the next few months.

3) Coordinating with ISRO to explore the possibilities of using LULC data to predict conflict and develop an app-based early warning system

4) Continuous behavioral monitoring of collared elephants and other elephant groups. We shall be using telemetry data to inform development of crucial elephant habitats, consolidate key travel routes of elephants and others.

5) Continuation and extension of training programs: The staff and volunteer training programs shall continue. We are also planning for an intensive field training for a small group of personnel (both FD staff and *Hati-mitrdal* volunteers) in Rajaji TR in order to make ready a band of personnel trained in range of elephant management operations.

6) Miscellaneous advisory role on issues pertaining to elephant conflict and conservation management in Chhattisgarh

Materials prepared

1) Standard Operating Procedure for managing conflict situations in Chhattisgarh – a draft (Annexure-1)
2) Collaring report-1 (Annexure-2)
3) Collaring report-2 (Annexure-3)

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ANNEXURE-1: Conflict management SOP

(Only the face page is shown here)

Standard Operating Procedure (SOP) for managing situations when elephants come in to human use areas: Chhattisgarh scenario

I. CONTEXT

Chhattisgarh has been witnessing 're-colonization' of elephants during the last two decades, probably from the neighboring states due to habitat loss and other threats to their habitats. The habitat in the state, although expansive, is highly fragmented creating a very difficult mosaic of landscape for elephant conflict management. The level of fragmentation is too high, that some level of conflict is inevitable. For example, even if elephants have to move between forest patches, they have to move through human use areas. Therefore, conflict management of elephants in Chhattisgarh is far more difficult than in other elephant ranging states where levels of fragmentation are low.

Additionally, the villagers are not used to elephants and thus, unaware of how to manage the situation when elephants come in to human use areas. As a consequence, there are human deaths and retaliatory killing of elephants. There is also severe crop and property loss. The factors influencing crop and property loss can be manifold such as, habitat-related issues, elephant behavioral ecology, spatial and social organization and land-use and other people-related issues. Understanding these factors is crucial to find lasting solutions to reduce crop and property damage. However, reducing human causality in conflict situations is of paramount importance as not only precious human lives are lost, but also local support for conservation of highly endangered species like elephants diminishes. This document is an attempt to list down basic procedures that could help in better managing the conflict solution. Essentially, the SOP is a stopgap measure to handle a conflict solution till long-term solutions are advanced.

II. ELEPHANTS AND CONFLICT

Social structure and behavior

Elephants are social animals. Elephant societies, like humans, are noted for their intelligence and close family ties. They live in multi-tiered well-knit societies. Such societies are highly fluid and dynamic in nature with fission (where groups split in to smaller units) and fusion (where multiple groups come together to form a large group). Thus, the group sizes that we observe in the field may not remain constant. The group size of elephants may change very often depending on environmental, social and anthropogenic factors. Female societies in elephants consist of mother-offspring units to bond groups (joint family) and clans (extended family). Generally, larger families with older matriarchs may dominate families with younger matriarchs. Such dominance can influence the land-tenure patterns of elephants operating in an area. A female elephant may usually be found in groups ranging from basic family unit (mother and offspring) to bond groups (comprising of several adult females) to clans (comprising of tens to hundreds of elephants). Very rarely female elephants are found alone.

Male elephants disperse from their natal ranges when they are about 10 to 15 years of age. They may be sexually mature by the time they leave their natal families. Such young males may join up with other males. After attaining 25 to 30 years of age, they start experiencing longer duration of *musth* (a period of heightened sexual activity marked by temporal gland secretion) and may operate alone, or in company of other males.

Thus, elephants that come in to conflict with people can be solitary (mostly adult males), small group of elephants (all-male group or small family groups) or large group of elephants. Further, male elephants that come in to conflict can be in musth. More

DRAFT

ANNEXURE-2: Collaring report-1

(Only the face page is shown here)

First ever deployment of a satellite collar on a bull elephant from the imperiled central Indian regional elephant population

A short communication to GAJAH

Authors:
1.
2.
3.
4.
5.
6.

INTRODUCTION

Wild elephants in India occur as four regional populations namely southern, northern, northeastern, and the central. The central Indian elephant population spans across Odisha, Jharkhand, south West Bengal, and Chhattisgarh states (Sukumar, 2003; Rangarajan et al., 2010). A few splinter groups from this regional population also infrequently move into neighboring Madhya Pradesh and Andhra Pradesh as well. The scenario of elephants in the state of Chhattisgarh is quite convoluted: Historically, there were wild elephants in northern Chhattisgarh (Forsyth, 1871; Areendran et al., 2011). For reasons that are difficult to discern now, elephants have disappeared from northern Chhattisgarh at the turn of the 19th century. After being absent for many decades elephants re-colonized Chhattisgarh during the late 1980s. This re-colonization was considered to be a consequence of displacement of herds from their established ranges in the neighboring states where mining and associated developmental activities threatened the elephant habitats. Presently, an estimated 200 to 250 elephants occur in over nine districts of the state. Although the population size is small, since the state is dealing with displaced herds of herds, that too in habitats that are severely fragmented and degraded, there is substantial human–elephant conflict resulting in over 50 human deaths every year. Managing human–elephant conflict has become a priority in the state.

One of the prerequisites for managing wild elephants is to understand their home range and space-use strategies. Additionally, understanding elephants' home ranges can provide valuable insights on elephants' social organization, foraging and reproductive strategies and essential components of the habitat (Powell, 2000). In Chhattisgarh, elephants operate in a vast landscape across northern and north-central districts in a matrix of natural forests and human-use areas. The herds move frequently between forest fragments and in order to understand how elephants traverse in this mosaic landscape, telemetry studies are crucial. Accordingly, Chhattisgarh Forest Department with technical assistance from the Wildlife Institute of India conceptualized the plan to deploy satellite cum VHF collars on some of the elephants in the state. After obtaining due permits from the Directorate of Project

ANNEXURE-3: Collaring report-2

(Only the face page of the report is attached)

FIELD TECHNICAL REPORT: ELEPHANT CAPTURE AND COLLARING OPERATION AT SURGUJA, CHHATTISGARH

June 2018

Partners:

Wildlife Institute of India

Chhattisgarh Forest Department

भारतीय वन्यजीव संस्थान
Wildlife Institute of India

ANNEXURE-4: Elephant identikit

ELEPHANT IDENTIFICATION PROFILE: CHHATTISGARH

Date of the identity card	29-11-2017		
Profile created by	N. Lakshminarayanan / Ankit Kumar		
Elephant id number	CGM001		
Elephant name	Mac-1		
Sex	Male (makhna)		
First photograph details	**GPS**	**Location**	**Range, FD**
	23.28508/83.12438	Mohanpur waterhole	Surajpur, Surajpur
	Date	**Habitat**	**Photographer**
	6-11-2017	Inside RF	LN
Height	Front foot circumference: Not measured Estimated shoulder height: Not measured		
Estimated age	>40 years		

Left profile picture

Photo details: 00010,00011 (6-11-17) and

Right profile picture

1) Tusk/ tush

A makhna (rudimentary tush in the right – does not protrude the lipline)

	Right	*Left*
(i) Arrangement (parallel, divergent, convergent, crossed)	-	-
(ii) Direction to ground (parallel, angled down 30°, angled down 60°, angled down straight)	-	-
(iii) Length (long, medium, short)	-	-
(iv) Thickness (thick, intermediate, slender)	-	-

2) Ear pinnae

	Right	*Left*
(i) Size	Medium	Medium
(ii) Fold orientation	Top inward, side inward	Top inward, side inward
(iii) Fold type	U-fold	U-fold
(iv) Fold extent	100%	100%
(v) Ear lobe shape	Blunt-V	Blunt-V (There is a wide "fork formation" just above the lobe)
(vi) Tears, nicks, holes, and cuts	1) A cup notch of 1" in the outer ear margin (in the middle) 2) A 2" long tear on the outer margin of ear (in the middle)	
(vii) Prominent depigmentation	Did not observe	Did not observe

Conservation Management of Elephants in Chhattisgarh

Capacity Building Initiatives on the Dispersal and Ranging Patterns of Elephants for Effective Management of Human - Elephant Interations

Second Annual Report (2018 - 2019)

Submitted to

Chhattisgarh Forest Department

भारतीय वन्यजीव संस्थान
Wildlife Institute of India

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Executive Summary

Insights gained from our first year (July 2017 – June 2018) of study paved inroads to assess the conservation conundrum posed by the Human – Elephant conflict in Chhattisgarh with an aspiration to try and mitigate them.

There are just over two to three hundred elephants in the state and they currently occur in vast swathes of forests spanning several districts in Surguja, Bilaspur and Raipur forest circles and yet, there is intense conflict between people and elephants culminating into a major social, economic, political and conservation problem. In response to prevailing conflict situation, the state forest department has been trying a suite of site-specific mitigation measures. Additionally, Wildlife Institute of India and Chhattisgarh forest department has embarked a long-term study in response to repeated calls for better understanding of elephant conflict situation by focusing on patterns of dispersal and ranging behavior of elephants among other objectives. Fieldwork for our study began a year ago, during July 2017, and we have completed the first year of the study. In this report, we discuss the activities that were carried out during the period, preliminary findings of some of the objectives and the way forward.

The period, July 2018 to June 2019, marked the end of the second year of our field research on elephants in Chhattisgarh. During this period, we continued to regularly monitor the two elephants CGM001 (Behradev) and CGF010 (Gautami) that were collared during the previous year. These two satellite-collared elephants provided valuable details on how elephants use the mosaic landscape in Surguja circle. CGF010 (Gautami) and its group have also provided valuable insights on the inter-state movement of elephants as well. During the current period, we did manage to collar three more elephants in Surguja circle with satellite collars. Of the five elephants that we have collared, two elephants dropped their collars soon after deployment. The other three elephants have provided us valuable data for a longer period. Home range of Behravdev, Gautami and Pyare were estimated to be 1170.80 km², 2337.50 km² and 997.00 km² respectively (using Minimum Convex Polygon approach – 95%). Utilization distributed (95%) were also estimated and were found to be 280 km², 334.70 km² and 235.10 km² for Behradev, Gautami and Pyare respectively.

By working as a team, along with the frontline staff of the Forest Department, we continue to monitor all the collared elephants regularly. More importantly, it is very pleasant to note how effectively the Forest Department is using the satellite locations of collared elephants to manage conflict situations. Chapter-1 of the report provides detail of the collared elephants, their ranging behavior and utility of collars in managing conflict.

In addition to collared elephants, we have been monitoring some of the individually recognized elephants to understand their ranging patterns using a re-sighting approach. In particular, we have observed elephants CGF002 (Torn Ear) and CGF003 (Wave Ear) and their herds for a longer duration and computed their home ranges using a Minimum Convex Polygon (MCP) approach. Home range for Torn Ear and Wave Ear were estimated (MCP – 95%) to be 8484.46 km² and 385.49 km² respectively.

The individually recognized elephants have also helped us in understanding the patterns of recent range expansion of elephants from Chhattisgarh into Bandavgarh and Sanjay Tiger Reserves in Madhya Pradesh. Chapter-2 of the report provides the particulars about the manual of eighty individually recognized elephants and the details about CGF002 and CGF003's overall ranging patterns.

While we continue to monitor elephants, human deaths due to elephants continue to be a major cause of concern for the management. During the current year, we continued to collect fine-scale details of human deaths due to elephants. We have analyzed the data collected for a period of two years to provide basic details about patterns and circumstances of human deaths. Our preliminary analysis highlights that sixty four of the victims were men and forty six percent were elderly (>50 years). Similar analysis also showed that sixty percent incidents occurred in the vicinity of the house and agriculture field. Fifty percent of the incidents took place in night (1900 – 0400 h). Sixty percent of the offending elephants involved in the casualties were found to be males. and also discuss key challenges facing management in this regard as elucidated in Chapter-3 of the report.

We have been collecting elephant fecal samples (dung) to understand their social organization through non-invasive DNA analysis. The idea behind this exercise is to find out how many different groups of elephants operate in Chhattisgarh and from where they have dispersed in the first place. Extending the genetic component of our work to the neighboring states of Odisha and Jharkhand may throw light on this. In this preliminary effort of looking at relatedness between elephants within Chhattisgarh, highlights two genetic lineages of elephants in Northern Chhattisgarh. The background and methods are discussed in Chapter-4 of the report.

Whilst the aforementioned activities are part of our organized work plan, elephant conflict management involves site- and time-specific issues – some of which are emergency in nature, where timely intervention is crucial and helpful for the management. WII is fortunate to work closely with Chhattisgarh FD on a wide range of conflict management issues, thereby playing an advisory role. We have discussed some of them in Chapter-5 of the report. In the same chapter, we have provided details of the trainings that we have conducted during the period.

For the period August 2019 to July 2020, we intend to continue monitoring of the collared elephants and other elephant groups in Surguja circle. Additionally, we realize the urgent need to expand our field activities of identifying and monitoring elephants in Bilaspur circle as well as conflict appears to be escalating in some of the forest divisions there. We are also planning to complete the last phase of collaring another six to eight elephants in the state during the period. Alongside, we shall ramp up the training programs intended to frontline staff and other and continue our advisory role with active participation in a suite of real-time elephant conflict management issues.

Chapter

1

Home Range and Movement Patterns of Elephants in Northern Chhattisgarh: Preliminary Findings

1.1 Introduction

Elephants generally require a great deal of space to meet their basic life history requirements of finding food, water, mate and shelter for young ones. Elephants that occur in relatively intact natural habitats exhibit profound fidelity to their home ranges. Due to this site fidelity, their movement patterns may be predictable (Moss, 1988). Generally, in relatively intact habitats where optimal habitat conditions prevail for elephants, their home ranges tend to be relatively small.

Figure 1.1: The state of Chhattisgarh has a forest cover of more than forty percent. However, contiguous stretch of forests are present only in certain protected areas. In the left, we can see one such contiguous forest cover, whereas the image on the right provides a glimpse of the mosaic landscape with an overlap of elephant and human use areas

In Chhattisgarh, where elephants have started "re-colonizing" habitats after a gap of several decades, not only their home ranges appear large, they seem to be fluid as well. The highly complex landscape mosaic in Chhattisgarh where elephants currently operate precludes direct application of conventional fence-based conflict management approach. Thus, there is a pressing need to be both innovative and unflinching readiness to experiment novel strategies. While we go ahead experimenting various conflict mitigation strategies, gaining an understanding of how elephants use the landscape is fundamental. In other words, it is important to know the landscape from elephants' point of view and not just based on how we see it.

Figure 1.2: A herd of elephants feeding on paddy in an agricultural field close to a forest in Dharamjaygarh Forest Division.

Pinpointing elephants' locations regularly using high-resolution satellite collars can provide us fine-scale details about their habitat use patterns. It will help us generate high-quality maps showing how elephants traverse the mosaic landscape. We can also visualize their intensive-use 'core' areas and identify habitats that can be improved to support elephants. Moreover, collared elephants can provide details on patterns of conflict as well – the locations of houses they break, seasonality of damages to crops and property, and their general time-activity patterns. Such details can help us formulate site-specific conflict management strategies and also in providing evidence-based policy recommendations to the Government. Additionally, we can get insights on inter-state movement of elephants, which can be used to initiate dialogues to formulate landscape-level elephant management plans and foster better coordination between the states. The points listed above are the primary uses of collaring elephants. Needless to say, telemetry studies – especially the advent of satellite collars have revolutionized the way we understand and manage wild animals across the world. It is wrong notion that after collaring an elephant's behavior (be it conflict behavior or others) gets altered. Collaring elephants will not change their inherent behavior.

1.1.1 Elephant collaring in Chhattisgarh: A collaborative initiative between WII – Chhattisgarh Forest Department

Since the inception of the project during July 2017, till the period ending June 2019, we have collared five elephants in Northern Chhattisgarh in four phases of collaring operations.

Table 1.1: Phases of collaring operation in Chhattisgarh

Phase	Period	Elephant Collared
1	10/05/18 to 13/05/18	CGM001 (Behradev)
2	12/06/18 to 16/06/18	CGF010 (Gautami)
3	25/11/18 to 30/11/18	CGM003 (Pyare)
4	30/04/19 to 05/05/19	CGM011 (Mahaan) and NA (Karma)

During the first phase, we have collared an adult bull *makhna*, in Balrampur Forest Division. During the second phase, an adult cow elephant was collared in Surguja Forest Division. During the third phase, we have collared a young bull tusker on in Surajpur Forest Division. During the fourth phase, we have collared a young bull tusker on in Surajpur Forest Division and a young cow elephant in Tamor Pingla Wildlife Sanctuary (details in Table-1.2).

Table 1.2: Description of elephants collared in Chhattisgarh

Elephant ID	Name /Sex / Age class	Location	Date of collaring	Number of days monitored	Status
CGM001	CGM001 (Behradev)/M/ Adult, around 40	Rewatpur in Balrampur FD	12-05-2019	404	Dropped (after 13 months)
CGF010	CGF010 (Gautami)/F/Adult, around 20	Mainpat in Surguja FD	15-06-2019	429 and counting	Working
CGM003	CGM003 (Pyare)/M/ Adult around 25	Dumadand in Surajpur FD	28-11-2019	259 and counting	Working
CGM011	Mahaan/M/ Adult, around 20	Bagda in Surajpur FD	03-05-2019	13	Dropped (after two weeks)
NA	Karma/F/Adult around 15	Khond range in Tamor Pingla WS	04-05-2019	3	Dropped (within a week)

CGM001 *(Behradev)*

CGM003 *(Pyare)*

CGM011 *(Mahaan)*

CGF010 *(Gautami)*

Figure 1.3: Panel showing identified elephants collared during four phases

1.1.2 Fate of collars deployed

Of the five elephants that were collared, two elephants collared during Phase-IV operations have dropped their collars within a few days. The cow elephant that was collared in Tamor Pingla WS dropped its collar in a few days after collaring as we have deliberately kept the collar a little loose as the animal was young and increase in weight could choke the animal's neck if fitted tightly. The young tusker collared in Surajpur FD dropped its collar in a deep water-body inside the jungle. This water-body has many submerged tree stumps and we suspect that the collar would have been entrapped in some of the tree stumps that the bull had force-freed itself. The bull *makhna* that was collared in Balrampur FD during May 2018 too dropped its collar during June 2019 after providing locations properly for one year and one month. For this collar, the belt suffered damage after getting stuck in a GI wire used as a physical barrier. We have reported the issue of belt ripping to the collar manufacturer as well to properly ascertain the reasons for belt ripping. All the three dropped collars have been recovered and sent to the manufacturer for refurbishment so that they can be redeployed. Report of Mahaan and Karma dropping their collars was duly communicated vide a separate report.

Elephants dropping collars is not new. Many collared elephants in both Asia and Africa have dropped their collars soon after collaring – probably assisted by other elephants in pulling out. There are also cases of belts ripping and consequently collars dropping. While collaring young males, we prefer deploying the collars a little loosely so that it doesn't choke or injure the animal once it gains bulk. Thus, there is always a possibility of collars dropping as elephants can both gain, as well as suffer rapid reduction in body weight determining the tightness of the collars.

1.2 Methods

1.2.1 Drugs used for immobilizing elephants

During Phase-I collaring operations, we have used a combination of Xylazine and Ketamine drugs to immobilize the animal for deploying the collar unit. During Phase-II, III and IV collaring operations, we have used Etorphine – a narcotic and its additives for immobilizing elephants. A team that constituted veterinary professionals (from WII and Chhattisgarh FD), wildlife biologists, mahouts, expert trackers and field officers and frontline staffs of the respective forest divisions collared the elephants. The details of the drug dosage, field processes involved in administration of drugs, the logistics therein and successful revival of the animals have been separately provided in phase-specific collaring reports.

Figure 1.4: Capture and collaring of adult male – CGM003 (Pyare) in Dumadand, Surajpur FD on 29/11/18

1.2.2 Collar specifications and details

We have procured the collars from Savannah Tracking in Kenya. The collars have in-built VHF transmitters and Satellite transmitters that work on Iridium technology. We have programmed all our collars to provide a GPS fix at every one-hour interval. The data can be downloaded directly from the satellite to a specific software once in every six hours. Both the GPS fix intervals and the download frequencies are flexible and can be modified based on site-specific needs. The entire collar unit weighs about 15 Kgs, which is approximately 0.3 to 0.5% of the average body weight of an adult bull and adult cow elephant respectively.

1.2.3 Home range estimations using Minimum Convex Polygon (MCP) and Utilization Distribution (UD) approaches

Home ranges were estimated using MCP and UD approaches. MCP creates a smallest convex polygon by enclosing all the animal locations for the given period. The polygon, thus created is considered as the home range of the animal. MCP is widely used in animal home range studies, as it is easy to compute and interpret. In this study, we have estimated MCP at three levels namely 50%, 95% and 100%. These levels indicate the extent of the points used in estimating the home ranges. The UD approaches are comparatively recent and computationally intensive. Nevertheless, UDs are useful in assessing the intensity of habitat use by the animal, which can be pictorially depicted as 50% and 95% contours in the maps.

1.3 Results and discussion

1.3.1 Home range estimates

Of the five elephants that we have collared, CGM001 (Behradev), CGF010 (Gautami) and CGM003 (Pyare) were followed for longer period of time. We made efforts to follow these elephants directly in the field to record their behavioral data such as association patterns. Thus, during the study period, we had frequent direct sightings of all the three elephants. CGM001 (Behradev), CGF010 (Gautami) and CGM003 (Pyare) were observed for 62, 18 and 38 times respectively. Their home ranges estimated using both MCP and UD approaches have been pictorially depicted in Maps (Figure 1.6 to 1.11).

The home range estimates are provided in the Table-1.2

Table 1.3: The home range estimates of CGM001 (Behradev), CGF010 (Gautami) and CGM003 (Pyare)

Elephant	*MCP (Km²)*			*UD contours (Km²)*	
	50%	*95%*	*100%*	*50%*	*95%*
CGM001 (Behradev)	253.40	1170.80	1416.40	26.30	280.50
CGF010 (Gautami)	1039.20	2337.50	2562.60	36.00	334.70
CGM003 (Pyare)	168.50	997.00	1711.00	27.70	235.10

The home ranges computed using MCP approach were larger when compared to home ranges computed using kernel UD approach. In general, the MCP estimates tend to be large in highly fragmented and patchy habitats as animals frequently move between patches. Additionally, there is also directed long-distance linear movement of elephants (particularly observed for CGF010 (Gautami) and CGM003 (Pyare)) that inflates MCP home ranges. Thus, the MCP estimates show the overall area in which the elephants operate and UDs show the extent of areas that are intensively used within MCP range estimates. Using a combination of both the estimation approaches is often useful.

1.3.2 Home range stabilization

CGM001 (Behradev) and CGF010 (Gautami)'s home range attained asymptote in 6th and 7th month of tracking respectively. CGM003 (Pyare)'s home range is yet to stabilize as the number of months tracked is less, and also it exhibits fluid association patterns with different elephant groups.

1.3.3 Ranging patterns of collared elephants

1.3.3.1 Ranging pattern of CGM001 (Behradev)

During the study period, CGM001 (Behradev) ranged in Surajpur, Pratapuur and Gui ranges of Surajpur FD and Rajpur range of Balrampur FD and a small fraction of area in Ambikapur range of Surguja FD. It

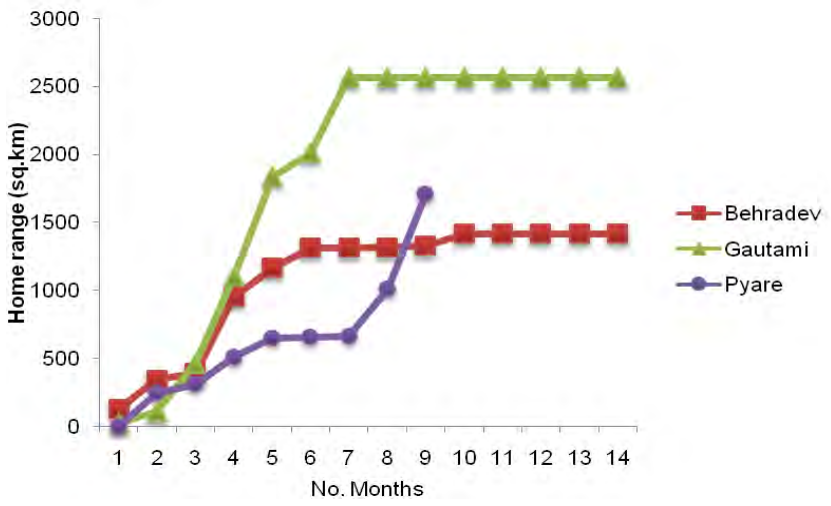

Figure 1.5: Relationship between home range size and number of months tracked, for the 3 collared elephants.

did not use any protected areas during the study period although for a few weeks it operated close to Tamor Pingla WS. This bull has raided cultivated crops regularly and damaged a few houses too. The bull got into *musth* during the 2nd week of August 2018 and remained in *musth* for almost three months till 1st week of November. During *musth* the bull associated with family groups of elephants that operated in Surajpur FD.

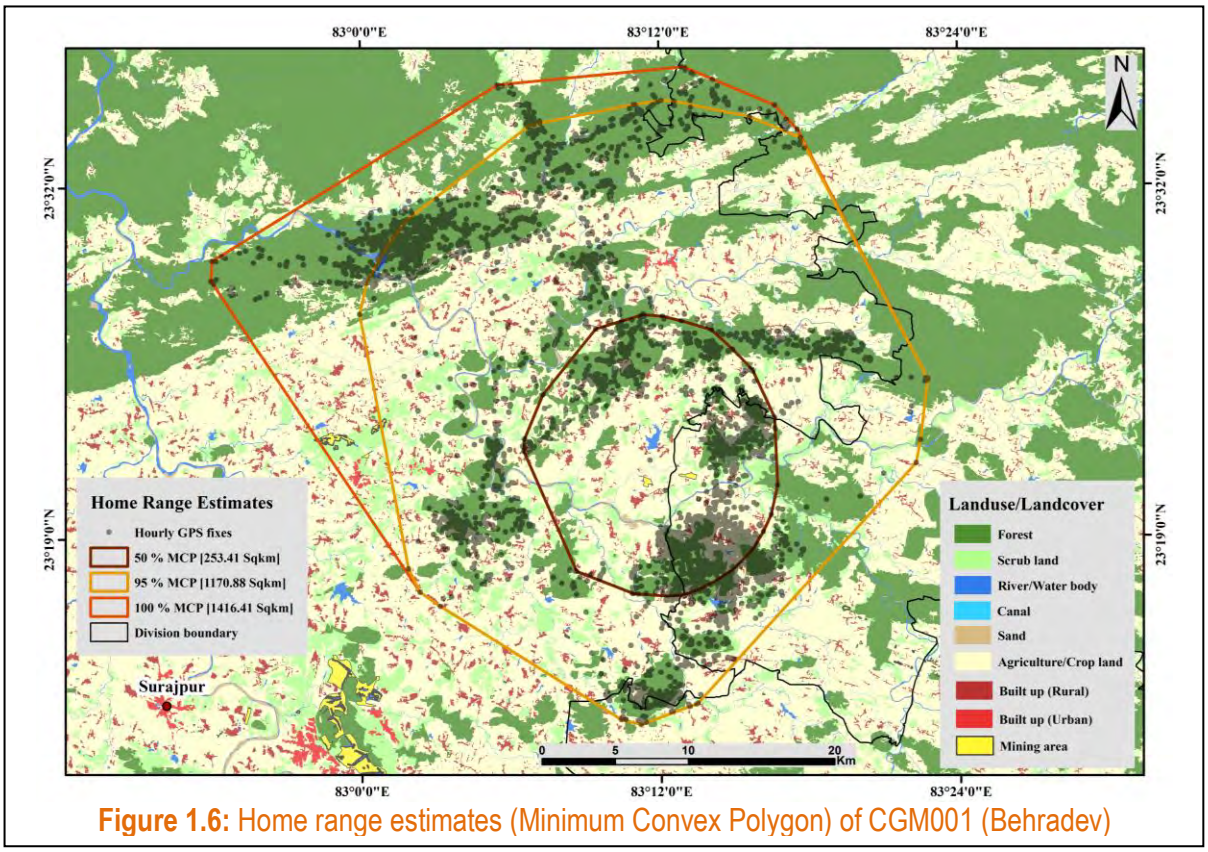

Figure 1.6: Home range estimates (Minimum Convex Polygon) of CGM001 (Behradev)

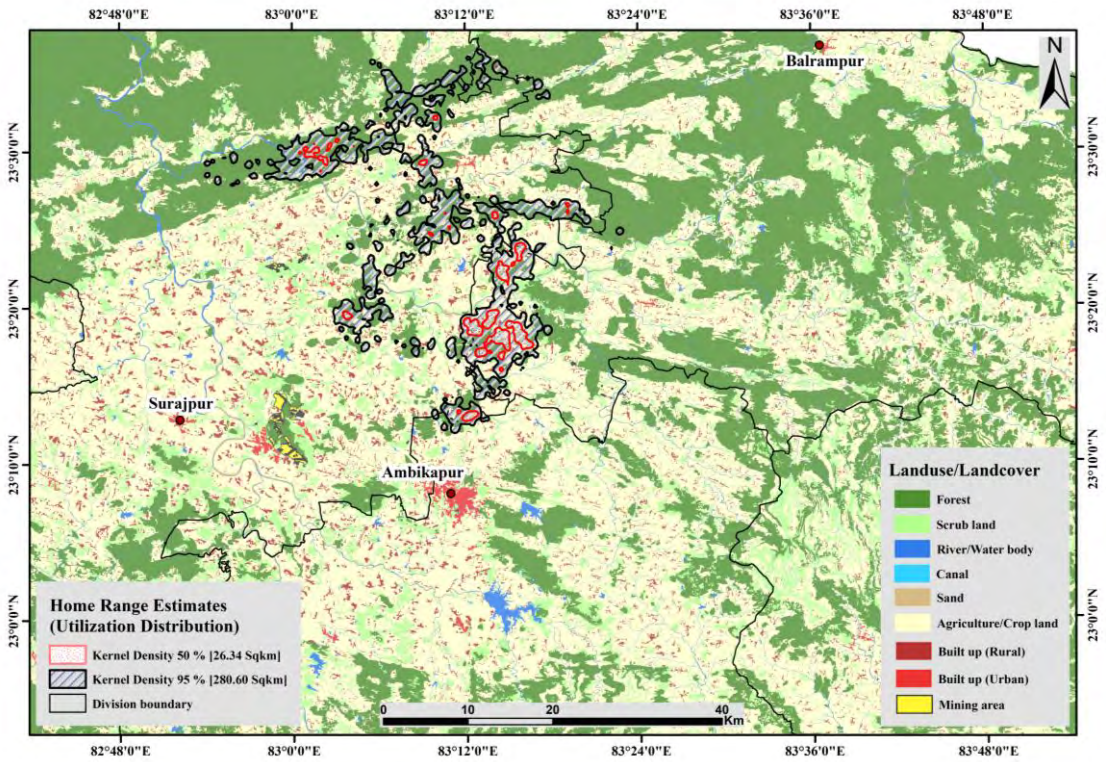

Figure 1.7: Home range estimates (Utilization Distribution) of CGM001 (Behradev)

1.3.3.2 Ranging pattern of CGF010 (Gautami)

During the study period, CGF010 (Gautami) and its herd ranged extensively in Mainpat and Lakhanpur ranges of Surguja FD, Kapu and Boro ranges of Dharamjaigarh FD and Pathalgaon and Tapkara ranges of Jashpur FD within Chhattisgarh state. During October 2018, the herd moved into Sundargarh FD in Odisha and returned back into Chhattisgarh during February 2019. The herd has spent considerable time in the densely forested Mainpat slopes causing minimal conflict. Nevertheless, during the study period the herd was responsible for four human casualties – two each in Surguja and Jashpur FDs during the year 2018. Figure 1.8: Home range estimates (Minimum Convex Polygon) of CGF010 (Gautami)

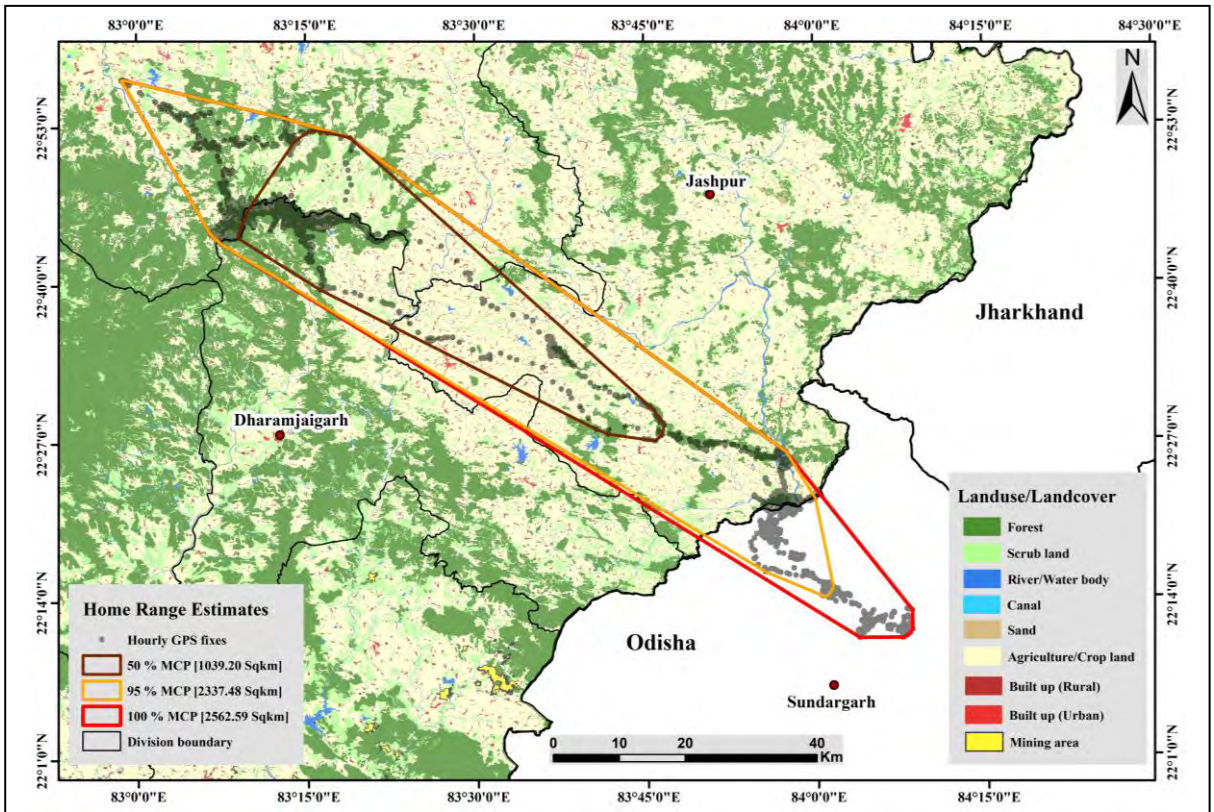

Figure 1.8: Home range estimates (Minimum Convex Polygon) of CGM010 (Gautami)

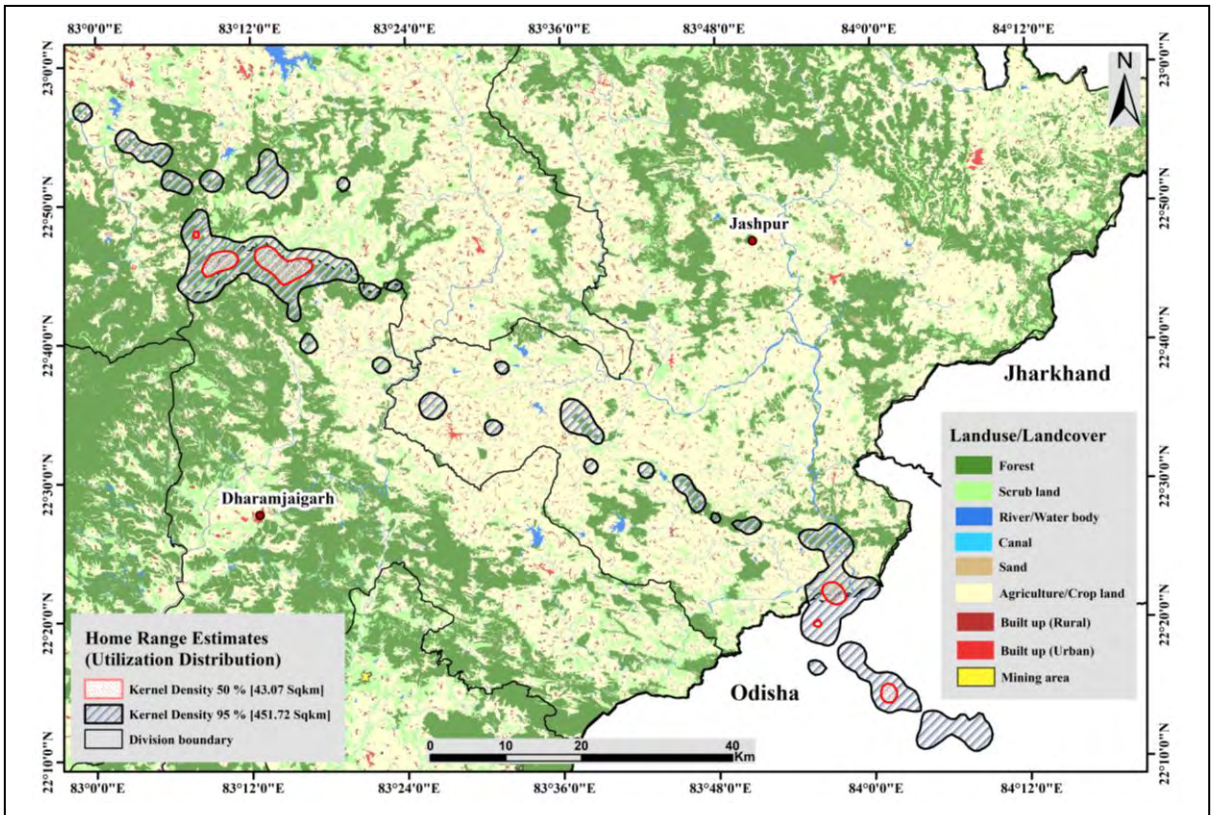

Figure 1.9: Home range estimates (Utilization Distribution) of CGF010 (Gautami)

1.3.3.3 Ranging pattern of CGM003 (Pyare)

During the study period, CGM003 (Pyare) ranged in Surajpur and Gui ranges of Surajpur FD, Ambikapur and Lundra ranges of Surguja FD and Batauli range of Jashpur FD. Unlike CGM001 (Behradev), CGM003 (Pyare)'s *musth* lasted for a very short period of just 15 to 20 days. During the entire study period, CGM003 (Pyare) mostly remained associated with family groups of elephants and showed high flexibility in associating with different groups. It did remain solitary as well for a few days and associated with other younger bulls too in all-male group associations.

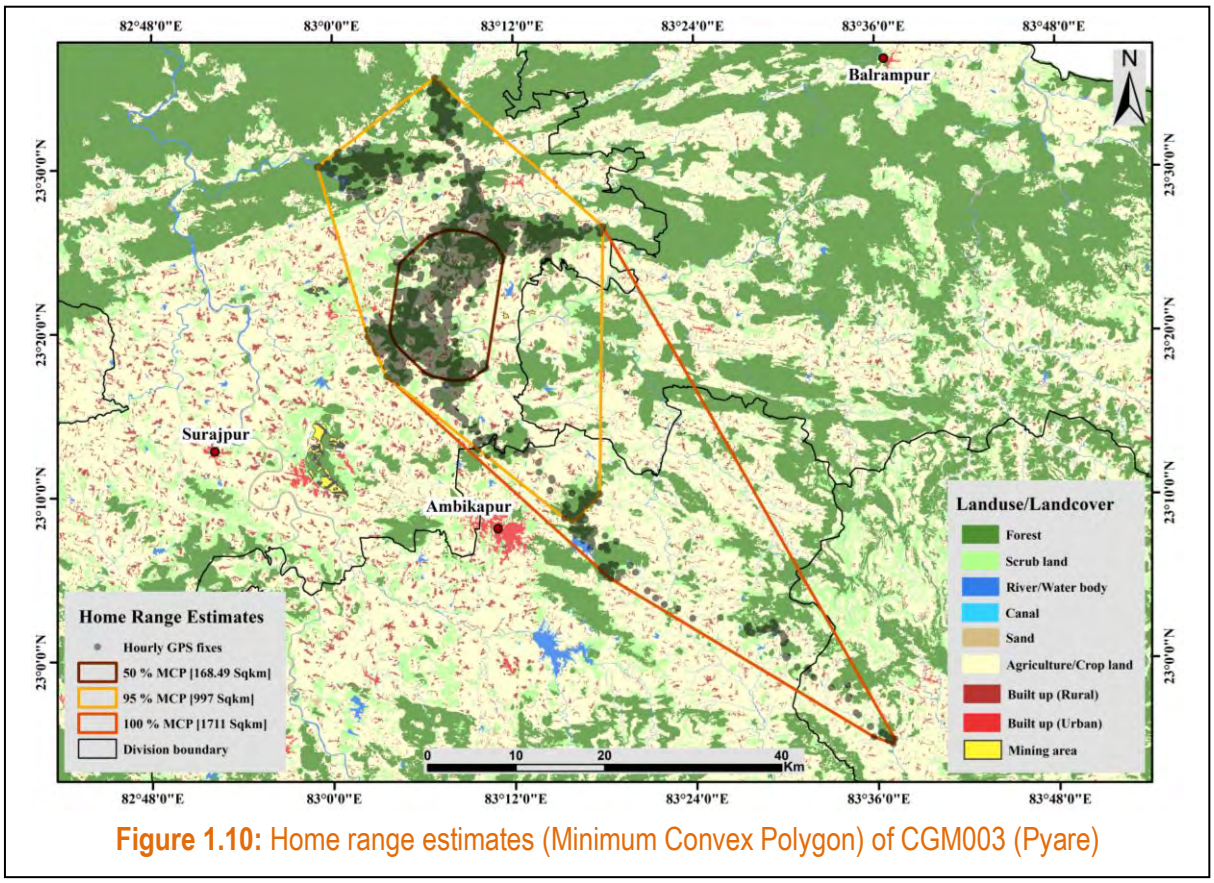

Figure 1.10: Home range estimates (Minimum Convex Polygon) of CGM003 (Pyare)

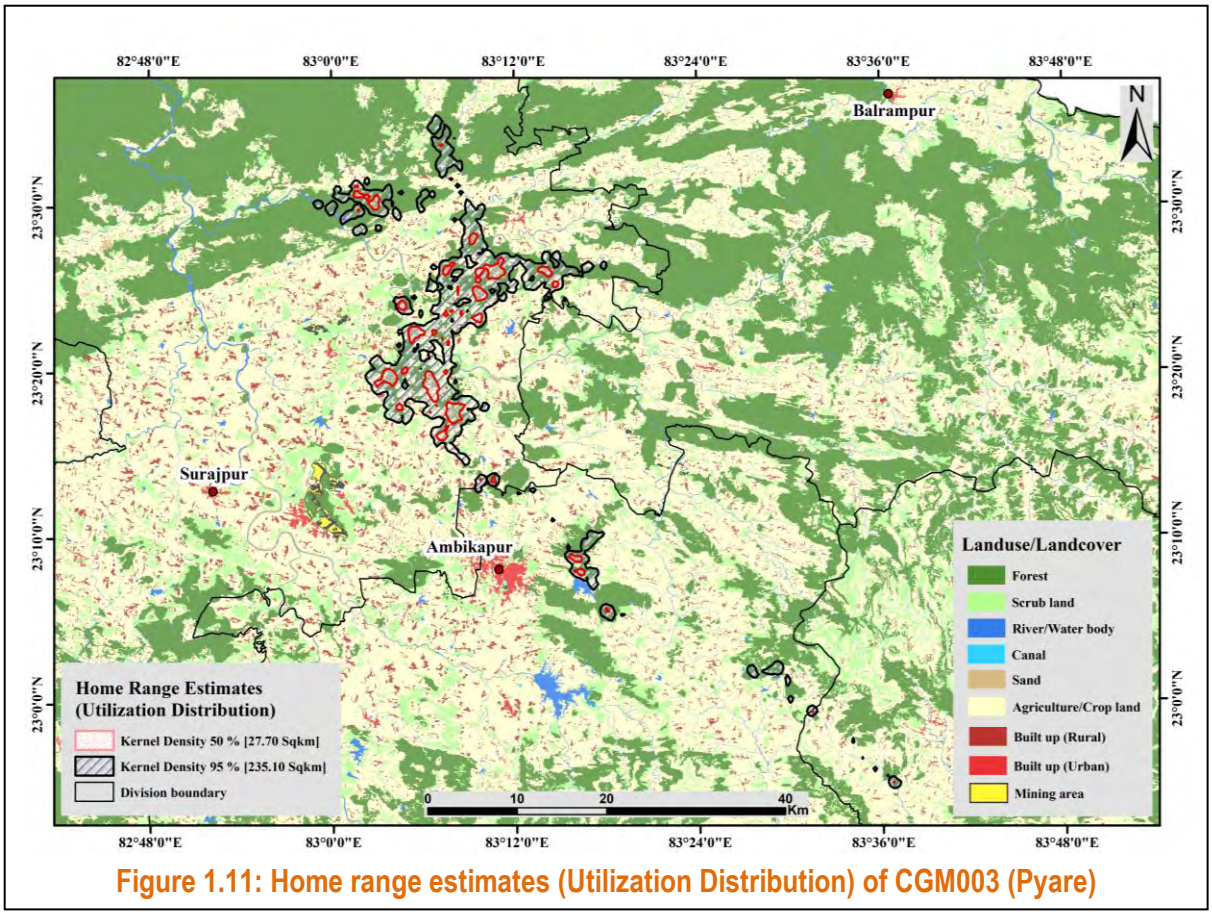

Figure 1.11: Home range estimates (Utilization Distribution) of CGM003 (Pyare)

1.3.4 Habitat use of collared elephants

Kernal estimates show the intensity of habitat use by elephants (Table-2). Of the computed 95% UD estimates, CGM001 (Behradev), CGF010 (Gautami) and CGM003 (Pyare) had spent about 68%, 63% and 63% of their total time in the forest and scrub areas. It is noteworthy that CGM001 (Behradev), CGF010 (Gautami) and CGM003 (Pyare) have spent a significant 32%, 37% and 37% of their total time in the areas outside the forest.

Table 1.4: Utilization distribution (50%) and (95%) of CGM001 (Behradev), CGF010 (Gautami) and CGM003 (Pyare)

Elephant	*50% UD contours (Km²)*			*95% UD contours (Km²)*		
	Forest	Scrub	Outside	Forest	Scrub	Outside
CGM001 (Behradev)	19.00	0.75	6.50	178.90	12.40	89.10
CGF010 (Gautami)	29.60	4.10	2.30	172.00	39.30	122.80
CGM003 (Pyare)	20.60	1.40	5.70	131.20	17.00	87.00

1.3.5 Comparing home range estimates across different landscapes

We have compared 95% MCP home range estimates of elephants collared in Chhattisgarh with home range estimates of elephants collared in other range states in India. Home range of elephants in the intact habitats of the Nilgiris was estimated to be around 400 km^2 (Desai, 1991) whereas in fragmented habitats, elephant home ranges tend to be comparatively large. This is evident from Figure- 1.12, which depicts two peaks in home range clusters of elephants in both West Bengal and Chhattisgarh. It is noteworthy that in both West Bengal and Chhattisgarh the habitats are more fragmented when compared to home range estimates of elephants in Terai and Nilgiris landscapes.

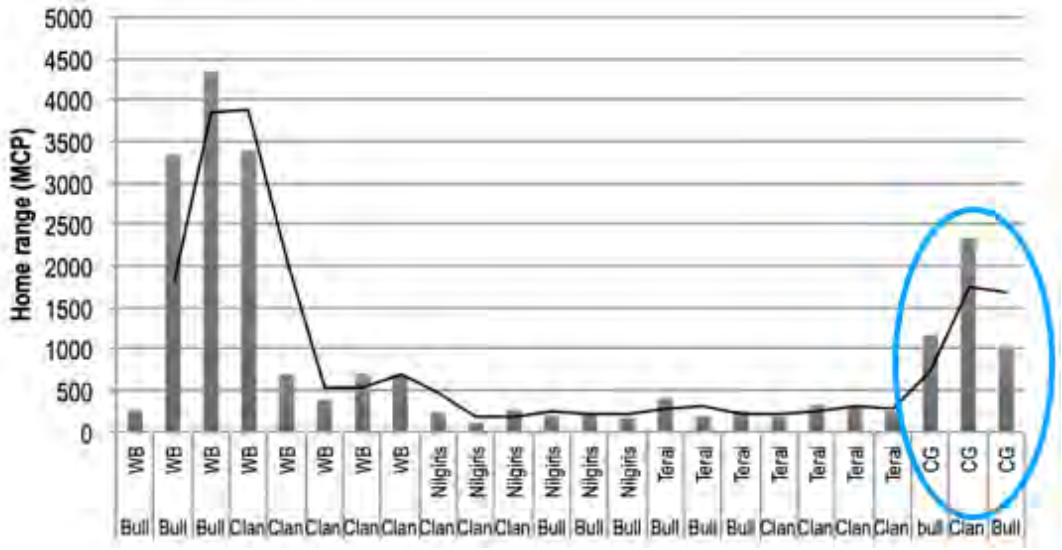

Figure 1.12: Comparison of home range estimates of collared elephants in Chhattisgarh with estimates from other states.

1.4 Movement Patterns of Elephants in Northern Chhattisgarh

1.4.1 Use of corridors by elephants

Identifying and restoring corridors is often a cornerstone in conservation of wildlife populations in highly fragmented habitats. Corridors may facilitate daily and seasonal migrations and also periodic dispersal of animals to maintain population and genetic connectivity. Corridors' utility standout in areas where the difference between habitat and non-habitat is striking, with non-habitats offering a hindrance for animal movement. However, in areas where the difference between habitat and non-habitat is diffuse, as is the case in most of northern Chhattisgarh, identifying corridors just based on structural connectivity is seldom easy.

In northern Chhattisgarh, elephant landscape is a hinterland of forest patches interspersed with settlements and agriculture. Stark differences between forests and non-forests do not exist in the rural areas, as agriculture is still highly marginal and seasonal in most areas. Thus, the landscape appears to offer minimal resistance for elephants to move, especially in the cover of the night. There are numerous forest patches, scrubland, forest plantations and uncultivated fallow lands. All this can provide daytime refugia for elephants. Further, the settlements are usually tiny and most villagers go asleep soon. Night-

light in the landscape is minimal as well when compared to many other developed states. These conditions may facilitate free movement of elephants. Figure 1.8 and Figure 1.10 clearly show how our collared elephants CGF010 (Gautami) and CGM003 (Pyare) have traversed through human use areas. Elephants have not limited their movement only through large forest patches, but used areas outside the forests to move through.

1.4.2 Inherent *vs* induced movement

Environmental factors such as water and fodder availability and elephant behavioral factors such as conspecific attraction or dominance-related avoidance strongly influence the elephant movement patterns in the landscape. This we refer to as inherent movement. Conspecific behavioral avoidance can be a strong trigger for elephant movement. To illustrate, during April 2019, a large bull *makhna* in *musth* joined a family herd of elephants in Surajpur FD. During this time, our collared elephant CGM003 (Pyare), which is a much younger bull left the herd and started operating alone – possibly to avoid confrontation with a bull in *musth*. We observed CGM003 (Pyare) joining the herd only after the *musth* bull had left. It is important to note that elephant behavior and environment related elephant movements are beyond our control.

In addition to environmental and behavioral drivers, in human use areas, anthropogenic factors such as fencing and drives can influence elephant movement. This we refer to as induced movement. In northern Chhattisgarh we have only had opportunistic observations in this regard. For example, CGF010 (Gautami) herd was driven from Manja beat in Lakhanpur range for over five kilometers through human-use areas (Figure 1.13). The herd crossed the Ambikapur–Bilaspur highway and reached areas where they have never been in the past. During the drive, a village youth was killed, several hectares of crops were damaged and elephants have explored new areas where conflict could spread. Thus, unplanned drives cause more harm than good. Thus, controlling unplanned drives is very important.

Figure 1.13: Movement patterns of CGF010 (Gautami) herd through human-use area following drive by villagers from Manja beat

1.4.3 Interstate elephant movement

During the study period, one of our collared elephants, CGF010 (Gautami) along with a herd moved into Sundargarh FD in Odisha during early October 2018. The herd returned back to Chhattsigarh during the month of February 2019 after spending over two months in Odisha. It is noteworthy that both

Figure 1.14: One of our collared elephant GGF010 (Gautami) along with other elephants moving through forest

Odisha and Chhattisgarh actively coordinated with each other in tracking the movement patterns of the herd to alert people on a timely manner. In addition to CGF010 (Gautami) herd, a few other elephants that we have been monitoring without collars have ranged into Madhya Pradesh as well (Chapter-2). Therefore, managing elephants and conflict requires landscape-level approach and active inter-state coordination between Odisha, Chhattisgarh, Jharkhand and Madhya Pradesh.

1.4.4 Utility of collars in conflict management

One of our collared bulls, CGM001 (Behradev) had associated and operated with a family of elephants that we named “Wave Ear” family for about two months. Due to this it was possible to closely follow and pinpoint the locations of about 20 – 30 elephants on a daily basis from August 2018 to November 2019 in high-conflict zones of Surajpur and Pratappur ranges in Surajpur FD. During this period, due to timely information about elephant movement and consequent close monitoring, loss of human lives due to surprise encounters was averted. It was the peak crop harvest season and timely collar locations helped in mobilizing field teams, and due to that there was no human death.

Figure 1.15: Stopping the traffic to facilitate smooth movement of elephants

During November 2018, CGM003 (Pyare) was collared in Surajpur. This bull mostly operated with a large family herd of 20 – 30 elephants in Surajpur and Pratappur ranges. The bull continues to be associated with a herd of elephants thereby facilitating easy monitoring of elephants till date. Due to close monitoring, human casualties due to elephant herds in Surajpur and Pratappur ranges have reduced considerably.

During February 2019, by looking at the movement patterns of collared elephant CGF010 (Gautami) and its herd, we predicted that elephants might return to Mainpat plateau. Because of this timely alert, mobile barriers were strategically used by the department in Mainpat (where elephants can reach the plateau only through select passes) to contain elephants in the jungle. This helped in reduction of crop damage and house damage in Mainpat, which was a major concern in the plateau just a year before CGF010 (Gautami) was collared.

The most redeeming aspect of collaring elephants in the state is the involvement of frontline staff and the village volunteers in timely broadcasting of elephant locations to villagers thereby effectively using collar data as an Early Warning tool. Based on timely collar locations, villagers using forest roads are pre-warned and settlements are alerted. We believe that this kind of timely alerts and active engagement serve as a major confidence-building measure amongst local villagers.

Chapter

2

Individual Identification of Elephants and its Utility in Understanding Ranging Patterns with Additional Insights on Recent Dispersal of Elephants into Bandhavgarh and Sanjay - Dubri Tiger Reserves in Madhya Pradesh

2.1 Introduction

Individual recognition of elephants and developing identification files would be useful in many ways: The herds' movement can be tracked and plotted, individuals that are suitable for collar deployment can be identified, and in conflict situations that require urgent interventions (such as capture and translocation), individual recognition of elephants is indispensable. Although elephants appear strikingly similar to each other, with closer and careful prolonged observation, one can appreciate the differences between individual elephants. In this chapter, we assess the home range patterns of two groups of elephants, in which we have identified a few cow elephants and opportunistically followed them over time. Further, we have also documented a recent dispersal of some of the identified elephants from Chhattisgarh into Madhya Pradesh.

2.2 Methods

2.2.1 Identifying an individual elephant with certainty

Using a combination of variety of body characteristics such as ear, tusk/tush, tail and others such as warts, lumps, abscesses, scar tissues on body, deformities and injuries it is possible to reliably recognise an individual elephant. The more number of characteristics we record for an individual elephant, the better it is. This technique of identifying elephants has been used in both Africa and Asia for the last many decades (Douglas-Hamilton et al, 1975; Moss, 1988; Vidya et al, 2014; De Silva et al, 2013).

2.2.2 Photographing elephants for individual recognition

Identification of elephants involves both field and desk efforts. In the field, apart from the camera equipment to photograph elephants, carrying a field notebook is essential. Ideally, after taking each photograph, it is important to note the references in the field notebook so that the features are not confused between the individual elephants. Taking multiple pictures of elephants in the group without making references in the field notebook is a major source of confusion when we try assigning the pictures to an individual elephant. Well-kept notes avert this confusion.

Ideally, for each elephant we need to get at least four pictures: both left and right side profiles, a head-on picture with ears cocked and a rear profile showing the rump.

2.2.3 Organising the photos

The photos and videos should be name-tagged and stored in the computer. The nametags should consist of the location details, date and time, herd size and composition. Along with field notes, these photos and videos can be used to create individual identification files. For record keeping, we assign individual identity cards with all recorded features for each identified elephant. In the identity cards, the additional information we record include elephant's number and name (if names have already been assigned), its gender, age-class, and the location from where it was first photographed. We follow a numbering system that is different for both males and females.

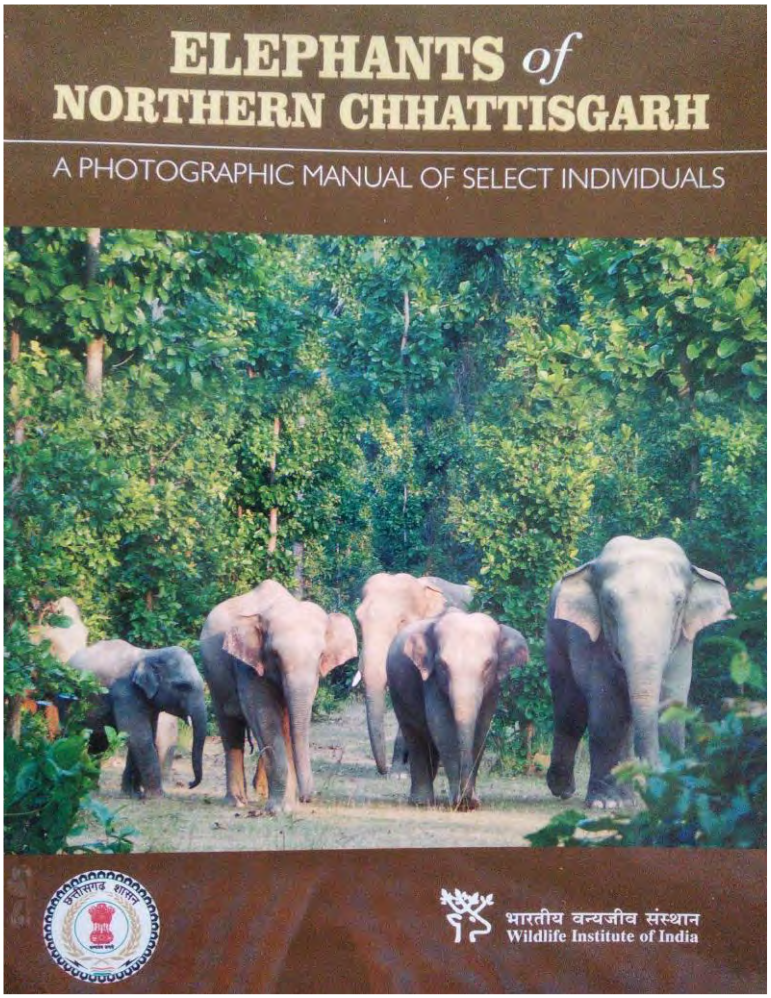

Figure 2.1: Cover page of the photographic manual of identified elephants

A total of 80 elephants have been individually identified during the period from August 2017 to July 2019. Identification files for these individually identified elephants are available in the manual *Elephants of Northern Chhattisgarh – A photographic manual of select individuals* (Lakshminarayanan et al, 2019).

2.3 Computing home ranges for identified elephants

2.3.1 Home range estimates

The home ranges of CGF002 (*Torn ear*) and CGF003 (*Wave ear*) estimated using both MCP and UD approaches have been pictorially depicted in figures (figures 2.2 to 2.4).

Table 2.1: Home range estimates (Minimum Convex Polygon) of CGF002 (Torn Ear) and CGF003 (Wave Ear)

Elephant	*MCP (Km²)*		
	50%	*95%*	*100%*
CGF002 (Torn Ear)	3493.26	8484.46	9076.66
CGF003 (Wave Ear)	120.46	385.49	830.12

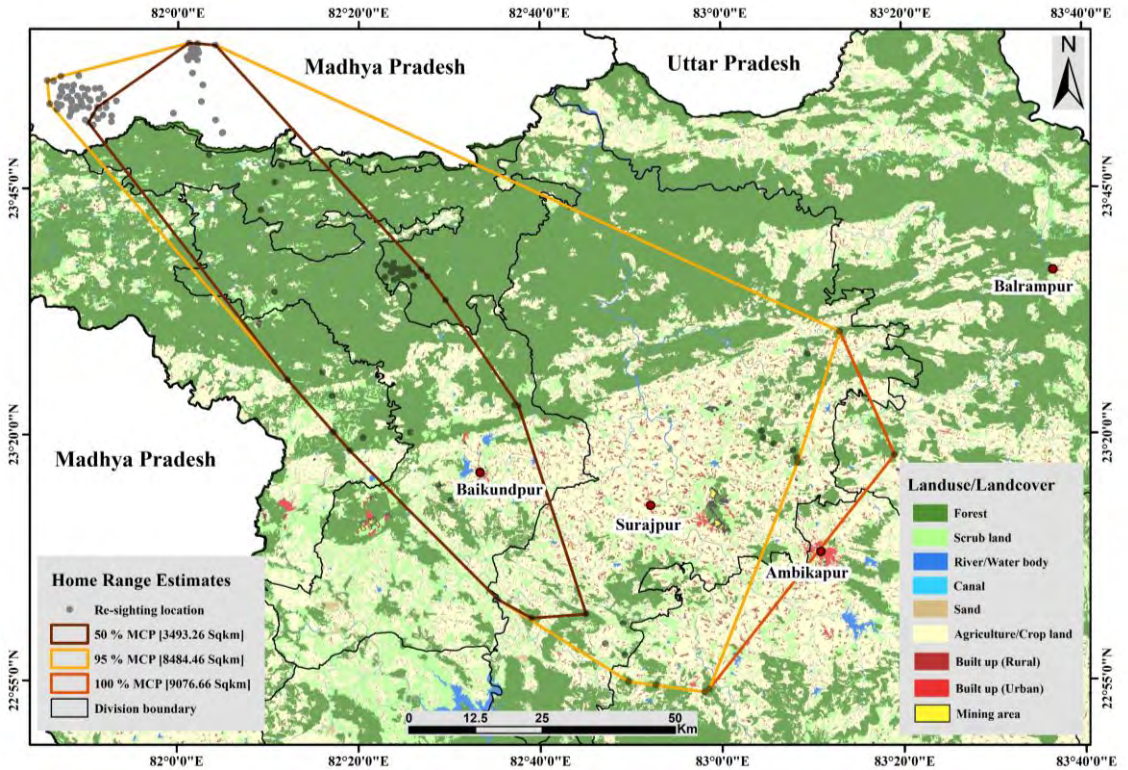

Figure 2.2: Home range estimates (Minimum Convex Polygon) of CGF002 (Torn Ear)

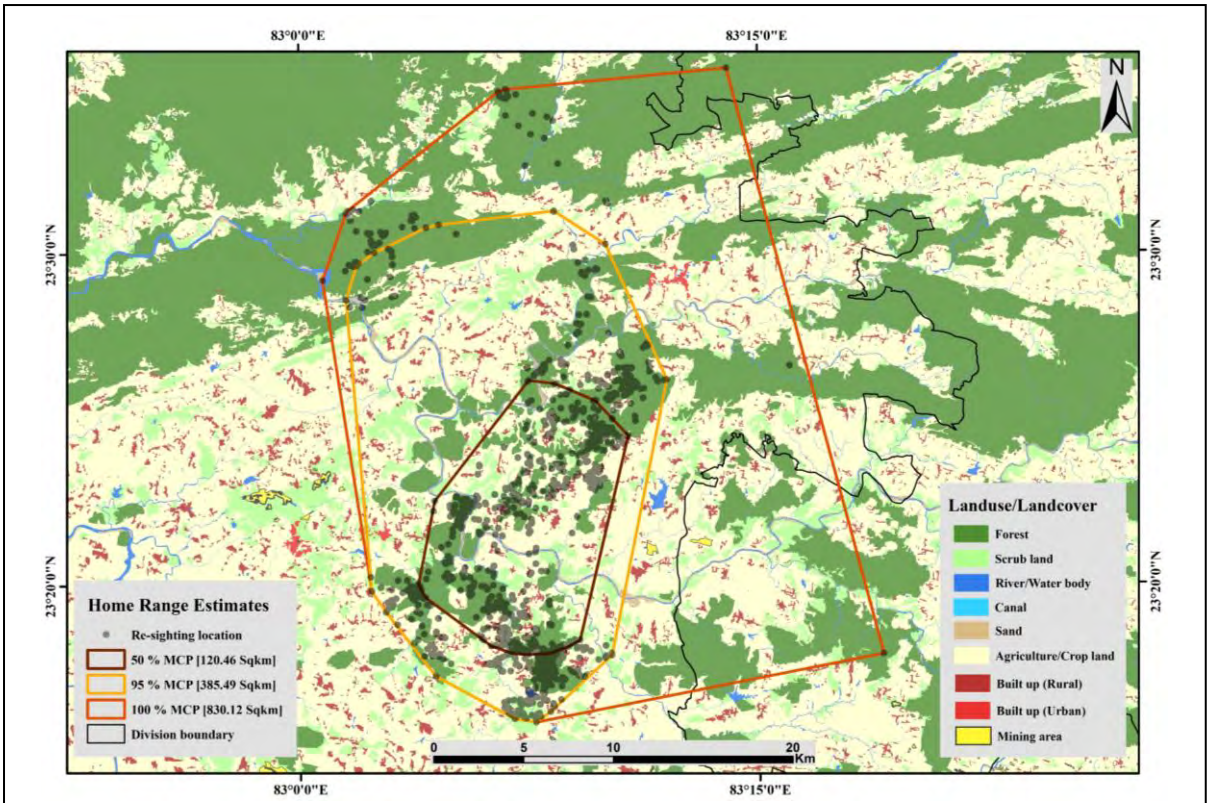

Figure 2.3: Home range estimates (Minimum Convex Polygon) of CGF003 (Wave Ear)

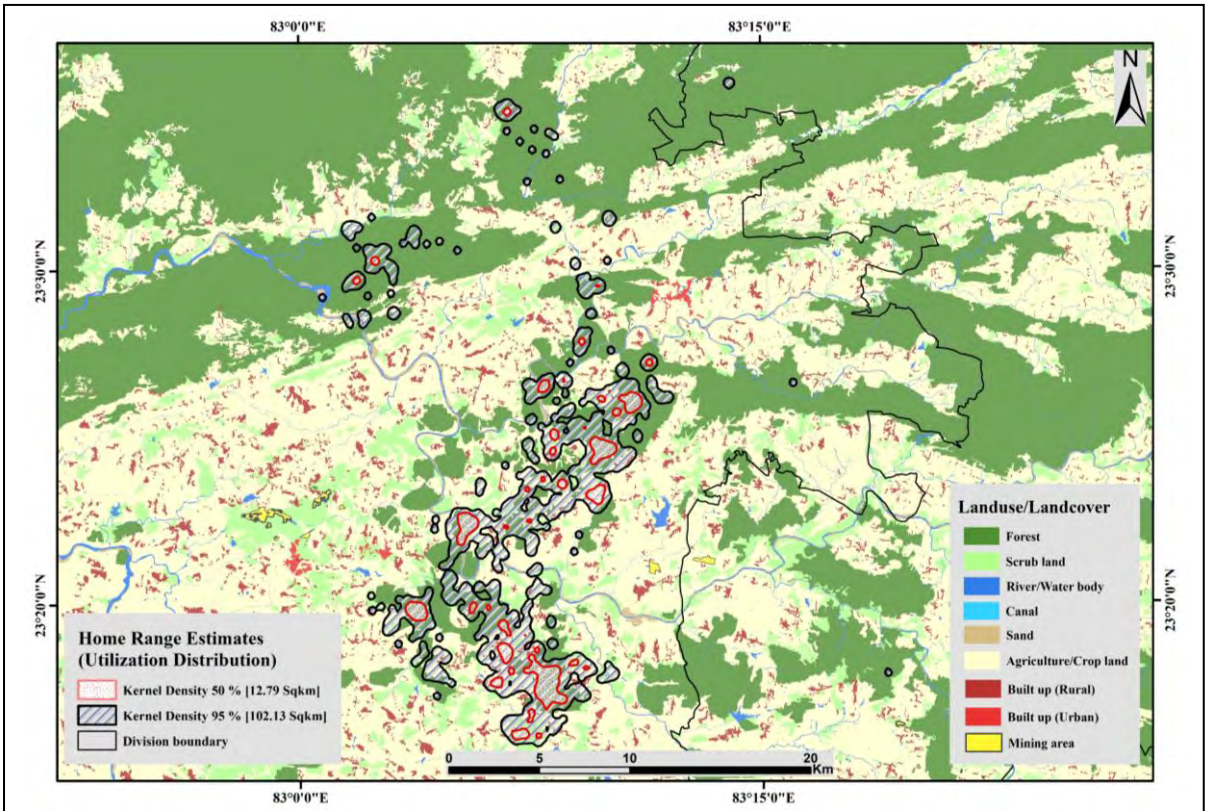

Figure 2.4: Home range estimates (Utilization Distribution) of CGF003 (Wave Ear)

MCP approach tends to overestimate home ranges in general and in particular for animals that move linearly. The latter is probably the reason why the home range estimates of CGF002 (Torn Ear) are large. Notwithstanding this, the group has been moving widely covering Surajpur (Pratappur, Premnagar and Surajpur ranges), Surguja (Udaipur and Lakhanpur ranges), Koriya (Baikundpur and Sonhat ranges), Gurughasidas NP (Sonhat, Ramgarh and Janakpur ranges) and Sanjay-Dubri Tiger Reserve in Madhya Pradesh.

CGF003 (Wave Ear) and its herd were followed for a longer period of time. This herd range extensively in Pratappur and Surajpur ranges of Surajpur FD and Rajpur and Wadrafnagar ranges of Balrampur FD.

2.4 Recent range expansion of elephants into Madhya Pradesh

While there may have been isolated recorded movement of elephants from Chhattisgarh and Jharkhand into various districts of Madhya Pradesh that occurred before we commenced our study in Chhattisgarh, we have directly observed some of the recent range extensions from Chhattisgarh into Madhya Pradesh.

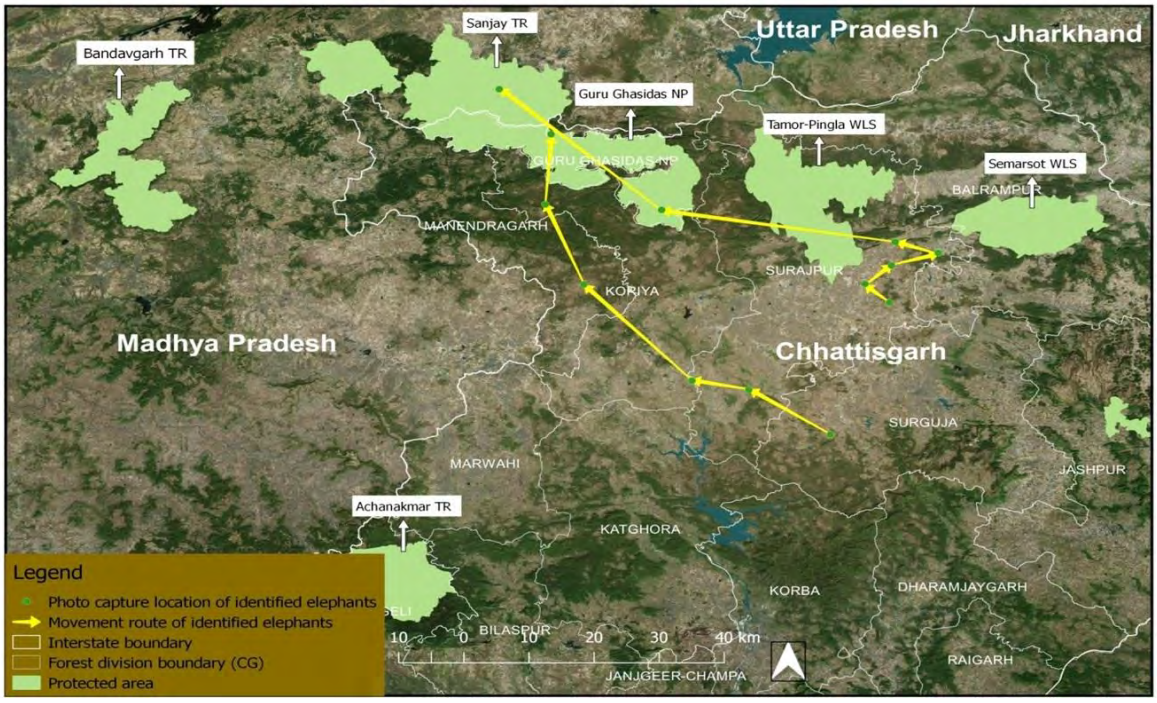

Figure 2.5: Route taken by elephants from Chhattisgarh into Sanjay-Dubri Tiger Reserve in Madhya Pradesh based on sighting.

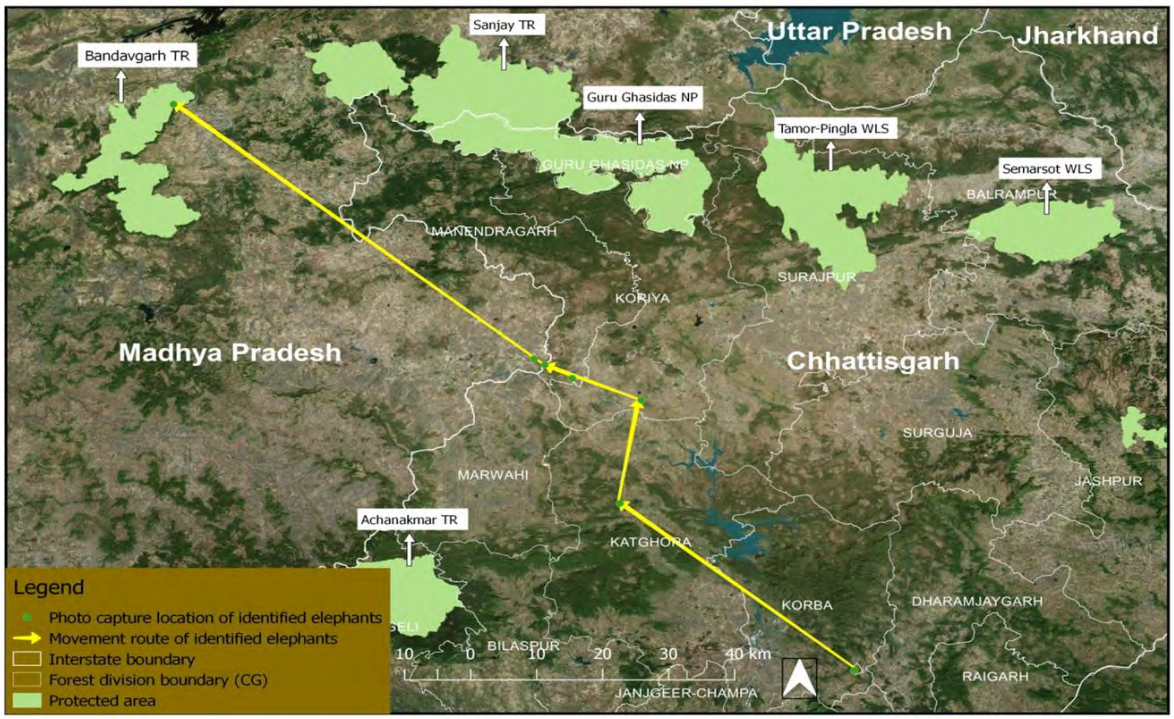

Figure 2.6: Route taken by elephants from Chhattisgarh into Bandhavgarh Tiger Reserve in Madhya Pradesh based on sighting.

We have been regularly following elephant CGF002 (Torn ear) and its herd. This herd has been frequently moving back and forth into Sanjay-Dubri Tiger Reserve in Madhya Pradesh via Guru Ghasidas National Park in Chhattisgarh. The herd size of this group has been dynamic. During November 2017, when we have photographed them in Mohanpur of Surajpur FD for the first time ever, there were over 19 individuals. However, there were just seven individuals when we had last observed them in Sanjay-Dubri Tiger Reserve during April 2019. Fission and fusion of groups is a common phenomenon in elephants. While quite a few individuals have been individually recognized in this group, the project team has photographed three adult females from this group in Sanjay-Dubri TR during April 2019. In our individual elephant database these elephants are CGF001 (Matty), CGF002 (Torn ear) and CGF005 (Sundri).

During July 2018, a small herd of five elephants moved into Manendragarh district in northwestern Chhattisgarh. The herd comprised of an adult female, a young female, a sub-adult male in the cusp age (around 15 years) and two juvenile males. All the three males were tuskers. We compared the photos of the elephants with our database of individually recognized elephants and found that the adult cow was already documented. Our field team had photographed this cow once in Patkura of Lakhanpur range in Surguja Forest Division with a herd of elephants. This herd was identified as 'CGF010 (Gautami) herd' as one of the females in the herd was fitted with a collar and named CGF010 (Gautami).

During September 2018, a herd of elephants ranging in Koriya district of Chhattisgarh moved into Bandavgarh Tiger Reserve passing through Anuppur district. The herd of around 30 elephants has reportedly been operating inside Bandavgarh Tiger Reserve for the past many months. Our field research team visited Bandavgarh Tiger Reserve during April 2019 and observed the herd. By comparing the photos obtained from Bandavgarh TR with our database, we could identify at least eight different individuals that we had earlier recorded in Korba, Koriya, Katghora and Dharamjaigarh Forest Divisions. This long-distance movement itself is a testimony that the elephants – if not all, but at least a few groups continue to explore the landscape in search of habitats.

Elephants observed in both Chhattisgarh and Sanjay TR

CGF001 CGF002 CGF005

Figure 2.7: Identified elephants observed initially in Chhattisgarh which were later observed in Sanjay-Dubri Tiger Reserve

Elephants observed in both Chhattisgarh and Bandhavgarh TR

CGM020 CGF021 CGF031

CGM013 CGF022

CGF032 CGF026 CGF027

Figure 2.8: Identified elephants observed initially in Chhattisgarh which were later observed in Bandhavgarh Tiger Reserve.

Chapter

3

Analysis of Human Casualties Due to Human – Elephant Conflict in Northern Chhattisgarh

3.1 Introduction

Human casualties due to elephants is often considered as the most acute form of human–elephant conflict. More often, human casualties lead to local antagonism towards conservation as a whole and turn into political flashpoint. There are also ethical and moral compulsions to reduce human casualties due to conflict situations. Nevertheless, in places like northern Chhattisgarh where elephants range extensively in a landscape mosaic with highly overlapping human use areas and natural forests, containing human casualties due to conflict is far from easy. In order to advance mitigation strategies that could help in reducing conflict-related human casualties, an understanding of circumstances leading to human casualty is helpful. Such an understanding shall help in identifying locations and activity patterns of villagers that predispose them to attacks. However, it is seldom easy to gather information regarding casualties as it often dies with the victim. Nonetheless, by visiting the sites of incidences immediately to record circumstantial evidences and also by interacting with eyewitnesses and field staff, it may be possible to weave pieces of information together coherently. With this aim, during the period between August 2017 to June 2019, we have collected fine-scale details on 46 cases of elephant-caused human casualties in northern Chhattisgarh by directly visiting the sites (*primary data*). Additionally, we have also collected secondary details from Forest Department records from Surguja circle (*secondary data*). Pooling both the primary and secondary data together, we used basic descriptive statistics to understand the patterns and possible correlates of human casualties due to elephants and discuss management implications.

3.2 Methods

We have visited sites of human casualties caused by elephants and recorded basic details that include site characteristics (habitat, distance to forest, habitation, micro-habitat and others), details about the victim (age, gender, physical condition, activity the victim was engaged during the incident and others) and details about elephants (group size, gender etc). We have also interacted with eyewitnessess and collected other circumstantial direct evidences. Additionally, we have also recorded elaborate field notes based on our direct observations and discussions with staff and villagers.

Figure 3.1: Site assesment and primary data collection pertaining to the human casualty, from the site of incident

3.3 Results

3.3.1 Age and gender of victims

Of the total number of victims, about 46% (n=37) were elderly, 28% (n=23) were middle aged and 19% (n=17) were youth. These three categories constitute the majority. In addition to this, there were infants (5%, n=4), children (1%, n=1) and teens (2%, n=2)

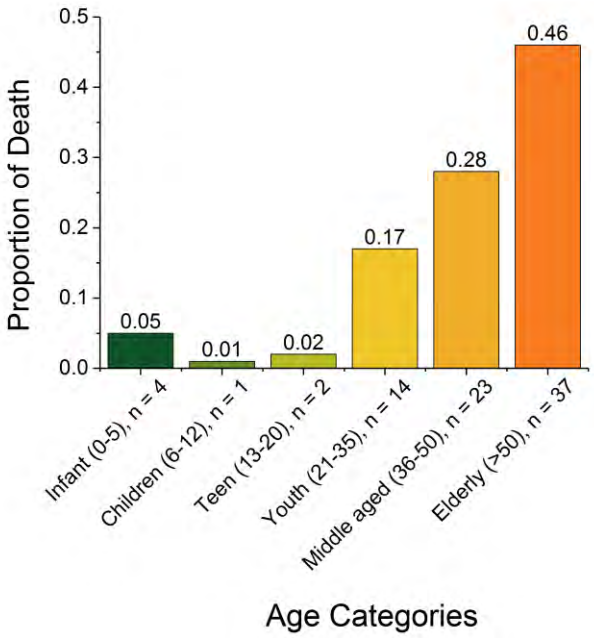

Figure 3.2: Age categories of victims, from the combined primary and secondary data.

Overall, more men (64%, n=56) were killed by elephants in comparison to women (36%, n=31) (Figure- 3.3). Comparison across three years for the period from 2017 to 2019 also shows that every year more men are killed than women (Figure-3.4)

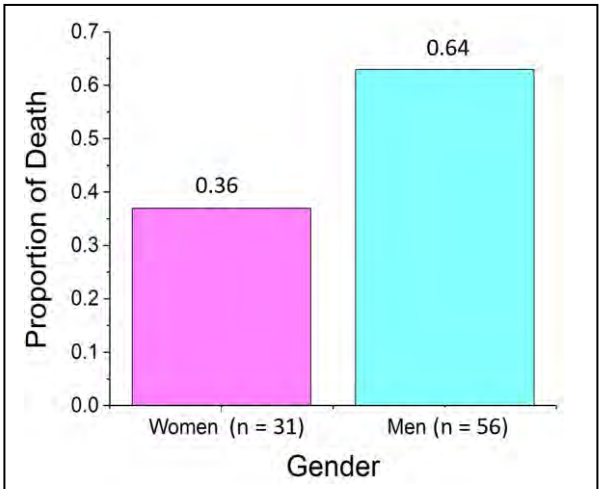

Figure 3.3: Overall gender-wise proportion of casualty, from combined primary and secondary data.

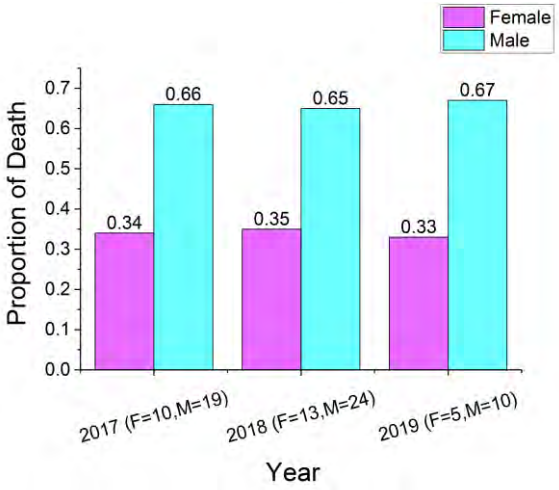

Figure 3.4: Year-wise casualty as per gender

3.3.2 Sites of incident

Out of the recorded primary cases (n=46), a large fration of casualties have occurred in and around the vicinity of the houses (30%, n=14) and in agricultural fields (30%, n=14). An almost equal number of casualties occurred in the forests (28%, n=13). Five casualties (11%) occured in the scrub lands. The category " inside/vicinity of the house " represents the sites where the incidents have occurred inside the or within the radius of 100 m from the house, for houses located both inside settlements as well as those close to forest.

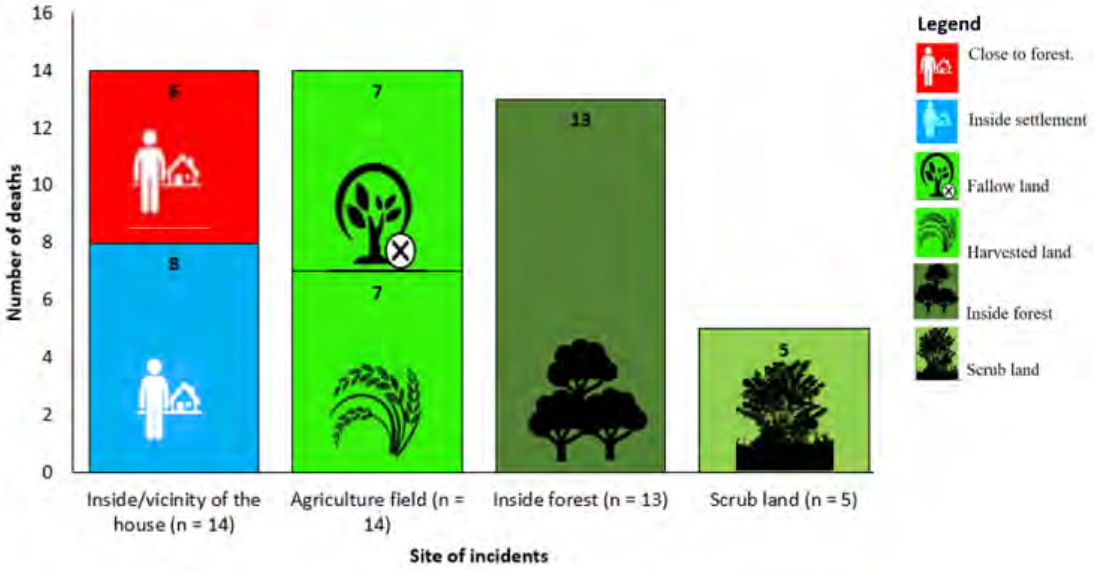

Figure 3.5: Number of casualties recorded with respect to site of incident. Agricultural fields been divided into fallow fields and harvested fields."Inside/vicinity of the house" category has been divided into a) close to forest (for incidents occuring inside or within the radius of 100 m from the house close to forest) and b) inside settlement (for incidents occurring inside or within the radius of 100 m from the house inside the settlement).

3.3.3 Periodicity of human casualties and time of incidents

Human casualties due to elephants have been recorded all through the year (Figure 3.6) and not limited to any particular period.

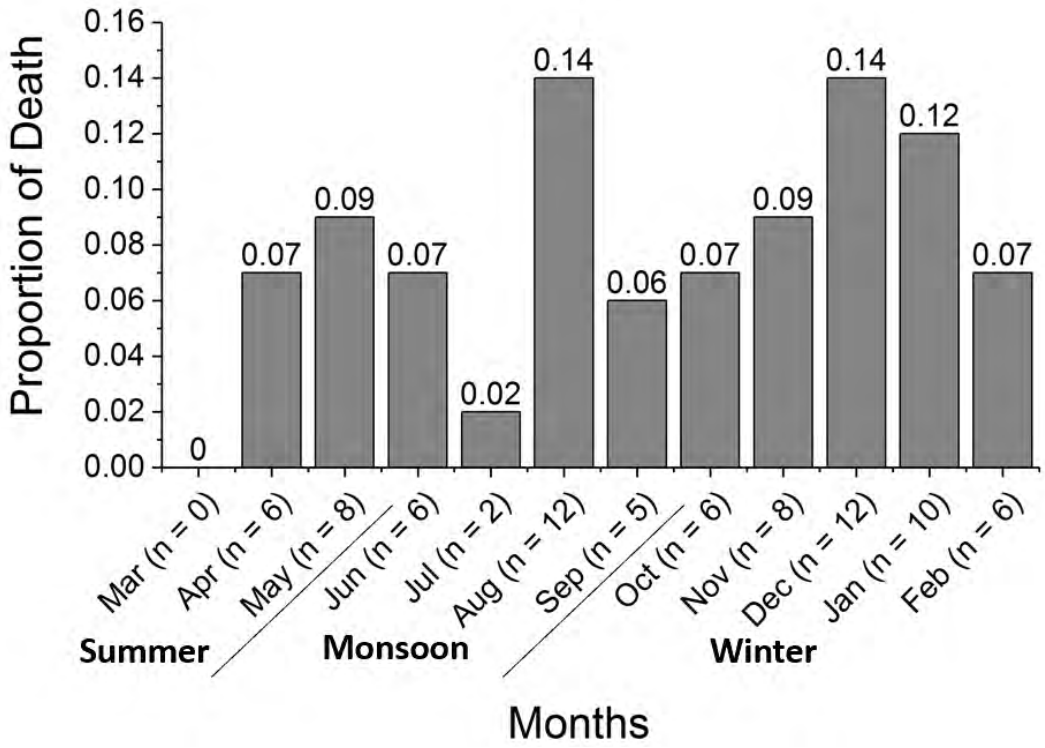

Figure 3.6: Proportion of casualties through the months of a year. Months have been grouped together into seasons summer, monsoon and winter. Note: From left, months begin from march.

As far as time of incidences are concerned, most of the human casualties due to elephants occurred at night (50%, n=23). Further, many casualties took place when the visibility was relatively poor due to light conditions, i.e. dusk (24%, n = 11) and dawn (15%, n = 7). There were five (11%) casualties that occurred during broad day light between 0700 h to 1600 h (Figure 3.7)

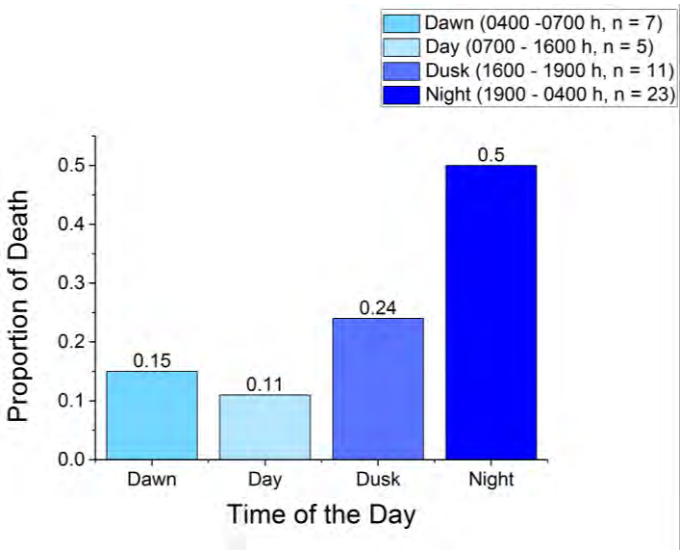

Figure 3.7: Proportion of human casualties as per the time of the day categorised as Dawn, Day, Dusk and Night. The 24 h cycle has been divided based on the light/visibility conditions.

3.3.4 Activities of victims during the incident

The activities listed in Figure 3.8 are not mutually exclusive. A large fraction (16/46) of casualties occurred in and around the houses of the victims when they were in their homes and probably taken by surprise. A few casualties occurred when the victims were sleeping/sitting and in a few cases, they were trying to run away from their homes to escape from the elephants. In about 17% of cases, the victims were moving inside the forest (n = 8) either on foot (4.3%,n = 2) or in their cycles / two-wheelers (11%, n = 5). About 15%(n = 7) of casualties occurred during collection of forest produces. About 15% (n=7) of casualties were due to elephant drives wherein; elephants turned aggressive during the drives and charged at people.

There were three casualties (6.5%) during which the victims were working in their agricultural fields and there were two casualties (4.3%) where victims went to relieve themselves in the bush around their homes. There was a lone case (2%) of victim going to a waterbody next to their homes to fetch water and during two cases (4.3%), the victims approached the elephants either out of curiosity or to photograph them.

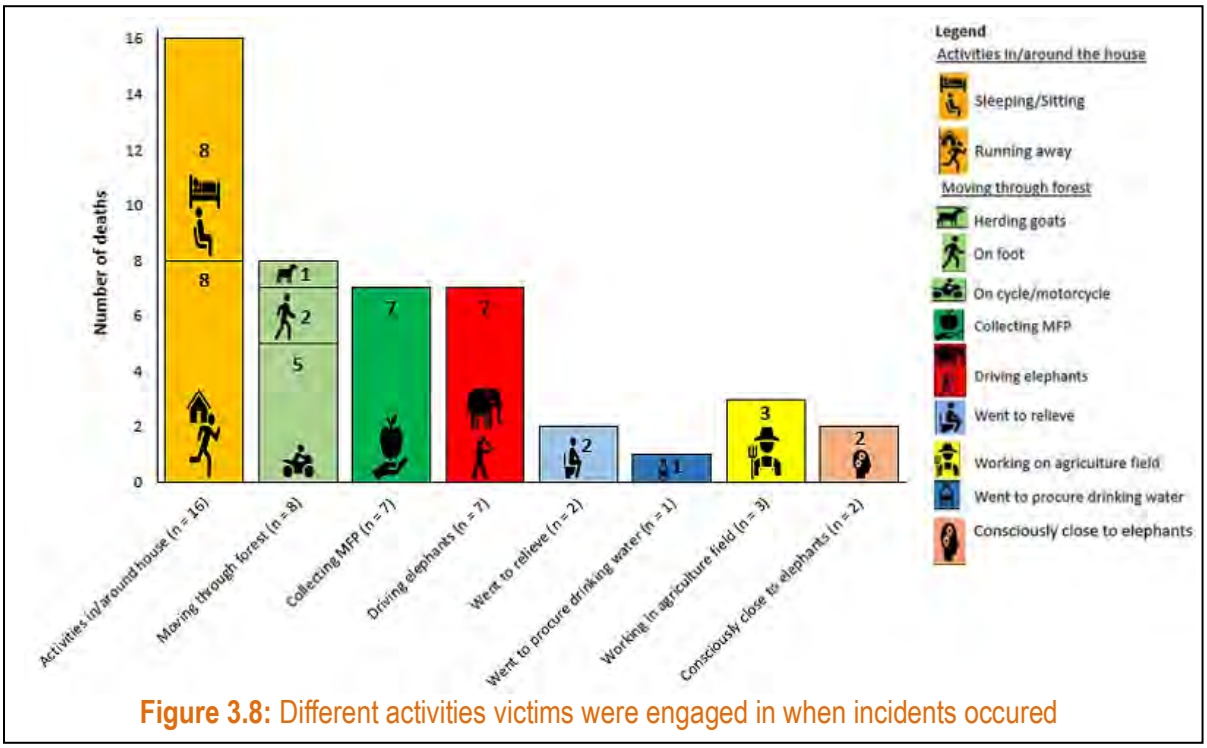

Figure 3.8: Different activities victims were engaged in when incidents occured

3.3.5 Human casualties and responsible herds

In the overall cases (n=45), female herds were responsible for over 40% cases (n = 18), while males (solitary or all-male groups) were involved in 60% of human casualties (n = 27), however, no significant differences between these numbers were observed (p = 0.17) (Figure 3.9).

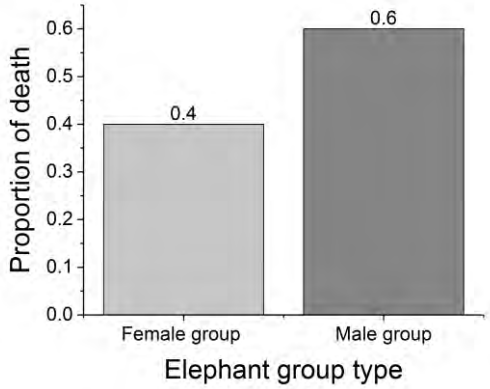

Figure 3.9: Overall casualties casued by respective elephant group type, as per the primary data (N = 45)

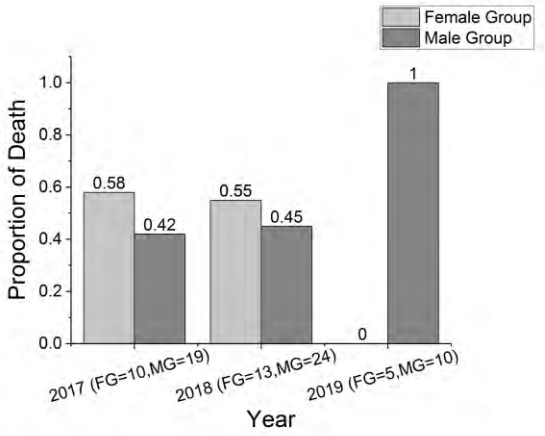

Figure 3.10: Yearwise pattern of involvement of elephant groups in human casualties.

3.4 Discussion

Given that elephants are ranging extensively in northern Chhattisgarh landscape where forests and human use areas tightly overlap, containing human casualties is a huge challenge (Chapter-1). From our study, certain intuitive patterns emerge: More men die in comparison to women during human–elephant conflict situations. Further, more elders are killed during encounters with elephants. This is possibly due to the fact that village elders (both men and women) often go to forests to collect forest produces and also, their physical faculties that are needed to detect and evade elephants tend to be poor.

Figure 3.11: Non-timber forest products such as Tendu leaves (left) and Mushroom (right) being collected by the local villagers. These products serve as important economic source for sustenance of local communities

In Surguja and Bilaspur circles, it is not uncommon to see frail elders taking their cattle inside the forests to graze. An equal fraction of youth & middle aged men die as well. In addition to grief, casualty of middle aged earning member can economically cripple down families and jeopardize their social

security in the long-run. This highlights the fact that human–elephant conflict is both an economic and a social problem.

With regards to periodicity, human casualties due to elephants are spread out throughout the year and not limited to any particular period. This pattern merits explanation: In northern Chhattisgarh, although intensive cultivation of crops is seasonal (except in some districts that have better irrigation facilities), standing crops that small groups of elephants can feed on such as vegetables, pulses and fruits are always there, albiet in small quantities. Some of the bulls and even small groups of elephants raid even the gardens in the backyard of dwelling places. Thus, the frequency of interactions elephants and people in and around human habitations is always high. Similarly, the local communities are also highly dependent on forests for their livelihood. They frequently venture to forests to collect a variety of forest produces across different seasons. Thus, the chances of encounters between people and elephants inside the forest is always high.

A large number of human casualties have occurred in the vicinity of houses and other dwelling places. Casualties have occurred around solitary houses in the jungle and in the settlements as well. Elephants do break houses to raid stored grains, salt and possibly liqour. Elephants breaking houses creates pandemonium in the darkness of the night as people in the house are usually taken by surpsrise by the elephants. There are reported cases of victims fleeing from their houses in the darkness of the night and bumping into the elephants. It is usually impossible to safely move out women, elders and children when elephants surround their houses in the night. Because villagers fear that elephants will raid their houses in the night, some of them resort to driving away elephants from the forests during daytime. There were quite a few casualties due to drives as well. Thus, elephants coming closer to houses and at times breaking them is a serious concern in this landscape.

Nevertheless, addressing the problem of house breaking by elephants is not an easy task as the problem is spatially widespread; villagers continue to live in isolated houses within the forests; and some of the elephant herds and individuals appear to be habituated to breaking houses. The worrisome part is, younger elephants learn from older elephants – the process known as cultural transmission and thus, the problem of house breaking may persist if we do not develop solid plans to reduce it. In high-conflict areas, holding dialogues with villagers and consolidating the settlements and developing community-managed fences (with trip alarm) around the settlement may be experimented.

Further, some of the individual elephants and groups that are more habituated to breaking houses may have to be deterred and negatively conditioned using powerful kumki elephants and other means. This of course is easier said than done.

Figure 3.12: Property broken/damaged by elephants

Our study also show that around 20% of human casualties have happened on the roads and trials in the forest. In places like Dharamjaigarh and Korba Forest Divisions where there are village enclaves within the forests, despite having comparitively wider roads (or kucha roads) villagers use numerous narrow forest roads and trails to travel (either on foot or in bi-cycles and motorcycles) to cut down the distance meagrely. This is dangerous as wild animals including elephants have the habit of using these trials for directed movement and thus, chances of close encounters between people and elephants are usually high. Further, villagers moving in motorcycles are more vulnerable as engine noise of their motorcycles preclude detection of elephants nearby. Thus, it is imperative to engage with the local villagers and try and reduce use of narrow roads and instead use wider roads with good visibility.

It is noteworthy that over 30% of human casualties have occurred in the crop fields – possibly while guarding crops or driving away crop raiding elephants. In northern Chhattisgarh, the farmers are highly marginal and crop loss is perceived as a direct threat to livelihood.

That's the reason why villagers guard crops despite knowing the risks associated with it. Teaching them simple, but safe crop guarding techniques can be helpful. For example, we have observed many farmers guarding their crops from flimsy thatched huts erected in the fields. With numerous sturdy Mahua (Maduca indica), mango (Mangifera indica) and ficus trees around, it is prudent to guard crops

from *machans* erected over a sturdy tree as is done by many forest dwelling communities in south India. Timely disbursement of ex-gratia to affected farmers is crucial as well.

Figure 3.13: A flimsy makeshift "machan" used by the farmers to guard crops

Our study shows that male elephants were responsible for more human casualties than the female herds. Even in cases of human casualties involving herds, it is ambiguous whether females elephants were responsible for human casualties or young males that operate along with the herds. During our study period, we have identified numerous young males that are in the dispersing age-class (around 10 to 15 years). These young males move out of their natal ranges, operate alone or sometimes associate with other males or family herds. In general, young males that move out of natal ranges tend to be more excitable when they operate alone as they lack social buffering that older and experiened elephants provide when they are in the herd. It is difficult to continuously monitor young males as they form loose associations and may move widely. Fitting collars on young males is difficult too as there are several in the landscape and males have rapid growth spurt and thus the collars would soon choke them. Human casualties due to family groups are comparitively less as family herds can be better detected and monitored.

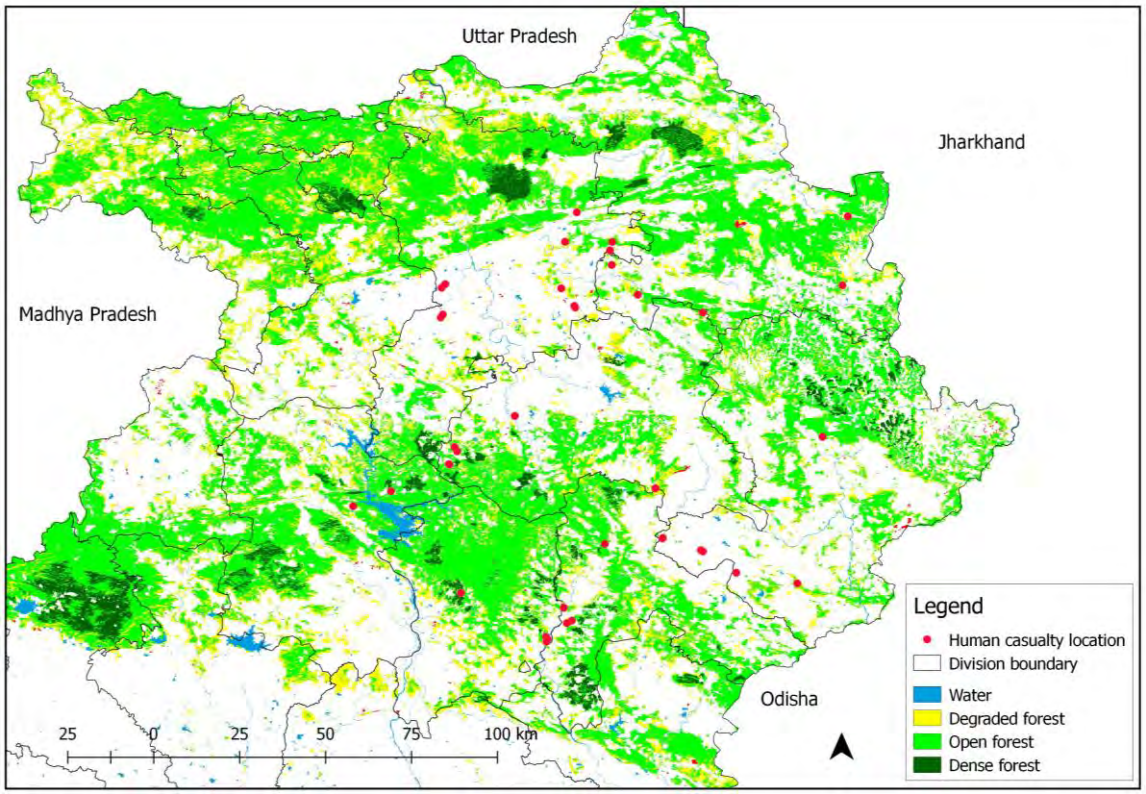

Figure 3.14: Site of human casualty observed in the study area

Chapter

4

Population Genetics of Elephants in Northern Chhattisgarh: Preliminary Findings

4.1 Introduction

Elephant society is profoundly characterized by *fission-fusion* social organization, whereby; the groups break-up and re-group in response to environmental and behavioural reasons. Thus, the group sizes (number of individuals in the group) are neither constant nor rigid. In Chhattisgarh, elephants range in over nine divisions across three circles namely Surguja, Bilaspur and Raipur. Based on spatial sorting, there could be a temptation to consider different elephant groups as discrete. However, to understand if these groups are inter-related or not, it is important to assess the population structure through genetic relatedness. Such an assessment can throw light on how many genetically distinct clans occur in Chhattisgarh. Further, if we sample in the neighbouring states of Jharkhand, south West Bengal and Odisha as well, it may be possible identify the number of different lineages in the Central regional elephant population and also possibly identify areas within the landscape from where elephants often disperse into new areas. With the initial set of samples that we have collected from the field from various forest divisions in Chhattisgarh, we tried to understand genetic diversity of elephants that operate within Chhattisgarh and also the minimum number of different lineages. Additionally, we have also tried to identify individual elephants using genetic tools.

4.2 Methods

4.2.1 Sample collection

Dung samples of elephants were collected between 2017 to 2019 from Korba, Jashpur, Dharamjaigarh, Surajpur, Mahasamund, Sarguja, Katghora and Balrampur forest divisions (FDs) and Tamor Pingla WLS of Chhattisgarh state. Opportunistically tissue and blood samples of elephants were also collected during radio-collaring and other veterinary interventions of elephants. Sampling was based on prior information about the presence of elephants in various human-elephant conflict areas.

4.2.2 Laboratory examination

DNA extraction

In the field, top layers of fresh dung samples were collected in butter paper (wax paper) for genetic analyses along with GPS coordinates. In the laboratory, DNA extraction was carried out from all the dung samples using the protocol described in Biswas et al. (2019). For blood and tissue samples we used standard DNA extraction protocols with appropriate precautions to avoid any cross contamination among samples.

Individual identification:

In the laboratory, a panel of 14 microsatellite loci were standardized for unambiguous individual identification of elephants. All the dung DNA samples were amplified to generate data at individual levels. Post data validation, identical genotypes from multiple samples (or recaptures) were detected using CERVUS (Kalinowski, Taper & Marshall, 2007). P_{IDsibs} (Probability of identity for siblings) was calculated using GIMLET (Valiere 2002). P_{IDsibs} refers to the probability that two siblings drawn at random from a population will have the same genotype at multiple loci.

Genetic diversity indices

Using the 14 microsatellite markers the overall genetic diversity of this elephant population was measured by calculating mean number of alleles (MNA), expected heterozygosity (H_e), observed heterozygosity (H_o), and allelic size range using ARLEQUIN 3.1 (Excoffier et al. 2005).

Spatial clustering analysis

To identify genetic structure (or population subdivision) among the elephant individuals, a multivariate analysis in the form of discriminant analysis of principal component (DAPC) (Jombart 2008) was performed.

4.3 Results

A total of 258 elephant dung samples were collected during the sampling period from the study area (Figure 1). Additionally 10 tissue samples and four blood samples of elephants were collected from the Tamor Pingla rescue centre. Tissue samples were used for standardizing genetic markers.

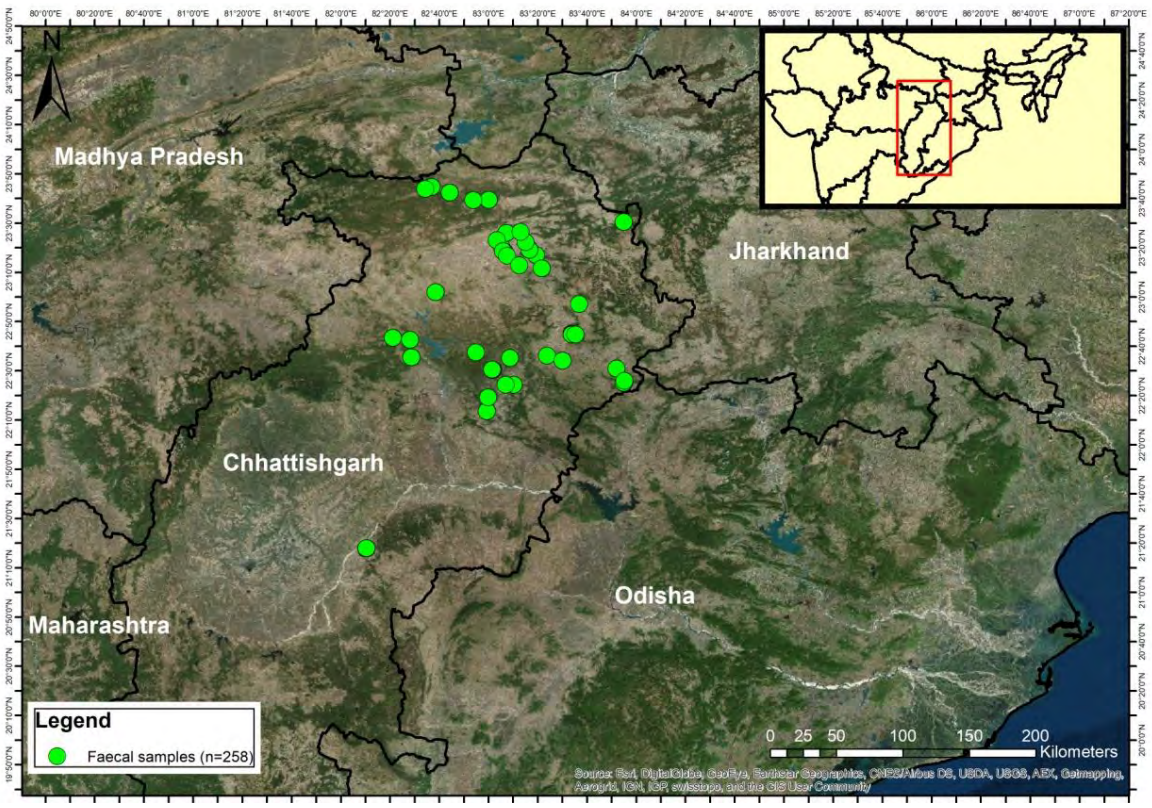

Figure 4.1: Description of study area and sampling locations

did not provide sufficient data in genotyping and hence were discarded from downstream analyses. The remaining 209 samples were used for further analysis. Out of these, 76 samples were found to provide 11-14 loci data and were selected for individual identification**. Using 14 microsatellite loci we identified 55 unique individuals with 21 recaptures from the dung samples. Our subsequent analyses showed that elephant population in Chhattisgarh has moderate genetic diversity, with mean number of alleles of 7.5±1.9, expected heterozygosity (H_e), observed heterozygosity (H_o) and allelic range of 0.72885±0.09971, 0.34947±0.15559 and 20.929±10.866 respectively (Table 4.1).**

Table 4.1: Genetic composition of elephant population in Northern Chhattisgarh

Sl. No	Locus	MNA	Allelic range (bp)	H_o	H_e	P_{IDsibs}
1	EMX-2	4	9	0.58824	0.60513	5.10E-01
2	LafMS03	7	14	0.56604	0.73872	2.10E-01
3	EMU03	8	18	0.33333	0.78228	8.06E-02
4	LafMS05	12	28	0.41667	0.82171	2.88E-02
5	Lat24	8	52	0.06061	0.82984	1.03E-02
6	Lat25	6	12	0.53704	0.49896	5.97E-03
7	EMU04	7	12	0.39216	0.75189	2.42E-03
8	FH103	9	24	0.28571	0.74182	9.85E-04
`9	FH94	8	22	0.22727	0.75131	3.99E-04
10	LafMS02	10	18	0.35417	0.7568	1.59E-04
11	LA6	5	20	0.23077	0.5435	8.73E-05
12	EMU17	8	34	0.10811	0.80415	3.25E-05
13	EMU15	7	18	0.3125	0.79276	1.22E-05
14	FH60	6	12	0.48	0.78505	4.68E-06
Mean		7.5	20.929	0.34947	0.72885	
S.D.		1.955	10.866	0.15559	0.09971	

Further spatial clustering analysis identified two genetic clusters of elephants in the study area (Figure 2). **This result indicate two genetic lineages of elephants present in Chhattisgarh.** However, the lineages does not seem to be spatially segregated indicating that although they are genetically differentiated they occupy the same area. More effort is required to understand the reasons and possible implications of this patterns in this landscape.

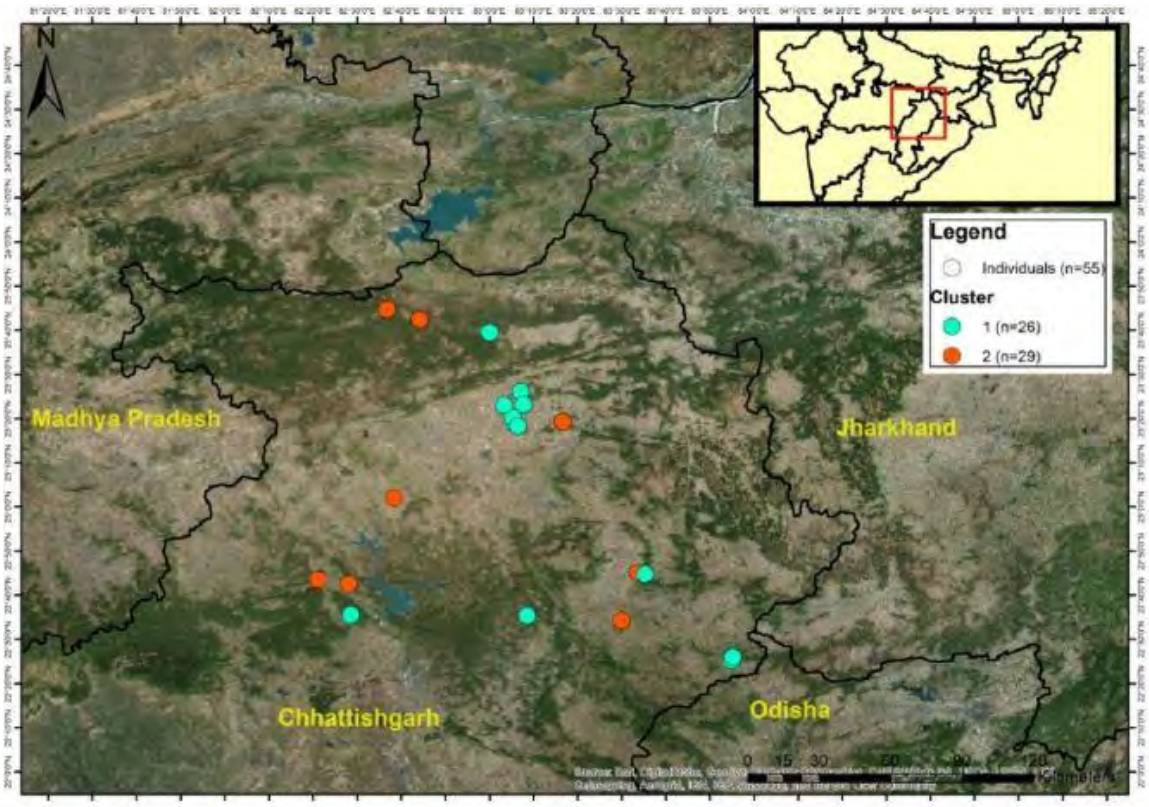

Figure 4.2: Elephants population in Northern Chhattisgarh showed two genetic clusters

Chapter

5

Miscellaneous Activities

Our field research team based out of Chhattisgarh and scientists based out of Dehradun – our headquarters, actively participate on range of elephant management issues across the state. Many of these are need based. Most of the issues are of priority in nature and case-specific reports pertaining to such activities have been submitted to the officials concerned then and there.

5.1 Training and welfare of captive elephants in Pingla elephant rescue centre

The field research team have been working closely with mahouts from both Tamil Nadu (who have come to train elephants and mahouts in Chhattisgarh) and Chhattisgarh on issues pertaining to training of captive elephants for activities such as kumki operations (involving drive and capture of wild elephants). This frequent liasioning, helped in initiating the use of captive elephants for patrolling and monitoring purposes in Tamor Pingla Wildlife Sanctuary and for managing conflict situations in other sites.

The team has been helping the rescue centre authorities in health monitoring of elephants through frequent visits and during May 2019, a one-day health camp was organized by WII at Pingla elephant rescue centre. A detailed report in this regard was provided to the management.

Figure 5.1: Scientists and veterinarians from Wildlife Institute of India visited the Pingla elephant rescue center to investigate the health status of captive elephants, treat them and provide inputs to mahouts for elephant welfare.

5.2 Advisory role during emergency conflict situations

Conflict situations at times get acute with back-to-back human casualties, continuous damage to property and others culminating in to a crisis situation that warrants intensive monitoring and technical assistance. Such situations did emerge a few times in Surajpur, Korba and Dharamjaigarh Forest Divisions during the year. Our field research team closely worked with the divisional staff in handling the situation. Activities broadly include tracking elephants involved in conflict, advising management on appropriate conflict management strategies and training personnel. Such intensive engagement with site-specific problems usually span many days.

5.3 Capacity building and on-site training of forest officials and staff in animal tracking, capture and collaring

During the four phases of elephant collaring activities that involved pre- and post-collar monitoring of elephants in the field, planning and execution of logistics, documentation and data management, many frontline staff from the forest department and their volunteers were field-trained. The FD staff accompanied our field research team and expert trackers and gained first-hand exposure on radio-tracking elephants using hand-held VHF receivers. The newly appointed Game guards were trained in the theoretical nuances of radio-tracking and subsequent spoor tracking in the field.

In addition to field training in tracking elephants, office personnel were trained in downloading and visualizing satellite data. We must say that many field staff took to the joy of radio-tracking elephants, while at the same time understanding aspects of animal behavior as well. Developing these skills is crucial for managing elephants and handling emergency situations in the field.

5.4 Testing efficacy of early-warning systems

During the period, we have hosted an engineer Mr. Daniel from M/s. Savannah tracking in Kenya who supplied our satellite collars to test the utility of Early-Warning Apparatus that work on UHF (Ultra-High Frequency) technology. The apparatus were tested with collars fitted on two of our elephants CGM001 and CGM003 in Surajpur and Balrampur FD during December 2018. The experiment results were positive – in that the Early-Warning Apparatus were able to pick signals from the collared elephants. However, the range of detection was too less and thus, cannot be used as such for conflict mitigation. We are working with the collar maker to explore the possibilities of integrating Geo-Fencing approach with the collars. Under Geo-Fencing approach, an alert in the form of SMS will be sent to registered mobile numbers whenever elephants enter human-use or “no-go” areas.

Figure 5.2: Team of researchers from Wildlife Institute of India, together with front line staffs of Forest Department testing the Early Warning

5.5 Technical assistance during necropsy of elephants

During the one-year period, we have attended four cases of elephant necropsy – three in Surajpur and one in Tamor Pingla WS by coordinating with local veterinarians in assessing the causes of casualty and other details.

5.6 Partnering with Chhattisgarh Forest Department to conduct Central Regional Workshop on elephants

We helped the officers of the state by contributing in preparation of agenda for discussion of issues facing elephant management in Chhattisgarh during the visit of authorities from MoEF&CC. Our scientist has also made a presentation about our activities at Raipur workshop. WII was instrumental in developing action plans for the Department.

5.7 Technical collaboration with ISRO

During this year, WII actively worked with ISRO, which developed 10-m resolution land-use land-cover (LULC) layers and software to visualize and download movement data. The LULC layers have been provided to Surguja Circle for mapping and other GIS purposes.

5.8 Building regional capacity for scientific research on elephant

During the year, we guided a student of MSc in Wildlife Science from WII, Mr. Kushagra Mesharam, who pursued his thesis work on “patterns of habitat use by elephants in Surajpur FD”. Mr. Kushagra is

from Raipur. During the period, Ms. Ambalika, an environmental law student from Ambikapur interned with us. She worked on understanding the socio-economic aspects of human–elephant interactions in Surguja. Another student, Mr. Atul Kumar who is pursuing his Bachelor's degree in Forestry from Guru Ghasidas Vishwa Vidhyalaya did internship with us for a month to understand elements of field research such as radio tracking and others.

5.9 Other training programs

1. Based on the recommendations of CCF & FD, Udanti Sitanadi TR and CCF, Eco-development and planning, Raipur, our field research team went to Sanjay-Dubri and Bandavgarh Tiger Reserves and imparted training to the field staff for one day each. Wild elephants have recently moved into these two tiger reserves in Madhya Pradesh from the neighboring state of Chhattisgarh.

Figure 5.3: Advisory and training session for field staff in Sanjay-Dubri Tiger Reserve

2. During the year, we have conducted two training programs on elephant ecology and aspects of conflict for the newly appointed Game Guards at the JFM School, Ambikapur.

3. Capacity building of field veterinary officers in the area of Wildlife health management, including wild animal immobilzation and restraint. Dr. Chandra Kumar Mishra, veterinary officer Surajpur participated in the International training program titled "Interventions in Wild Animal Health (IWAH) – 2019" at Sariska Tiger Reserve between 27th January to 15th February 2019, jointly organized by Zoological Society of London, University of Edinburgh and Wildlife Institute of India.

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Chapter

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Chapter 23

Capture and translocation of gaur (*Bos gaurus*) in India

Parag Nigam, Sankar Kalyansundaram, Dave Cooper, Les Carlisle and Harbhajan Singh Pabla

Introduction

The gaur (*Bos gaurus*), also known as the 'Indian bison', inhabits a wide variety of habitat across South and Southeast Asia, with a presence in three disjoint regions: southwestern India, central India and northeastern India (including Nepal, Bhutan and Bangladesh) (Choudhury 2002a). The habitats broadly include the tropical wet evergreen and semi-evergreen forests in the Western Ghats; tropical moist deciduous and dry deciduous forests in Central India; and tropical evergreen, semi-evergreen, subtropical broadleaf, dry deciduous and temperate broadleaf forests in northeastern India (Hussain & Khader 1969; Johnsingh 1979; Choudhury 2002a). Though gaur were once widely distributed across India, there has been a decline in their number and range, which has been primarily attributed to habitat destruction, poaching, predation – especially at calf and subadult stage – disease, insurgency, straying and various developmental activities (Imam 1985; Choudhury 2002a, 2002b).

The turn of the twentieth century witnessed a remarkable decrease in the population densities, as well as local extinctions of gaur from some protected areas (PAs), namely Bandhavgarh Tiger Reserve (BTR) and Sanjay Gandhi National Park in Madhya Pradesh; Thattakad Wildlife Sanctuary in Kerala and Kanger Valley National Park in Chhattisgarh (Sankar *et al.* 2001). These known extinctions have happened in a relatively short span of time and have necessitated urgent measures to revive the populations. The possible solution besides habitat improvement, habitat connectivity and law enforcement involves active management of the species by reintroduction, or replenishing them in vacant suitable habitats.

Bandhavgarh Tiger Reserve, located in central India, with its tropical dry deciduous forest, provides an excellent habitat for the gaur. Though the reserve supported a small population of gaur (38 individuals) till 1995, the population disappeared between 1995 and 1998 due to unknown reasons. As a part of the conservation initiative, an attempt was made to establish the species in its historical range at BTR, from where it had been extirpated. The IUCN/SSC Guidelines for Reintroduction (IUCN 1998) formed the basis for these translocations. These guidelines propose establishment of 'a viable, free ranging population in the wild of a species, subspecies or race, which has become globally or locally extinct' as the goal for reintroduction programmes.

The objective of the project was to enhance the long-term survival of the gaur; to maintain and/or restore natural biodiversity of BTR, and also to provide long-term economic benefits to the local and/or national economy, to some extent.

In all, 50 gaur – 36 females and 14 males – were captured from Kanha Tiger Reserve (KTR) and translocated to BTR during January 2011 and March 2012. The animals had to be transported approximately 250 km by road and required 8–10 hours of travel time to reach BTR. This was the first successful mass capture and relocation of gaur carried out in India.

Preparatory phase

The initial phase of the project started in 2006–2007 and included carrying out a feasibility study to establish ecological requirements relevant to gaur; assessing the availability of food, cover and water during lean periods at BTR; evaluation of protection strategies against anthropogenic factors (human disturbances, interaction with domestic livestock, poaching) in BTR; identifying source for founder stock, developing an action plan and veterinary protocols for gaur capture and translocation and getting necessary administrative approvals and permissions for capture and translocation.

Analysis and simulation of gaur population viability analysis (PVA) at BTR was assessed using the software VORTEX 9.50 (Lacy *et al.* 2005) under different scenarios (Pabla *et al.* 2011). The simulation of scenarios indicated reintroduction of 50 animals with a sex ratio of 60% females and 40% males at a time, or reintroduction of 20 animals with same sex ratio and subsequent supplementation of another 30 at an interval of ten animals every two years. The overall objective was to maintain a viable population of approximately 50+ animals at BTR.

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Infrastructure and logistics

The project started with the design of a specialized, compartmentalized transport truck with dimensions suiting to the animals' needs. The major considerations included adequate ventilation, proper flooring and escape-proof doors and locks. Simultaneously, efforts were made to design a stretcher with suitable provision for weighing and carrying immobilized animals from the site of capture to the loading vehicle. A holding boma with a loading ramp was constructed at the site of capture in KTR to hold animals prior to loading on to the transport truck. As the project involved soft release of animals in BTR, a 50 ha enclosure with good vegetation, cover and water was selected and enclosed with a powered fenced.

Capture timings

Winter months (January to March) were selected as the time for the capture of animals as they coincided with the animals coming down from hilly areas to plains, thereby provided optimum temperature conditions for the capture and drier grounds for vehicular access. Capture and translocations were timed to coincide with the cooler hours of the day (below 25 ° C) to avoid heat-related complications (Dinerstein *et al.* 1990; Caulkett 2001). Morning captures were advantageous as the animals have limited rumen contents during early morning hours, thereby potentially decreasing the chances for tympany and regurgitation. It also decreases the chances for passive regurgitation, thereby preventing the potential occurrence of aspiration pneumonia (Curro 2007). Another important consideration during captures was to time the capture operation and movement of the animals in such a manner that the animals could be offloaded without any delay upon arrival at the release site.

Selection of animals

It was envisaged that 20 gaurs were to be captured for initiating a population at BTR. Kanha Tiger Reserve was identified to provide the source population for the reintroduction programme as the area had a well-established gaur population of 1600+ animals in 2006 (Pabla *et al.* 2011). Apparently healthy animals in different age and sex classes from spatially distinct areas were selected. Care was taken to avoid capture of old, pregnant and lactating females with calves, taking due care not to disturb herd dynamics. The animal herd was located during the early hours of the morning and subsequently approached using captive elephants (Figure 23.1). The herd was usually not disturbed by the close approach of captive elephants and the animals could be approached up to a distance of 15–20 m, though with caution. Captive elephants were used to gently push the herd into open areas that had access to the loading vehicle. Captive elephants could efficiently hold the animals within the herd and guided the darted animal away from waters or difficult terrain. This was important as the entire herd became cautious and excited if any member was sneaked out of the herd.

Capture procedure and immobilization

Drug delivery

Remote drug delivery was facilitated using all-plastic darts delivered through an air-pressurized Dan Inject (Model JM) projector. Selection of the dart projector was based on proven

Figure 23.1 Gaur herd being moved into open areas using captive elephants (photo by Ujjwal Kumar Sinha, WII). A black and white version of this figure will appear in some formats. For the colour version, please refer to the plate section.

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Figure 23.2 Identified Gaur darted within the herd (photo by Ujjwal Kumar Sinha, WII). A black and white version of this figure will appear in some formats. For the colour version, please refer to the plate section.

accuracy, compactness, easy manoeuvring on elephant back, low weight, minimal traumatization and negligible disturbance of the animal. Though the effective range of the equipment is up to 60 m, the majority of animals were darted from a distance of <15 m. All the animals were darted in the hindquarters as the area provides good muscle mass for efficient drug delivery (Figure 23.2). Plastic darts of 3 ml capacity were used and the needle length was 40 mm.

Criteria for drug dosage calculations

Body health condition, physiological status, age and estimated weight were considered while determining the drug dosage. Correlation between drug dosage and body weight has been proved to be important for several wildlife species (Harthoorn & Luck 1962; Pienaar & Van Niekerk 1963; Blane *et al.* 1967; Wallach *et al.* 1967; Yusof 1990). Weight of the selected animal was estimated based on published information and past experience and ranged between 250 kg and 800 kg for subadults and adults (Curro 2007).

Drugs for immobilization

The detailed published information on immobilization drugs and medicaments for use in gaur are minimal (Armstrong 1989; Wilson *et al.* 1993; Napier *et al.* 2011). Gaur (*Bos gaurus*) immobilizations have primarily been carried out in the captive stock using opioids, α2-adrenoceptor agents and dissociative anaesthetics. Drug combinations comprising Immobilon® (etorphine hydrochloride)-xylazine (Wiesner *et al.* 1982); carfentanil-xylazine (Armstrong 1989; Wilson *et al.* 1993; Napier *et al.* 2011); thiafentanil-medetomidine (Napier *et al.* 2011), tiletamine/zolazepam with or without xylazine (Wilson *et al.* 1993) and xylazine-ketamine (William *et al.* 2011) have been successfully used in captive populations. Free-ranging studies on Malayan gaur (*Bos gaurus laosiensis*) demonstrated effective use of Immobilon® (etorphine + acepromazine) alone and in combination with azaperone and Rompun® (Conry 1986).

The important concerns while selecting immobilizing drugs for use in free-ranging gaur in the operation were its appropriateness and local availability. The majority of drugs (opioids and neuroleptics) for use in gaur are not available in India. Their procurement and use required administrative clearances, approval and licence that required a considerable period of time.

As the immobilizations were to be carried out in a free-ranging situation, low drug volume, rapid induction and minimal knockdown time, availability of reversal drug and rapid recovery time were considered to be important criteria prior to selection. Opioids have been known to possess these qualities and hence were considered as the drug of choice for immobilizing free-ranging gaur (Haigh 1990). The ability to have immediate reversal of the immobilization has also proved to be valuable for their use (Wiesner *et al.* 1982). Etorphine hydrochloride and subsequently thiafentanil oxalate were used as primary drugs for immobilization. The procedures followed in either case are discussed later in the chapter.

Another important concern in capture and translocation of animals was to identify use of short- and long-acting tranquilizers to support capture and transport, and facilitate adaptation of the animal in the new environment. Studies have shown that capture, confinement, transportation or integration into a new herd or group are traumatic events and result in considerable excitement and stress to the animal. Animal may injure themselves, others in the group or may exhibit exhaustion with fatal consequences (Hofmeyr 1981; Ebedes & Raath 1999; Read *et al.* 2000; Read 2002). Long-acting tranquilizers have been

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effectively used in capture and transport, and produce calming in animals by moderating excitement and reducing aggression and motor activity (Ebedes 1993). Besides these, tranquilizers have aided the animal in adjusting to newer environments by appropriately addressing the issues of exhaustion that may result from constant pacing and loss of condition due to refusal to eat and drink (Read 2002). Phenothiazine derivatives (acetylpromazine, propionylpromazine, perphenazine enanthate, zuclopenthixol acetate), butyrophenones derivatives (azaperone, haloperidol) and benzodiazepines (flumazenil, sarmazenil) have been used in a variety of wild animals as tranquilizers (Ebedes 1993; Ebedes & Raath 1999; Kock & Burroughs 2012). Based on the published information and past experience of their use in South African ungulates, azaperone, haloperidol and perphenazine enanthate were identified to provide tranquilization to support captures and subsequent procedures in gaur.

Azaperone was used as an adjunct to primary anaesthetic to hasten smooth induction and recovery, and provides tranquilization support to the animal during the initial time of capture. The drug has also been reported to counteract some of the respiratory depression caused by opioids and has the advantage of lack of effect upon thermoregulation (Marsboom 1969; Haigh 1990). The sedative effect of azaperone has been reported within ten minutes after intramuscular injection, and the duration of the effect is up to 6–8 hours (Kaandorp 2005). Haloperidol, another short-acting tranquilizer, was preferred as a loading dose to prolong the sedative effect and provide effective sedation during transport that would be maintained by the long-acting tranquilizer. The drug has been used in a variety of ungulates (Blumer 1991; Curro 2007) with onset of action within 5–10 minutes that lasts for 8–18 hours (Curro 2007). Perphenazine, a long-acting tranquilizer given intramuscularly, provided sedative effect to the animals at the release site and during the adaptive phase in the release boma. The drug effect is slow and commences after 10–12 hours, and the duration of tranquilization is 7–10 days (Read *et al.* 2000; Curro 2007).

Capture and handling of gaur

During January 2011, a total of 22 gaurs were immobilized using a drug combination containing etorphine hydrochloride (9.8 mg/ml, Captivion^{TM}, Wildlife Pharmaceuticals (Pty) Ltd.) and azaperone (40 mg/ml, Stressnil®, Janssen Pharmaceutica (Pty) Ltd). Of these, 19 gaur were translocated to BTR. The dose rate for etorphine ranged from 0.007 to 0.012 mg/kg for all the animals with mean ± SD of 0.009 ± 0.001 mg/kg. Azaperone up to 100 mg was mixed to make up the 3 ml dart; however, in two subadult animals 60 mg of azaperone was used. Hyaluronidase (1500 IU, Hyalase®, Wockhardt, UK Ltd.) up to 2500 IU was concurrently added to the drug mixture during initial capture to increase the rate of absorption and reduce induction time; however, its use was subsequently discontinued owing to excessive excitement resulting from rapid and fast induction. Subadult animals required slightly higher dose of etorphine compared to adults.

Subsequent gaur captures during March 2012 were carried out using thiafentanil oxalate (10 mg/ml, Thianil^{TM}, Wildlife Pharmaceuticals (Pty) Ltd) at a dose rate of 0.007–0.013 mg/kg, with mean ± SD of 0.01 ± 0.001 mg/kg. The drug was mixed with 100 mg of azaperone in the 3 ml dart. Thiafentanil was selected owing to pronounced opiate agonist activity, rapid induction, less cardiopulmonary depressant effect (Napier *et al.* 2011) and quick antagonism by naltrexone (Wolfe *et al.* 2004). A total of 31 gaurs were successfully immobilized and translocated to BTR.

The animal was left undisturbed till proper induction for safe handling was achieved. The dosages of neuroleptic analgesic used were successful in bringing the animal into sternal or lateral recumbency. However, all the animals were assisted during induction by covering their eyes using blindfolds to avoid visual stimulation, plugging ears to avoid auditory stimulation (Figure 23.3), grasping both horns and hindquarters to restrain and rolling the animal back into sternal recumbency. The sequence of response to immobilization included initial excitement, poor coordination, aimless walking, a high-stepping "hackney" gait, extension of the head, dog-sitting position followed by dropping into sternal recumbency (Figure 23.4–23.5). Similar findings have also been reported for other species (Haigh 1990; Zainuddin *et al.* 1990; Napier *et al.* 2011; Kock & Burroughs 2012). Induction time after etorphine and thiafentanil ranged from four to seven minutes and two to five minutes, respectively, for all animals. However, two animals had longer induction following etorphine immobilization owing to animal excitement prior to darting and local disturbance during induction. The field study revealed that variation in induction time was influenced by drug dosage and use of hyaluronidase in the drug mixture. The dosing of animals was based on estimated body weight (Dinerstein *et al.* 1990; Zainuddin *et al.* 1990). The animal was said to be stable and adequately immobilized for safe handling when the animal showed minimal response to tactile stimulation of head and hindquarters and physiological parameters were within acceptable range.

The vital physiological parameters such as rate and depth of respiration, rectal temperature and pulse rate were monitored throughout the operation. During immobilization, the respiration was deep and regular for the majority of animals and ranged from 16–18 per minute following opioid sedation. However, in two cases marked respiratory depression with rates below 12 per minute was recorded. Supplementation of oxygen was helpful in stabilizing the animals. Rectal temperature ranged between 38.3 °C and 38.9 °C (101 °F and 102 °F), whereas the pulse ranged between 62 and 72 per minute in both cases. Hyperthermia did not occur with either immobilization. Besides this, engorgement of the ear veins and pink conjunctival/oral mucous membranes were good external indicators of cardiac and respiratory functions and were continuously monitored till the animals were crated.

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Figure 23.3 Plugging of ears and blindfolding of immobilized animal to avoid visual and auditory stimulation (photo by Aniruddha Majumder, WII).

Figure 23.4 Excitement and poor coordination during drug induction (photo by Parag Nigam, WII). A black and white version of this figure will appear in some formats. For the colour version, please refer to the plate section.

Supplementation of ketamine (100 mg/ml, Ketamil-100®, Troy laboratories, Australia) intravenously at doses of 0.10–1.0 mg/kg was beneficial in animals that were insufficiently immobilized as the drug acted fast and provided sedation levels safe for handling and carrying out further procedures. Ketamine (100–200 mg) given intravenously has been reported to be effective as a 'top-up' drug in animals that are not sufficiently immobilized by the opioid and sedative/tranquilizer mixture (Burroughs *et al.* 2012). The ketamine effect was noticed within 20–30 seconds after intravenous administration and lasted for about 10–15 minutes.

Partial reversal was achieved in an adult female that showed severe cardiac and respiratory depression (muscle tremors, collapsed peripheral veins, extension of head, slight regurgitation of gut contents) by administering 6 mg of butorphanol tartarate (2 mg/ml, Butrum-2®, Aristo pharmaceuticals, Mumbai, India). The drug was administered intravenously and provided immediate relief as manifested by resuscitation of respiration and improvement in vital physiological functions.

Maintaining the animal in sternal recumbency helped in decreasing the severity of hypoxemia and ruminal tympany

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Figure 23.5 Extension of head during drug induction (photo by Parag Nigam, WII). A black and white version of this figure will appear in some formats. For the colour version, please refer to the plate section.

(Curro 2007). At all times, efforts were made to keep the head of the animal high so as to avoid regurgitation of gut content into the trachea and to ensure patent airways. In case the animal was immobilized on a slope, the animal was immediately positioned in a manner that the head was positioned in the downward-most direction of the slope to allow the gut contents to flow out of the oral cavity and decrease chance of aspiration. The oral cavity was inspected for any blockages.

Following stabilization, the animals were gently pushed over onto the stretcher and maintained in sternal recumbency. The animals were secured using ropes and the stretcher was moved onto the loading vehicle (Figures 23.6–23.7) for either taking them to boma or directly loaded onto the transport truck (Figure 23.8). The animals were radio-collared for subsequent monitoring at the release site. Subsequently, biological sampling for health assessment, disease screening and genetic studies was done. Intra-dermal tuberculin testing, taking body measurements and filing of horn tips to avoid injury during transport were also part of routine procedures. The dose was based on the body weight and each animal received an additional injection of antibiotic to counteract secondary infections, as well as vitamin and mineral supplements.

The length of immobilization required to carry out these procedures varied from 11 to 26 minutes, except in two cases where the immobilization time was more (34 and 43 minutes). This was attributed to long induction time due to animal excitement, local disturbance and a long distance to the loading truck. The animals were then transferred to the transport truck, positioned in sternal recumbency and administered with the antidote.

Naltrexone (50 mg/ml, Trexonil^{TM}, Wildlife Pharmaceuticals (Pty) Ltd) was administered as an antidote to negate the effect of both etorphine and thiafentanil. The drug was given in the ratio of 20:1 and 10:1 of etorphine and thiafentanil, respectively, either intravenously or intramuscularly. Signs of recovery included twitching of ears, holding up of head and movement of limbs, which occurred within 1–5 minutes after intravenous administration. There was no renarcotization noted in any of the animals and all the recoveries were smooth and uneventful.

Once the animals were crated, they were left undisturbed to settle. The animals were subsequently moved during evening hours. The transport truck carried 4–5 animals during each trip. Care was taken to keep the adult bull and cow with calf in separate compartments during the journey to avoid aggression and minimize transport stress to the mother and calf.

Late evening hours were selected as they ensured movement during cool hours, minimized disturbance due to humans and vehicles on the road during the night and also allowed for timed early-morning releases at BTR. Special care was taken to maintain uniform speed during the journey, with speed adjusted to avoid sudden jerking and huddling together of animals. The animals were monitored throughout the journey to ensure they were comfortable and did not injure each other. Most of the animals were calm during the journey and did not display any overt signs of distress. The distance between Kanha and Bandhavgarh was approximately 250 km and it took an average of 8–10 hours to reach the release site.

During the January 2011 captures, one adult female was revived immediately after capture as a young calf was seen following her after darting, whereas another female was immobilized again for loading on to the container as she resisted leaving the boma even after repeated efforts. A subadult female died as a result of aspirating rumen contents. The animal

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Figure 23.6 Animal loaded on to the stretcher, being taken to the loading truck (photo by Aniruddha Majumder, WII).

Figure 23.7 Animal loaded on to truck for transport to boma (photo by B. Navaneethan, WII).

aspirated while in lateral recumbency and before the body position could be corrected.

A total of 51 immobilizations were carried out at KTR. Of these, 19 animals – comprising three subadult males, six subadult females, ten adult females and two adult males – were successfully translocated to BTR during January 2011 and seven subadult males, 13 subadult females, nine adult females and two adult males were successfully translocated to BTR during January 2012.

Gaur release at BTR and subsequent monitoring

The gaurs were brought in batches and released in a 50 ha power-fenced enclosure at BTR for acclimatizing in the new area, which provided ample food, water and shelter. The herd was finally released into the wild after one month. To study the home range, habitat use and food habits of reintroduced gaurs, in total 27 gaurs (six males and 21 females) were radio-collared

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Figure 23.8 Loading of immobilized gaur directly into the transport container (photo by B. Navaneethan, WII).

Figure 23.9 Gaur herd at Bandhavgarh Tiger Reserve after the release in wild (photo by B. Navaneethan, WII). A black and white version of this figure will appear in some formats. For the colour version, please refer to the plate section.

(GPS/Argos/VHF). The collared animals were tracked intensively through 'homing in' and 'triangulation' techniques (White & Garrot 1990).

Till March 2012 the gaurs reintroduced during January 2011 ranged over an area of 268.7 km^2. The annual home ranges of the males and females were 254.4 km^2 and 200.4 km^2, respectively.

The group size was found to be fluid, ranging from 1 to 19 individuals (Figure. 23.9). The two gaur bulls were found solitary on many occasions, but joined the family groups after 2–3 days. In total, 68 plant species were recorded as food plants of gaur, which included 28 trees, six shrubs, ten herbs, 21 grasses and three climbers. Among the initial reintroduced stock there were three mortalities, two attributed to natural deaths (both adult females) and one subadult female was predated by a tiger. One uncollared female went missing from the park. There were three births, two from the first reintroduced stock and one from the second stock of animals. The present population of gaur in BTR is 50.

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Evaluation of Prey Availability and Habitat Suitability for Tigers and its Ranging Patterns in Sanjay Tiger Reserve, Madhya Pradesh

FINAL REPORT

भारतीय वन्यजीव संस्थान
Wildlife Institute of India

June 2017

Evaluation of Prey Availability and Habitat Suitability for Tigers and its Ranging patterns in Sanjay Tiger Reserve, Madhya Pradesh

Final Project Report

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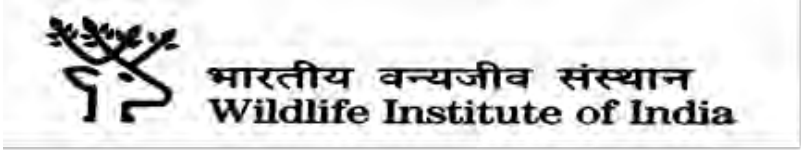

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ABSTRACT

Tiger conservation in human dominated landscape such as Sanjay Tiger Reserve (STR) has always been challenging for the managers and conservation planners. Anthropogenic factors have affected the area negatively, causing habitat degradation, depletion of prey base and unviable tiger population. STR is considered to be low density tiger population area and require recovery strategy, involving translocation from other areas, since natural colonization is not possible to boost the population to viable state. As a precursor to active population recovery, the project was conceived and implemented to establish baseline on prey availability and habitat suitability for tigers, which also involved understanding ranging patterns of tigers using radio-telemetry.

Prey availability in terms of density of wild ungulate was estimated and was found to be low (8.2 ± 0.8 animals per Km^2), but there is an increasing population trend during the study period (2014-2017), largely owing to active protection measures. Amongst the wild ungulates, density of chital was the highest (3.0±0.6/km^2) followed by wild pig (2.0±0.6/km^2), nilgai (1.8±0.3/km^2), chinkara (1.1±0.3/km^2) and four horned antelope (1.0±0.4/km^2). Livestock (11.6±5.5/km^2) was the most abundant animal using the reserve throughout, also contributing to prey base to some extent. Home range of one radio-collared adult male tiger was estimated to be 208.6km^2 during May 2015 to July 2015 and the animal got killed to a territorial fight with another male tiger. Similarly, home range of radio-collared (captive-raised) tigress was estimated to be 154.1 km^2 during October 2016 - May 2017. Exploring large areas could be attributed to limitation of mate choice and a depleted prey base. Habitat suitability of tiger was assessed based on habitat covariates and it was found that 44% of the total area of tiger reserve is potential suitable habitat in the current status of prey availability, but the suitability can increase to 61% if prey base can be restored in other areas of the reserve.

Carrying capacity of tiger was determined for STR based on the current prey density. It was found that STR can support 11 tigers in this present situation. Population Viability Analysis (PVA) with the carrying capacity of 11 tigers and current population (four individuals, one adult male, two adult females and one juvenile) of tiger in STR showed a poor survival probability (0.12 ±0.03) over a time span of 25 years. However, given the availability of habitat space and potential to increase prey base, doubling of carrying capacity from 11 to 22 tigers is possible with a supplementation of two tigers in every three years until year ten and it will ensure very high survival probability (0.87±0.03). Active recovery strategy should target the futuristic carrying capacity and management actions would have to be geared towards this. In this context, active population recovery and long-term monitoring strategy has been proposed towards successful population recovery and establishment of viable tiger population, along with other habitat covariates.

1. INTRODUCTION

1.1 Context

Species do not occur uniformly over space, they are often found in patches influenced by other local and landscape factors that provide them with the suitable environment for their survival and multiplication. Population influx and out flux caused by individual immigrations and emigrations determine the viability of a population (Bowers and Matter 1997). This perspective is clearly relevant when considering species such as tiger (*Panthera tigris*) that occupy large home ranges utilizing variedly distributed habitat and prey species populations. Based on a number of studies it has been established that when tigers are protected from poaching they tend to thrive in landscapes that have an abundance of wild prey. Relatively disturbance free and large areas linked by a number of corridors (Smith *et al*. 1998, Karanth *et al*. 1999, Sunquist *et al*. 1999, Seidensticker *et al*. 1999, Wikramanayake *et al*.1998, 2004, Johnsingh *et al*. 2004, Sanderson *et al*. 2006, Jhala *et al*. 2011). Habitat fragmentation has become one of the main factors for the change in the tiger‘s landscape (Smith *et al*. 1998). The geographic range occupied by tigers has declined by 40% in the last decade and is only 7% of their historic range today (Dinerstein *et al*. 2007, Sanderson *et al*. 2006). Conservation efforts such as _Project Tiger‘ have been attempting to arrest the decline in populations of tiger, their prey and habitats, very rarely do most of these reserves have long term conservation of these populations (Woodroffe and Ginsberg 1998, Johnsingh *et al*. 2004, Wikramanayake *et al*. 2004). The ever-expanding human population coupled with controversies over land tenure and local rights of the rural poor (Tharoor 2007), these reserves have become satellites interspersed within area of human land use (Johnsingh *et al*. 2004, Wikramanayake *et al*. 2004, Ranganathan *et al*. 2008).

Population decline of tiger relates to not only to anthropogenic caused, but also to reproductive success of the population, which depends entirely on the availability of suitable habitat space and sufficient prey base. In habitats, where surplus proportions of the suitable habitat is available and a good number of individuals are produced, any alteration in the habitat resulting due to natural or anthropogenic reasons immediately has an effect on the stability and survival of the population (Pulliam 1988; Pulliam and Danielson 1991). Hence, fragmentation, loss of habitat and increasing rate of habitat degradation resulting in loss of habitat quality, inadequate prey base, increasing the demand on forest based resources affect tiger conservation in India (Panwar 1987, Johnsingh *et al*. 1991). Habitat characteristics, tiger‘s requirements for prey, selectivity of different prey species and the habitat requirement of essential prey species are aspects needed to be addressed for effective management of populations. Therefore, evaluating the habitat in terms of habitat suitability and prey base availability were considered as in important first step for conservation management of tiger population in STR, and thus, this project was conceived and implemented, with specific strategy for active recovery and monitoring of the population and habitat in STR.

2. STUDY AREA

2.1 Overview

Sanjay Tiger Reserve (STR) is situated in the northeastern part of Madhya Pradesh (Fig-1) and is bordered by Guru Ghasidas National Park of Chhattisgarh. The park has a total geographical area of 1643.83km^2 consisting of Sanjay National Park and Dubari Sanctuary as core (831.25 km^2) and buffer area (812.58 km^2) in Sidhi and Shahdol districts of Madhya Pradesh. Core area is situated in the district of Sidhi and buffer zone cover parts of Beohari Tehsil (District Shahdol), Majhauli and Kusmi Tehsil of District Sidhi. The entire tract of the Core and Buffer of Sanjay Tiger Reserve is situation between 82 10‘ 48” to 82 14‘ 40” and latitude of 23 48‘ 57” to 23 49‘ 06”. It is a part of Bandhavgarh-Sanjay-Guru Ghasidas- Palamau landscape and has been identified as one of the potential tiger meta- population landscapes.

The plains lay in the catchment areas of river Gopad, Banas, Son, Hasdo, Mawai and their tributaries. There are plenty of rivers and *nulla* in and around the park and sanctuary area. Some rivers are perennial and some are seasonal, however water lasts only for 4-6 months‘ post monsoon period. Water shortage reaches acute levels in the years where rainy season falls much below the optimum annual rainfall. Apart from the natural water sources, there are some artificial water holes created by the management. Consequently, populations of tigers are confined to forest patches interspersed within protected area, multiple use forests, agricultural land and human habitation. Some parts are under severe anthropogenic pressure, so it is important to focus on the habitat and prey distribution and their influence on tiger population across the landscape.

The general topography of the reserve is hilly and undulating over greater portion especially towards plateau portions. The elevation of STR varies from 1400 to 2400 (425m to 732m) above M.S.L. The mean annual rainfall is 1303.00 mm. The normal fluctuations of the mean annual rainfall are expected to have the range of 1059.70 mm to 1277.10 mm. Annual Temperature is found to range between 41.8 ºC to 7.4 °C . Almost 95% of the precipitation is received from the South-East monsoon and a very small portion from the North- East Monsoon during winter. The relative humidity ranges between 80 and 90% during the monsoon period.

2.2Vegetation

According to ―Revised Classification of Forest type of India” by Champion and Seth (1968), the forest area of the STR comes under ―North Indian Moist Deciduous forest sub group 3C, with sub type moist Sal bearing forest – CZ with sub division moist peninsular Sal. The general type is 3C/CZ. Sal forest (*Shorea robusta*) is a dominant plant community both in the National Park and Dubari WLS, occupying about 80% of the entire area followed by Mixed Forest, Bamboo Forest, Bamboo-Sal mixed forest, Scrubland, and Grass land.

2.3 Faunal Attributes

Sanjay Tiger reserve is found to hold a variety of fauna. For its structural diversity and wide array of fauna, including the ‗key species' tiger (*Panthera tigris*), other prominent carnivores are leopard (*Panthera pardus*), jungle cat (*Felis chaus*), hyena (*Hyaena hyaena*), jackal (*Canis aureus*), Indian fox (*Vulpes bengalensis*). STR also supports sizable population of Slothbear (*Melursus ursinus*). The major ungulates that form prey for these carnivores are chital (*Axis axis*), nilgai (*Boselaphus tragocamelus*), sambar (*Rusa unicolor*), four horned antelope (*Tetracerus quadricornis*), chinkara (*Gazella gazella*), barking deer (*Muntiacus muntjak*) and wild pig (*Sus scrofa*). The grey langur (*Semnopithecus entellus*) and rhesus macaque (*Macaca mullata*) are the two primate species found in the tiger reserve.

2.4 Human settlements

There are 39 villages inside STR with a sizable population. The entire population depends upon natural resources for their livelihood including for fuel-wood, agriculture equipment, food security, minor forest produce etc. from both the buffer and core zone areas. The discontinuity in habitat due to interspersion of villages and agricultural areas in the matrix has resulted in isolation of habitats. The increasing human population in these areas adds additional pressure on the habitat. Livestock population in the area surrounding the Tiger reserve is very high, which poses serious problems of over-grazing, man-animal conflict issues, spread of invasive weeds and thereby a destruction of habitat.

3. OBJECTIVES

1. To evaluate the current status of prey base in STR
2. To assess the habitat suitability for tigers in STR
3. To study the ranging and spatial dispersal patterns of tigers using radio- telemetry
4. Equip the forest department staff at the ground level with enough knowledge resources so as to continue the monitoring of tigers in the park after the project is completed.

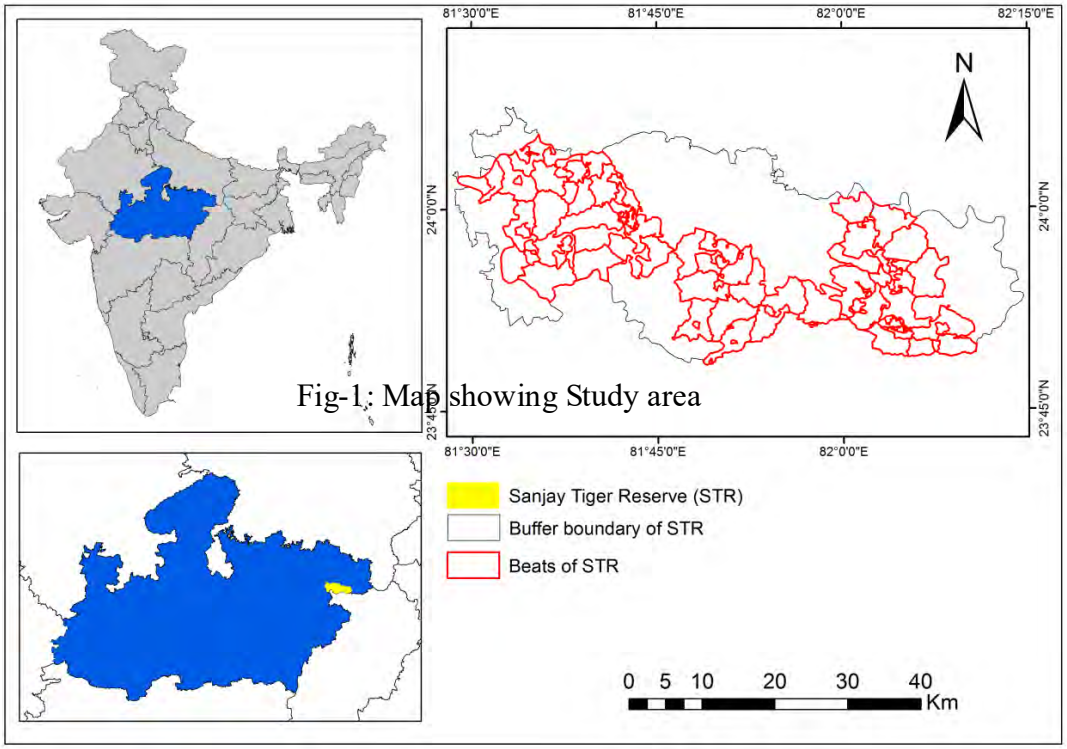

Fig-1: Map showing Study area

Fig-2: Map showing Study area

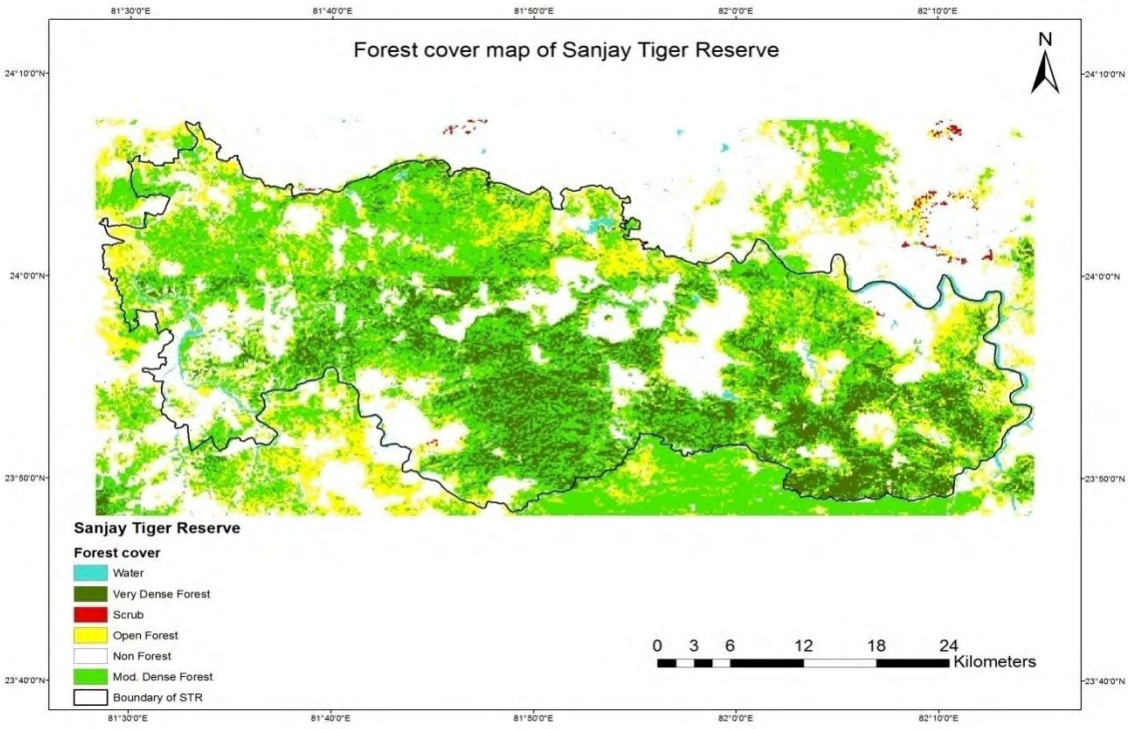

Fig-2: Map showing forest cover of Sanjay Tiger Reserve

4. OCCUPANCY AND ABUNDANCE OF CARNIVORES

4.1 Study design and methods

4.1.1 Carnivore sign survey

Carnivore sign survey closely followed All India Tiger Population Estimation and Monitoring Project (Jhala *et al*. 2011) and was carried out in selected beats during summer (March 2015- June 2015 and March 2016- June 2016) and winter (November 2014- February 2015, November 2015- February 2016 and November 2016- February 2017) to establish presence/absence of tigers and other carnivores. Sampling was carried out along forest roads, minor forest trails, river beds and streams. The signs observed were scats (old, fresh and very fresh), scrapes, rakes and pugmarks were recorded. A team of two persons along with a forest guard walked a trail of 15 km in three segments (spatial replicate) in each beat. Other parameters like GPS location, forest type, terrain type, elevation, sign type and conditions were recorded for every sign that was encountered during the survey. A total of 363.56 kilometers, 425.25kilometers and 491.48 kilometers were covered during November 2014 to February 2015, March to June 2015 and November 2015 to February 2016, respectively. During summer of March to June 2016 and winter of November 2016 to February 2017, 611.14 kilometers and 985 kilometers were covered throughout the core area of tiger reserve. The encounter rate for carnivore species was also calculated for different seasons. Occupancy estimation of four carnivore species namely tiger, leopard, sloth bear and hyena were analyzed using PRESENCE software (Hines *et al*. 2010, Mackenzie and Hines 2012) with a data string of 0‘s and 1‘s where 1 represents the presence of an animal whereas 0 indicates absence or non-detection, at a particular site (in this case a Forest Beat).

4.1.2 Camera trapping

To assess the abundance of tigers in STR, camera trapping was carried out in three sessions during winter (November 2014 to February 2015) and summer (March 2015 to June 2015) followed by another three sessions (November 2015 to February 2016 and March 2016 to June 2016) to cover the entire core area of tiger reserve. Camera trap sampling design was in line with the Phase IV protocol of All India Tiger Population Estimation and Monitoring Project (Jhala *et al*. 2011). The whole area was gridded into 4 km^2 area (2 * 2 km^2 grid) and one pair of camera was deployed in each grid. Each session was continued for 45 days. A total of 37, 33 and 35 locations were selected and camera traps were deployed during three consecutive sessions (November 2014 to June 2015) resulting in 1665, 1485 and 1575 trap nights, respectively. Similarly, 20, 111and 65 locations were selected and camera traps were deployed (November 2015 to June 2016). Out of 195 locations throughout the tiger reserve, data obtained only from 161 locations due to technical faults, theft and other logistic constraints. A total of 7245 trap nights in winter (2015-2016) and summer (2016) were sampled using 161 pairs of camera traps. In December, 2016, camera traps were deployed in 89 locations (pre-defined) to cover the

National park area of the tiger reserve which yielded 4005 trap nights. Photographs were downloaded regularly in the field using portable computer. Subsequently, individual identification was done using standardized methods and creation of matrices was done based on the photographs of both flanks of tigers.

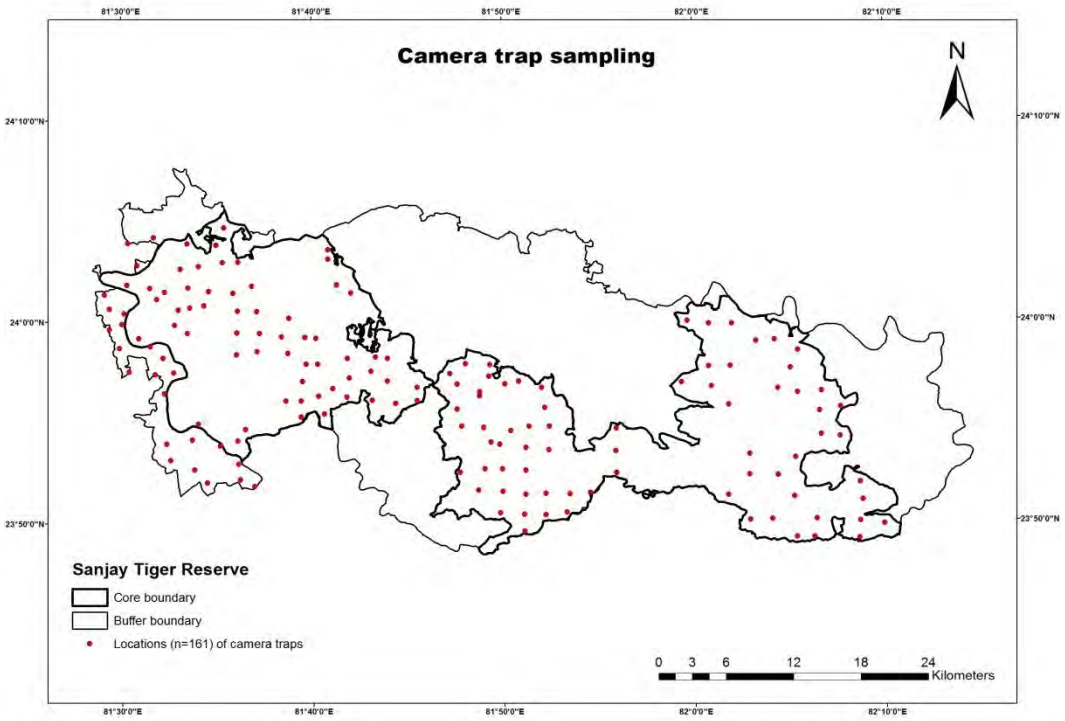

Fig-3: Map showing camera trap locations in Sanjay Tiger Reserve

4.2 Results

4.2.1 Carnivore sign survey

Encounter rate and proportion of sites occupied (psi) by tiger, leopard, sloth bear, hyena and other carnivores were calculated season wise and shown in Table-7 and Table-8. The encounter rate and psi value were found to be highest for sloth bear across the seasons. After sloth bear, leopard and hyena were found to be the widely distributed carnivores in terms of psi value. Proportion of site occupied by tiger ranged from 28% to 68%, indicating high uncertainly level and has very low intensity of space use (Table 1 & 2).

Species	Encounter Rate (No. signs/total distance surveyed)					
	Monsoon (2014) (72.11 km)	**Winter (2014-2015) (363.56 km)**	**Summer (2015) (425.22 km)**	**Winter (2015-2016) (491.48 km)**	**Summer (2016) (611.14 km)**	**Winter (2016-2017) (985 km)**
Tiger	0.11	0.03	0.02	0.05	0.02	0.05
Leopard	0.12	0.26	0.05	0.11	0.05	0.14
Sloth bear	0.45	0.49	0.39	0.57	0.64	0.26
Hyena	0.08	0.15	0.09	0.12	0.09	0.09
Wolf	0.01	0.03	-	0.01	0.01	0.01
Jackal	0.17	0.08	0.15	0.32	0.22	0.14
Jungle cat	-	0.03	-	0.12	0.02	0.02
Fox	-	0.04	0.01	0.02	0.01	0.01
Wild dog	-	-	-	0.01	-	-

Table-1: Encounter rate of carnivores in different seasons

Species	Winter 2014-2015	Summer 2015	Winter 2015-2016	Summer 2016	Winter 2016-2017
	Psi (SE)	Psi (SE)	Psi (SE)	Psi (SE)	Psi (SE)
Tiger	0.68 (0.21)	0.44 (0.29)	0.32 (0.1)	0.20 (0.09)	0.28 (0.06)
Leopard	1	0.52 (0.15)	0.81 (0.11)	0.59 (0.18)	0.63 (0.07)
Sloth bear	1	1	1	1	0.94 (0.03)
Hyena	1	0.98 (0.14)	1	0.74 (0.1)	0.79 (0.07)

Table-2: Proportions of site occupied by carnivores in different seasons

4.2.3 Population estimation of tigers

In total 11 tigers (four adults and seven cubs) are found in STR. However, during camera trapping, five tigers (Table- 9) were identified in the study area during November 2014 to June 2015. Out of five, two were adult females (T-001 and T-003) and three were adult males (T-002, T-004 and T-005). Two male tigers (T-002) and (T-004) were found dead during the above-mentioned period. T-001 died due to electrocution, while T-11 has been translocated from Bandhavgarh.

During November 2015 to June 2016, three adult tigers (Table-10) were identified based on camera trap photographs in the study area. Out of these, two were adult females (T-001 and T-003) and one was adult male (T-005). Two of the females T-001 and T-003 had given birth to eight cubs and the litter size was 5 and 3 respectively. The cubs‘ presence was confirmed by direct sighting, placing of opportunistic camera traps and pugmark tracking methods. Out of eight cubs, only five cubs attained the age to disperse. One adult female (T-001) was found dead

as a result of electrocution. During December 2016 to February 2017, two adult tigers were identified, of which one was a male (T-005) and another one was male cub (15 months old(T-013)) detected for the first time in STR.

Currently, during the ongoing the camera trapping session (March 2017-May 2017), three adult tigers (T-003, T-011 and T-005) were identified. T-011 is one radio-collared female tiger translocated from Bandhavgarh Tiger Reserve and was released into the wild about which details are provided in Chapter-5.

Apart from the identification of tigers, capture rates were determined for co-predators and prey species from each of the location of camera trap. Since prey density was found to be low in STR, due to poor detection in distance sampling method, capture rate could be useful to refelect the current status of prey base in STR.

Session	Camera trap locations	Trap nights	Number of tiger photographs	Number of individual tigers	Sex			
					Male	Female	Unknown	Cubs
I	37	1665	56	4	3	1	-	-
II	33	1485	18	1	1	-	-	-
III	35	1575	8	2	2	-	-	-

Table-3: Total number of tigers found in STR based on camera trap method (2014-2015)

Session	Camera trap locations	Trap nights	Number of tiger photographs	Number of individual tigers	Sex			
					Male	Female	Unknown	Cubs
IV	20	900	2	1	1	-	-	-
V	111	4995	5	1	1	-	-	-
VI	65	2925	109	6	1	1	-	4
VII	89	4005	11	2	1	-	1	-

Table-4: Total number of tigers found in STR based on camera trap method (2015-2016)

5. RANGING PATTERNS OF TIGER

5.1 Methods

Knowledge on home range and ranging patterns is a prerequisite not only to understand the biology of the species, but for the development of successful conservation action plan. To study the ranging patterns of tigers as a part of this project, an adult male tiger (P-212 or T-002) was radio-collared on 06.05.2015 by the team from WII with the support of Dr. Nitin Gupta, Veterinary Officer, Bandhavgarh Tiger Reserve (BTR) and Forest Department, Sanjay Tiger Reserve, under the leadership of Field Director. The animal was fitted with a Very High Frequency (VHF) radio-collar. Unfortunately the tiger was found dead on 19.07.2015 due to territorial fight with another adult male (T-005).Radiolocations of the aforesaid tiger were determined by ―Homing in" and ―Triangulation" from three to four known reference points (White and Garrot 1990).Coordinates of these reference points were taken with the help of Global Positioning System (GPS). A total of 38 locations were obtained from the collared tiger till 19.07.2015 to estimate the home range. Home range estimation was carried out using Hawth's tool in Arc Map 9.3. 100% minimum convex polygon (Mohr, 1947) method was followed to analyze the home range.

Subsequently, a sub-adult semi wild tigress was translocated from BTR to STR on 11.03.2016. Initially the tigress was released at Kanjra enclosure which was equipped with CCTV camera for intensive monitoring and kept there for the next seven months. On 18.10.2016, this female tiger (T-011) was captured, radio-collared and released into the wild by the team from WII with active support and cooperation of Dr. Abhay Sengar, Veterinary Officer, STR, Dr. Nitin Gupta, Veterinary Officer, BTR and the frontline staff of Forest Department, STR, under the leadership of Field Director. As a post release monitoring, 24x7 intensive tracking by two teams (one from WII and another from Forest Department, STR) was implemented. Radio locations (n=772) from October2016 to May 2017, were obtained and home range was estimated by the same technique mentioned earlier.

5.2 Results

Home range of the collared adult male tiger (T-002) was estimated based on 38 radio locations obtained from 8th of May to 19th of July were plotted on a map (Fig- 4). During this period, the animal had covered 208.62km^2 area within the Dubari Sanctuary, Sanjay National Park and buffer (Beohari) area of Sanjay Tiger Reserve, MP. The large homerange of the T-002 can be attributed to less number of breeding females and sub-optimal habitat in terms of substantially low wild prey base and high anthropogenic pressure in the study area.

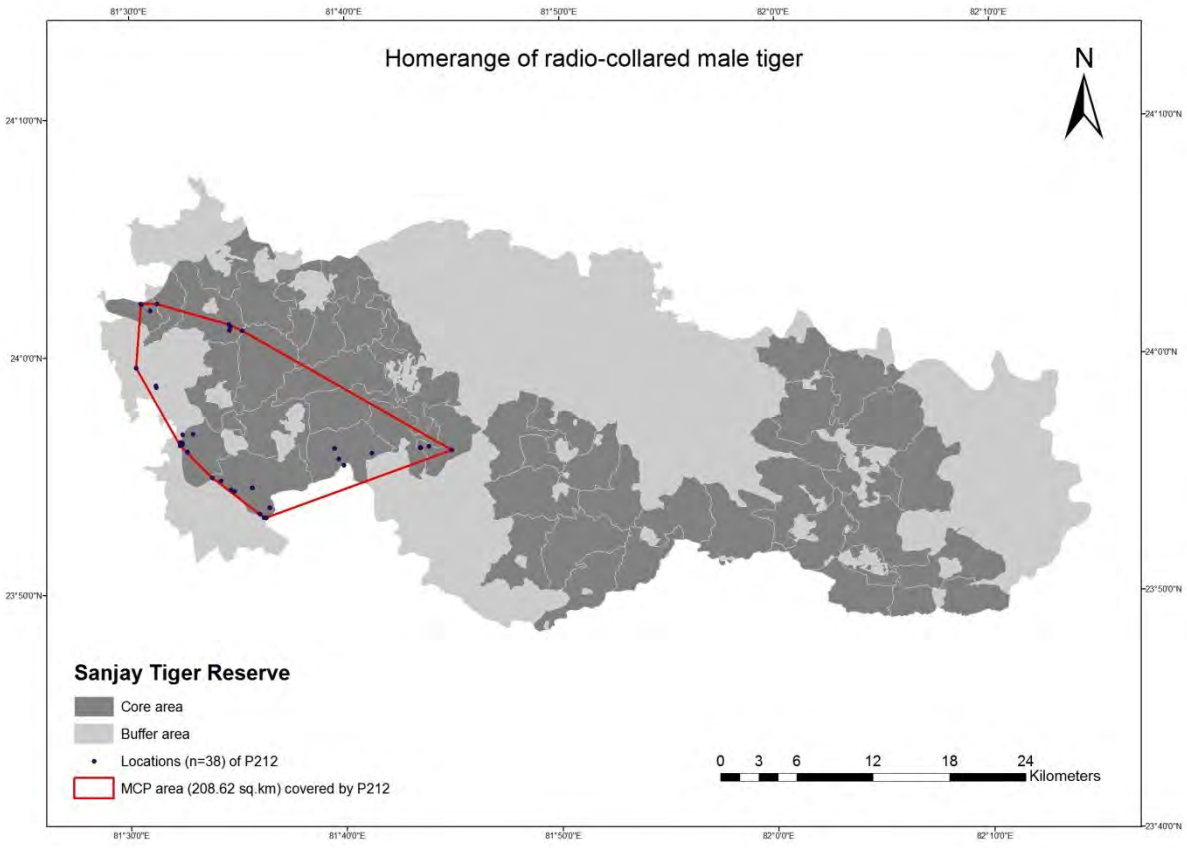

Fig-4: Home range of radio-collared male tiger (P-212)

Similarly, a total of 772 locations were used to estimate the home range of the radio-collared tigress (T-011). It was found that, during October 2016 to May 2017, the animal covered an area of 154.12 km^2 (Fig-6). The movement was mostly restricted to Dubari and Bastua Ranges of Dubari Wildlife Sanctuary. The large size of home range for a female tiger can be attributed to initial exploration done by the animal in order to establish its own territory and a low prey base with relatively high anthropogenic pressure persist in the study area.

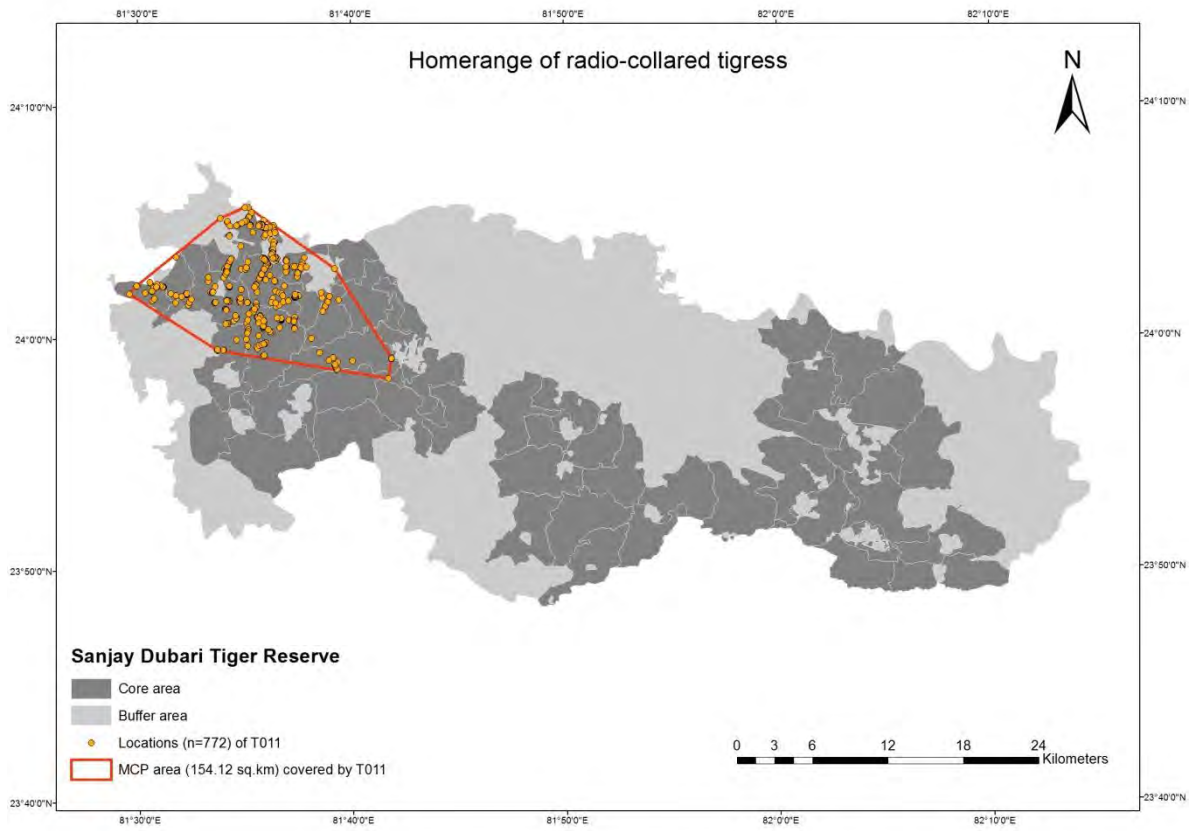

Fig-5: Home range of radio-collared tigress (T-011)

6. EVALUATION OF PREY BASE

6.1. Method

Population estimation of the prey species was carried out by using distance-sampling protocol (Burnham *et al.,* 1980, Buckland *et al.,*1993). A total of 44 transect lines (one line in each beat, Fig-4) were laid across the study area. It was ensured that these transects covered all the different habitats of prey species. The length of each line transect was fixed at 2kilometers, suited for efficient sampling for prey species in such habitats. Initially each transect was walked in the morning hours in between 6:00am to 8:00am and repeated (temporal replicate) for two more times in both summer and winter seasons. Since heavy underestimation in detection of livestock during morning hours, one replicate was walked in the early evening hours between 4:00 pm to 6 pm. During summer of March 2015 to June 2015 and March 2016 to June 2016, 29 and 43 line transects were selected and walked between 6:00am to 8:00am, respectively. During winter of November 2014 to February 2015, November 2015 to February 2016 and November 2016 to February 2017, 28, 44 and 55line transects, respectively were walked twice between 6:30am to 8:30am and 4:00 pm to 6pm. Altogether, the total effort on the line transect during the reporting

periods was 346 kilometers in summer and652kilometers in winter. The count included visual encounter of prey species along with group (cluster) size, sighting distance and sighting angles for each observation. Vegetation sampling and estimation of parameters such as ground cover, canopy cover, weed abundance, pellet count, human disturbance were also collected during the transects at an interval of 400m. Aforesaid plot sampling method was followed in each forest beat to estimate the status of prey distribution and densities and to evaluate habitat conditions including anthropogenic disturbance (Jhala *et al*. 2011). The Program DISTANCE 6.0 (Thomas *et al*. 2010) was used to estimate the density of prey species. The individual prey density and pooled density for all prey species were estimated, the half normal key function with cosine adjustment was the best fitted model for density estimation of all prey species. This was selected on the basis of the lowest Akaike Information Criteria (AIC).

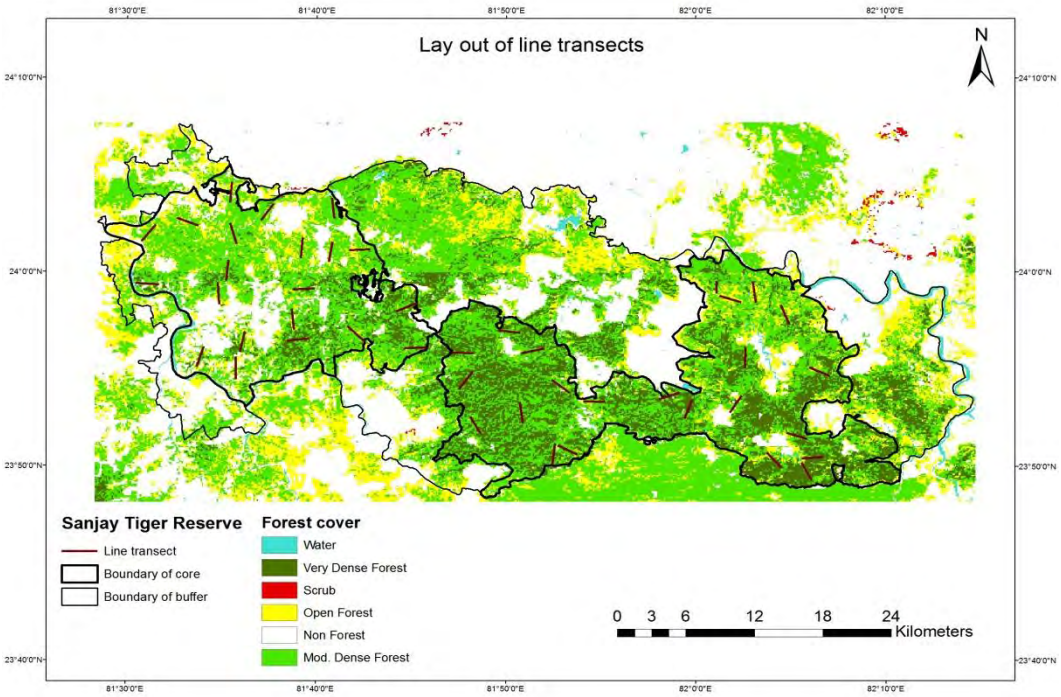

Fig-6: Map showing distribution of line transects in Sanjay Tiger Reserve

6.2 Prey density

The prey species in STR includes chital, sambar, nilgai, barking deer, four horned antelope, chinkara, livestock, grey langur and peafowl. However, for most of the species numbers of detection were found to be too low to estimate the density which can be reflected by the high standard error associated with density. Table 5-9 showed the year wise and season wise density estimates of wild ungulates, livestock and langur and lastly, table-10 showed the all over species wise prey density during the study period (2014-2017).

Species	AIC	Model	N	D	DS	% of CV		ESW
						D	DS	
Wild Ungulates	492.59	Half-normal – Cosine	52	2.83 ± 0.6	1.63 ± 0.3	24.47	22.62	71.68 ± 12.6
Langur	280.48	Uniform – cosine	34	25.89 ± 7.4	1.96 ± 0.4	28.59	21.46	38.88 ± 3.8
Rhesus macaque	60.61	Uniform – cosine	7	2.19 ± 1.3	0.38 ± 0.1	60.77	41.22	48.04 ± 9

Table-5: Prey density in 2015 (winter and summer)
AIC-Akaike information criteria, n-number of sightings, D-Density, DS-Group density, ESW-Effective strip width

Species	AIC	Model	N	D	DS	% of CV		ESW
						D	DS	
Wild Ungulates	690.75	Uniform – cosine	79	17.42 ± 3.0	5.75 ± 0.79	17.53	13.87	43.76 ± 3.56
Langur	511.45	Half normal – Cosine	57	17.66 ± 3.73	1.41 ± 0.24	21.14	17.20	49.75 ± 5.7
Rhesusmacaque	38.21	Uniform - Simple polynomial	6	4.58 ± 2.64	0.30 ± 0.12	57.54	40.32	24.14 ± 0
Livestock	181.75	Half normal – Cosine	21	11.60 ± 5.46	0.71 ± 0.27	47.08	0.27	36.20 ± 10.4

Table-6: Prey density in 2016 (winter and summer)
AIC-Akaike information criteria, n-number of sightings, D-Density, DS-Group density, ESW-Effective strip width

Species	AIC	Model	N	D	DS	% of CV		ESW
						D	DS	
Overall	301.78	Half-normal – Cosine	132	21.37 ± 3.51	4.06 ± 0.49	16.43	12.19	44.83
Barking deer	53.45	Half-normal – Cosine	6	0.25 ± 0.13	0.19 ± 0.09	52.31	50.37	44.16 ± 13.72
Livestock	0.00	Half-normal – Cosine	1	0.12 ± 0.12	0.00 ± 0.00	99.97	99.97	Nil
Chinkara	130.17	Half-normal – Cosine	14	0.51 ± 0.18	0.33 ± 0.11	35.97	34.23	59.00 ± 12.65
Chital	86.54	Hazard	9	0.37 ± 0.21	0.13 ± 0.07	55.82	52.52	95.16 ±

		rate – Cosine						33.64
Four-horned antelope	43.54	Half-normal – Cosine	5	0.46 ± 0.43	0.12 ± 0.13	95.31	72.56	38.66 ± 22.32
Black naped hare	50.29	Half-normal - simple polynomial	6	0.24 ± 0.14	0.24 ± 0.14	59.45	59.45	33.93 ± 9.84
Jungle fowl	10.33	Half-normal - simple polynomial	2	0.57 ± 0.64	0.57 ± 0.64	113.06	113.06	4.86 ± 4.31
Langur	467.96	Half-normal - simple polynomial	57	20.03 ± 4.94	2.18 ± 0.4	24.66	18.36	36.14 ± 3.72
Nilgai	220.29	Hazard rate – Cosine	23	0.82 ± 0.28	0.47 ± 0.14	34.14	30.84	67.49 ± 13.82
Rhesus macaque	54.07	Half-normal – Cosine	6	1.32 ± 0.78	0.18 ± 0.09	59.38	52.35	46.51 ± 11.47
Wild pig	40.14	Hazard rate – Cosine	5	0.80 ± 0.73	0.18 ± 0.12	91.35	66.39	36.39 ± 18.19

Table-7: Individual prey density in 2014-2015(winter and summer)

AIC-Akaike information criteria, n-number of sightings, D-Density, DS-Group density, ESW-Effective strip width

Species	**AIC**	**Model**	**n**	**D**	**DS**	**% of CV**		**ESW**
						D	**DS**	
All prey	301.78	Half-normal – Cosine	132	39.95	4.06 ± 0.49	16.43	12.19	44.83
Barking deer	54.27	Uniform – simple polynomial	6	0.23 ± 0.12	0.18 ± 0.08	51.59	49.70	56.09 ± 16.43
Livestock	49.24	Uniform – simple polynomial	7	7.34 ± 4.20	0.53 ± 0.27	57.26	51.90	21.92 ± 4.90
Chinkara	116.33	Uniform – simple polynomial	13	0.72 ± 0.26	0.36 ± 0.13	36.38	34.48	58.79 ± 12.89
Chital	153.18	Uniform – simple polynomial	17	1.69 ± 0.66	0.43 ± 0.12	39.15	27.49	65.64 ± 6.26
Black naped Hare	22.64	Half-normal –	3	0.26 ± 0.27	0.26 ± 0.27	105.97	105.97	18.91 ± 16.85

		Cosine						
Langur	382.46	Half-normal – Cosine	45	27.24 ± 6.48	1.75 ± 0.33	23.80	19.06	42.41 ± 4.58
Nilgai	186.07	Uniform – Cosine	19	0.84 ± 0.34	0.47 ± 0.18	40.97	37.81	67.00 ± 19.59
Rhesus macaque	54.14	Half-normal - simple polynomial	6	1.59 ± 1.20	0.21 ± 0.1	75.53	47.32	46.77 ± 11.72

Table-8: Individual prey density in 2015-2016(winter and summer)

AIC-Akaike information criteria, n-number of sightings, D-Density, DS-Group density, ESW-Effective strip width

Species	**AIC**	**Model**	**N**	**D**	**DS**	**% of CV**		**ESW**
						D	**DS**	
Wild ungulates	895.74	Half-normal – Cosine	102	18.81 ± 3.6	5.35 ± 0.93	19.50	17.50	48.63 ± 7.13
Langur	331.17	Uniform – cosine	39	29.76 ± 7.7	2.16 ± 0.38	26.08	17.91	45.89 ± 4.8
Rhesusmac aque	61.59	Uniform – cosine	8	4.01 ± 1.8	0.43 ± 0.1	46.62	34.06	46.98 ± 0

Table-9: Prey density in 2017 (winter)

AIC-Akaike information criteria, n-number of sightings, D-Density, DS-Group density, ESW-Effective strip width

Species	**AIC**	**Model**	**N**	**D**	**DS**	**% of CV**		**ESW**
						D	**DS**	
Sambar	30.14	Uniform /Cosine	4	0.12 ± 0.64	0.56 ± 0.27	51.04	49.82	43.30 ± 0
Chital	479.95	Uniform /Cosine	55	3.0 ± 0.62	0.64 ± 0.10	20.79	16.62	52.02 ± 3.97
Nilgai	636.64	Half-normal/ Cosine	68	1.84 ± 0.30	0.72 ± 0.10	16.77	14.19	57.12 ± 4.29
Chikara	482.03	Half-normal/ Cosine	53	1.14 ± 0.27	0.59 ± 0.13	23.88	22.88	54.39 ± 9.98
Four horned antelope	56.63	Uniform /Polynomial	7	0.95 ± 0.38	0.74 ± 0.27	40.17	37.52	57.11 ± 0
Barking deer	126.99	Uniform /Polynomial	15	0.15 ± 0.42	0.13 ± 0.33	26.89	25.38	68.93 ± 0
Wildpig	264.16	Uniform /Cosine	31	1.97 ± 0.64	0.46 ± 0.10	32.40	22.02	40.14 ± 5.15
Langur	1155.15	Uniform /Cosine	133	22.99 ± 3.13	1.79 ± 0.18	13.64	10.34	45.01 ± 2.6
Rhesusmac	169.71	Uniform	21	4.80 ± 2.23	0.39 ± 0.11	46.47	29.75	31.90 ± 6.63

aque		/Cosine						
Wildungulates	2090.47	Half-normal/ Cosine	233	8.18 ± 0.78	2.77 ± 0.21	9.62	7.74	50.96 ± 1.81

Table-10: Density estimates of all prey species during the study period (2014-2017)
AIC-Akaike information criteria, n-number of sightings, D-Density, DS-Group density, ESW-Effective strip width

7. HABITAT SUITABILITY ANALYSIS

Tiger, being a threatened species and in the need of conserving it, habitat evaluation could be considered a very first step towards a meaningful conservation (Kushwaha 2002). Habitat may be characterized by an array of the environmental features that are important for a species to survive. Such knowledge is often based on field experience and non-quantifiable human perceptions (Burgman and Lindenmayer 1998), which could be used to construct habitat suitability models (Pearce and Boyce 2006, Hirzel *et al*., 2006, Smith *et al*., 2007, Braunisch *et al.,* 2008). One of the widely used methods to evaluate suitability of a habitat for a particular species is habitat suitability index (HSI) modeling ((USFWS 1980, 1996, Burgman *et al*. 2001). HIS modeling can be helpful not only to evaluate the habitat suitability but also identify potential risks to the species, understand the implications of different land use practices and to identify sites for the reintroduction of an endangered species. This chapter explains a methodology that utilized Remote Sensing and Geographical Information System (GIS) and an extensive field survey to elicit habitat suitability of tiger in STR.

7.1 Material and Methods

7.1.1Spatial database:

The data collection involved downloading of Landsat 8 satellite image of 23rd Oct, 2016 (Image ID: LC81430432016297LGN00) from the USGS earth explorer. The boundary map of STR and other required data were collected from the database of Wildlife Institute of India. Table-11 shows different database and its sources

Sl.No.	Map/Data	Source	Primary layer	Output layer
1	Land use land cover (LULC)	Landsat 8	LULC	Forest cover map
2	Human settlement	Landsat 8 and database of WII	Village locations	Distance to nearest village
3	STR Boundary	Database of WII	STR Boundary	Boundary map with core and buffer
4	Elevation	Database of WII	Digital Elevation Model (DEM)	Elevation map
5	Slope	Database of WII	DEM	Slope map
6	Prey availability	Field data	Photo capture rate of prey animals	Surface map of prey availability
7	Location of Tiger	Field data	GPS points	Tiger location map

Table-11 Spatial and non-spatial data sources used and output maps generated

7.1.1.1 Software used:

ERDAS Imagine 13: Used for digital image processing, while Arc GIS 9.3: Used to create vector and raster database.

7.1.1.2 Image classification and preparation of LULC map

Classification of satellite image has a major role to create thematic map and spatial database for various objectives. For this study, unsupervised classification of satellite image was followed to obtain various land use and land cover classes. The resulting classified image is comprised of a mosaic of pixels, each of which belongs to a particular theme, and is essentially a thematic "map" of the original image.

After following the unsupervised classification, the image was classified into six classes, which are dense forest, open forest, scrub land, barren land, water bodies and agricultural land. All these classes are believed to affect the suitability of habitat of tiger in various ways.

7.1.1.3 Preparation of elevation and slope map from DEM:

DEM is an ordered array of numbers that represents the spatial distribution of elevations above some arbitrary datum in the landscape (Meijerink *et al*. 1994). DEM of India was acquired from database of Wildlife Institute of India and was extracted by using the boundary polygon of the STR. It was further used to prepare slope and elevation map for STR since elevation and steepness of terrain can be important factors for habitat suitability of tiger.

7.1.1.4 Distance from nearest village:

Human disturbance is considered to be one of the key factors which has a direct impact on the habitat of tiger. Hence, Euclidean distance from nearest village/settlement was calculated.

7.1.1.5 Prey availability:

Availability of prey animals is a deterministic factor for the distribution of tiger (Schaller 1967, Karanth and Sunquist 1995, Karanth *et al.,* 2004). Since STR comes under a sub-optimal habitat for tigers and its prey base, the detection probability of prey species on the line transect was also found to be low which gives a low density estimate. Although the animals were present there, but the density estimate got underestimated due to low detection probability. Hence, instead of using line transect data, capture rate of prey species from camera trap locations was used to create prey availability map. Taking each 2x2km^2 grid as a sampling unit, each value of capture rate for each species, was assigned to that particular location of camera trap placed inside the grid to generate an interpolation map for each prey species (Annexure-6). After that, layers prepared for each prey species, were combined together to get one single layer of prey availability.

All the above-mentioned spatial layers were used to generate habitat suitability maps by using rule based modeling.

7.1.1.6 Rule based modeling using Boolean Logic:

Based on the field experience and locations of tiger obtained from both collared and non-collared individuals and existing literature regarding the habitat use of tiger, the output layers of aforementioned variables were reclassified by ―0" or ―1" to construct the rule based model. This model works on the basis of Boolean logic, which relies on prior knowledge of the species and prescribes the area to be either suitable (1) or unsuitable (0) without any other middle level (Lenton*et al*. 2000). Unique numbers were assigned for each category in all the variables and then union analysis was performed to obtain final map of the potentially suitable areas for tiger in STR.

7.2 Results and Discussions

7.2.1 Thematic database generation:

- LULC map with six classes (dense forest, open forest, scrub land, agricultural land, barren land and water body) was prepared based on unsupervised classification. Amount of area (Table-12) was also calculated for each class.

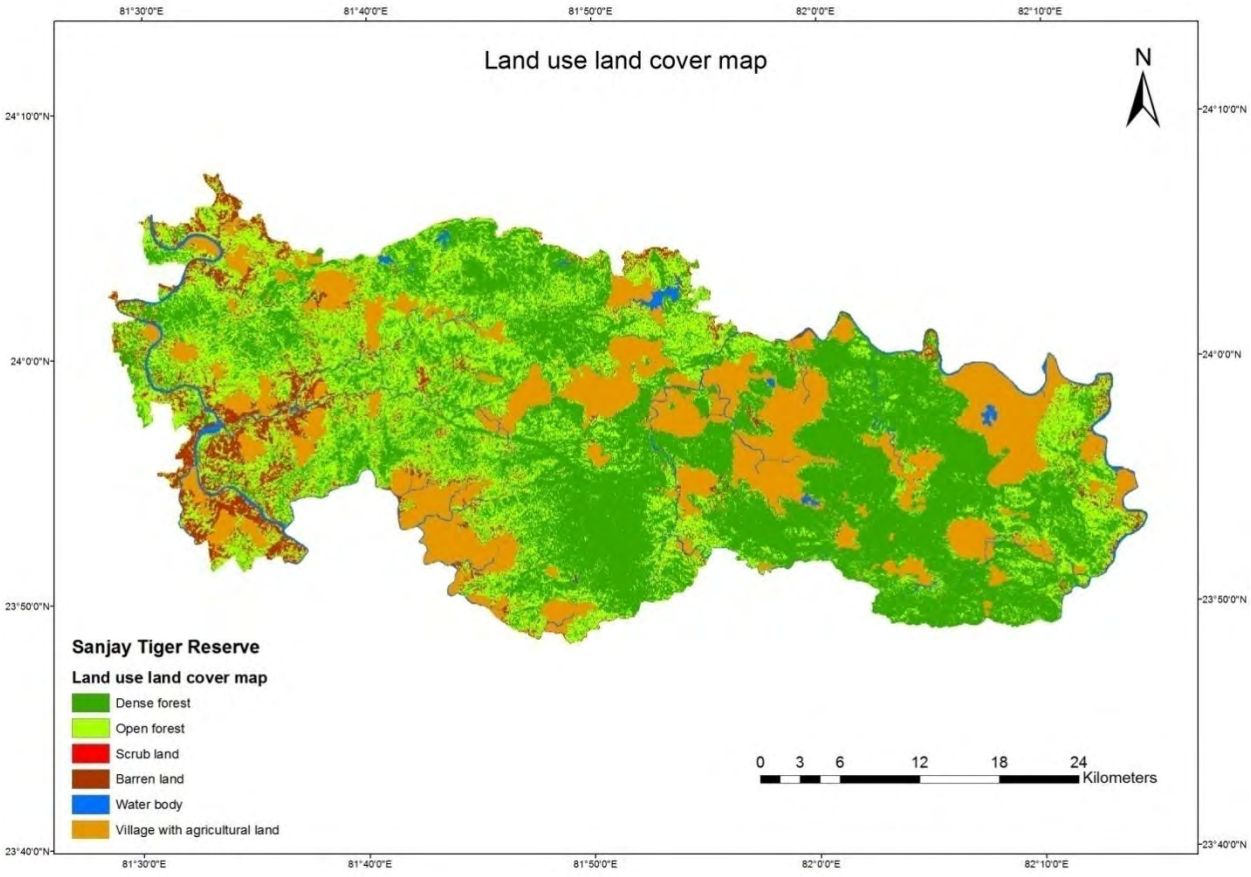

Fig-7: LULC map of STR

LULC classes	Area (in km^2)
Dense forest	707.66
Open forest	447.19
Scrub land	66.76
Agricultural land	303.25
Barren land	41.80
Water body	37.95

Table-12: Area in km^2 of each LULC class

- Elevation map and slope map were generated from DEM of STR. Elevation ranges between 239 m and 771 m and the mean elevation is 510.29 m. Slope ranges from 0 degree to 60.46 degree.

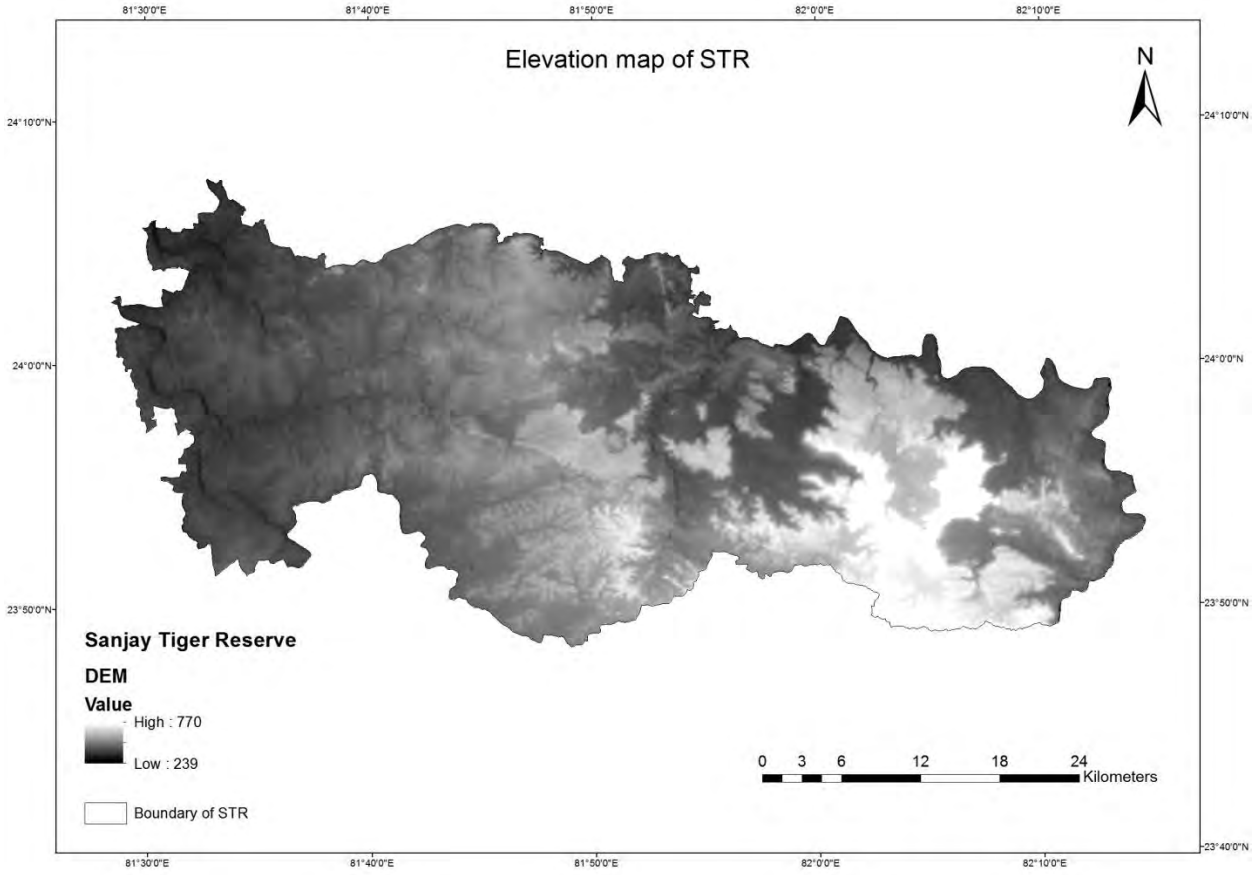

Fig-8: Elevation map of STR

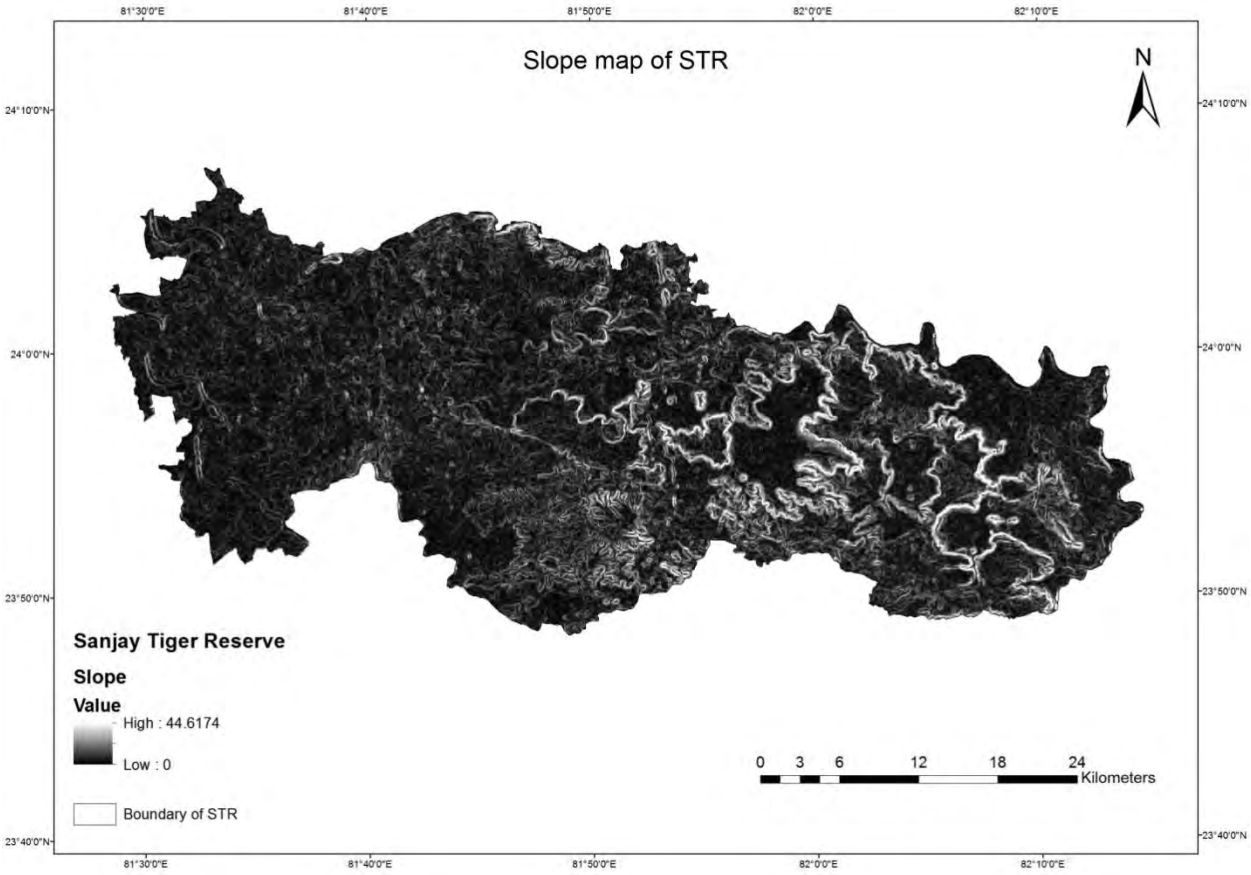

Fig-9: Slope map of STR

- Distance from the nearest village in terms of Euclidean distance was calculated. Euclidean distance from village showed a maximum distance of 6994.12 m.

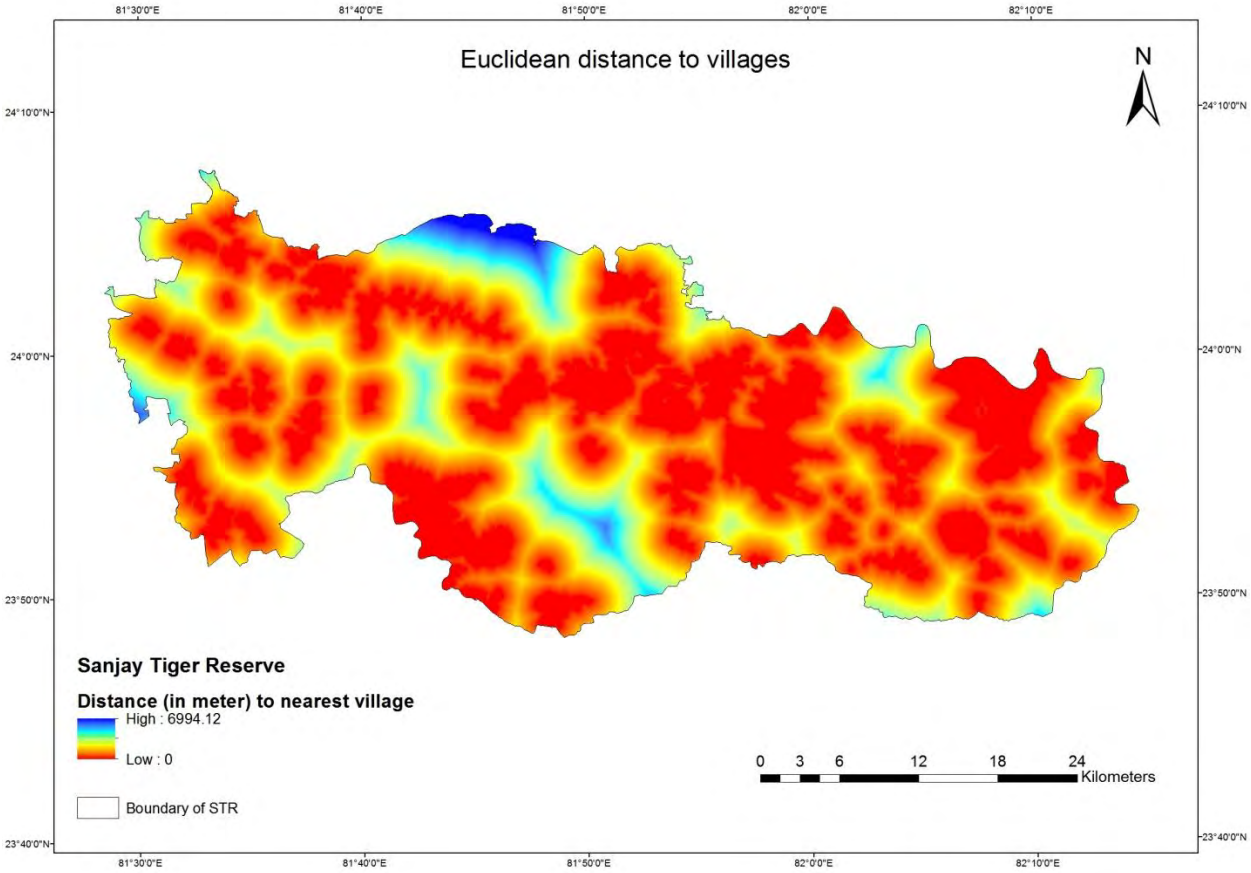

Fig-10: Map showing Euclidean distance from nearest village

- Distribution of prey species based on their photographic capture rate from camera trap locations was shown in the surface map generated by interpolation technique.

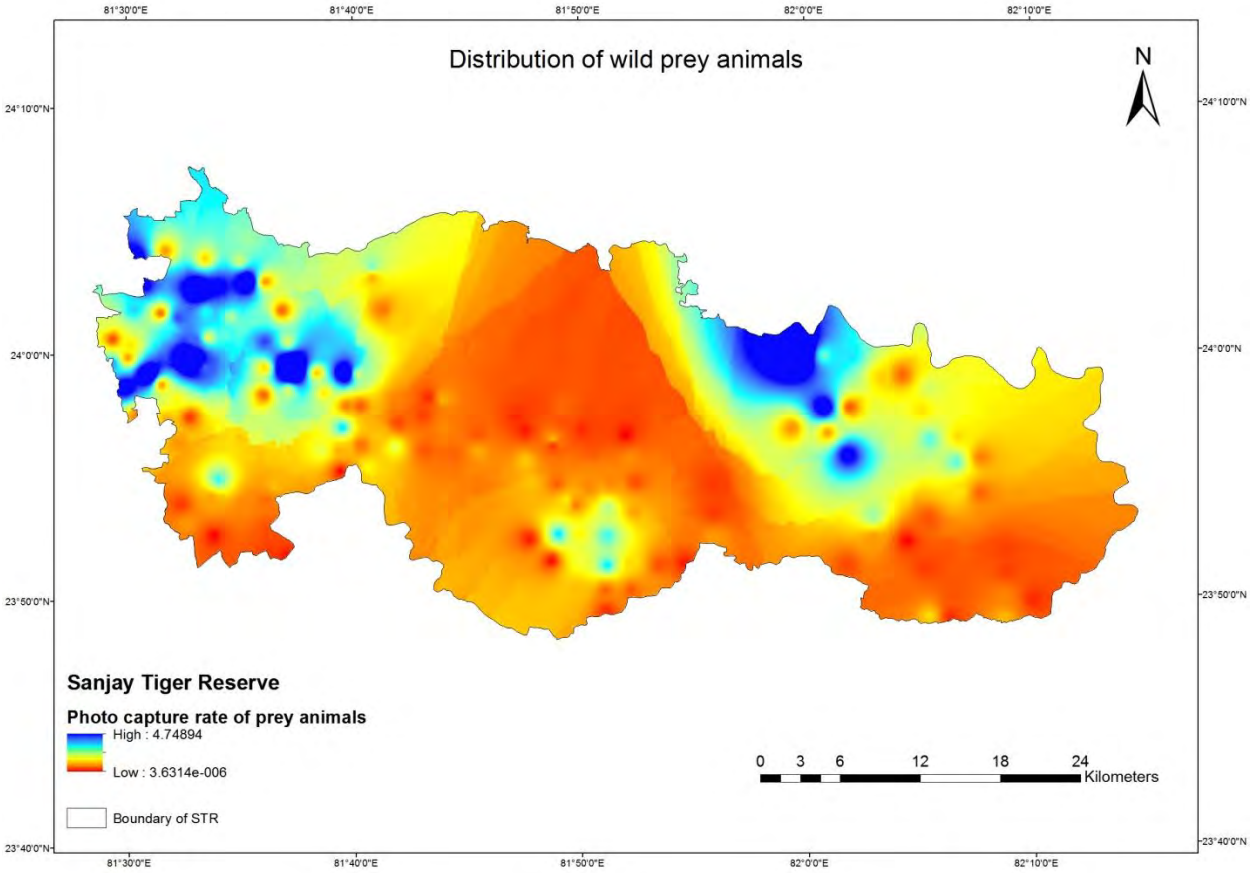

Fig-11: Distribution of prey animals based on photographic capture rate throughout STR

7.2.2 Habitat suitability of tiger

Based on the earlier studies and expert knowledge, the habitat suitability parameters are classified either to be suitable (1) or unsuitable (0).

Habitat suitability classes	Suitability parameters			
	LULC	Slope (degree)	Prey availability (photo capture rate)	Distance from village (m)
Suitable (1)	Dense forest, open forest	0-18	0.35-4.75	>1000
Unsuitable (0)	Scrubland, barren land, agricultural land	>18	<0.35	0-1000

Table-13: Suitability rating assigned for different parameters

Threshold map for each suitability parameter was generated, integrated together and rule based modeling was executed in GIS framework to evaluate the habitat suitability for tiger in STR. In order to get more precise result, two maps were generated-

1. Habitat suitability with wild prey availability and
2. Habitat suitability without wild prey availability

Both the maps of habitat suitability for tigers in STR were shown in Fig-12 and Fig-13 There is a marked difference of the suitable area for tigers observed between these two maps. Map which takes an account of prey availability, showed lesser amount of area (729.46 km^2) suitable than that of the map which excludes prey availability (1017.37 km^2). This result clearly indicates that prey availability and human disturbance play a major role by influencing the habitat suitability of tiger in STR. GPS locations (n=623) of tigers obtained from the radio-collared as well as non-collared individuals were plotted on the map (Fig-14) and it was found that tigers are using a mosaic of suitable and unsuitable areas. However, a larger proportion of the area (61.3%) comes under potentially suitable habitat if availability of prey is excluded. This result certainly has great conservation implication which says improvement of habitat quality and prey augmentation will ensure the revival of tiger population in STR. Being a fragmented habitat due to the presence of number of villages with vast areas of agricultural land inside the tiger reserve, relocation of villages will create more inviolate space to re-grow the population of tiger and its prey base in STR.

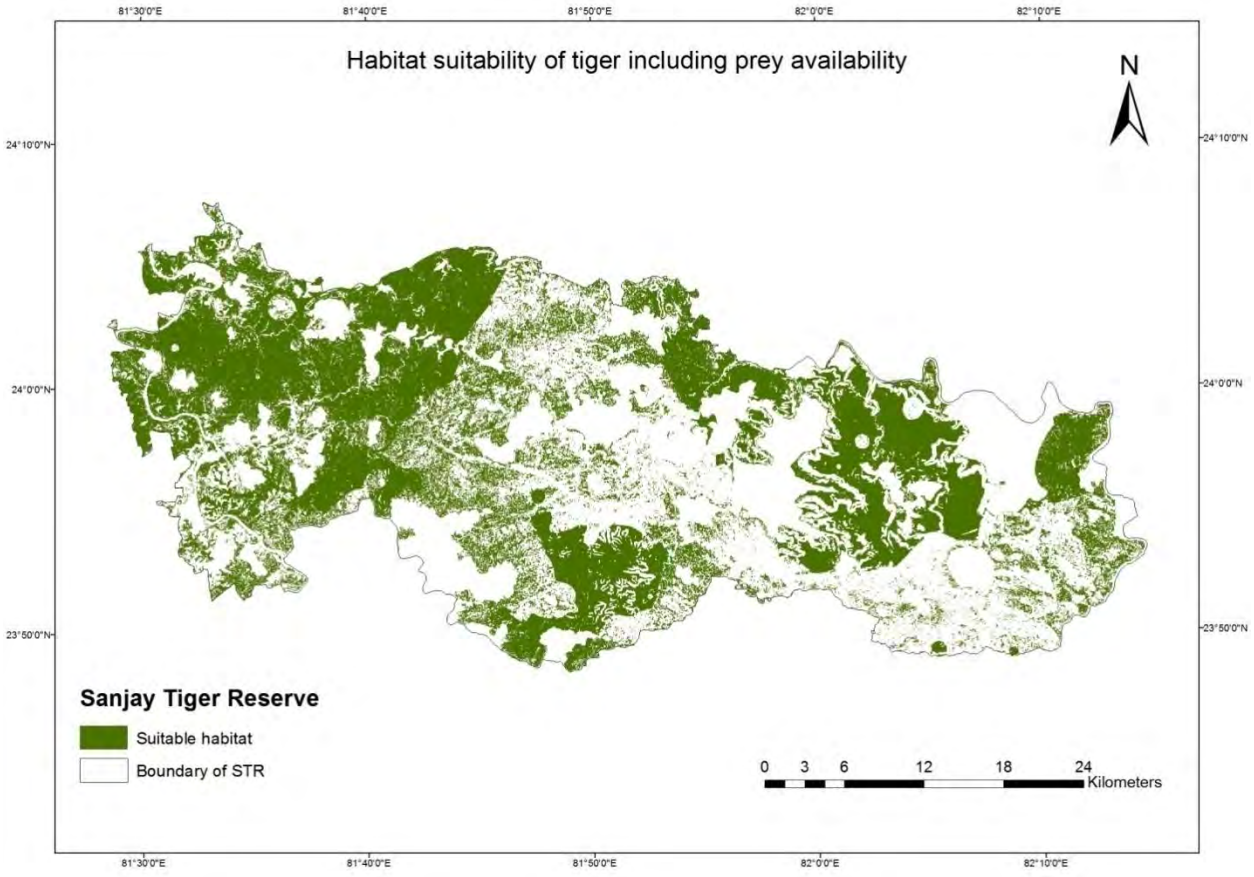

Fig-12: Habitat suitability map of tiger including prey availability

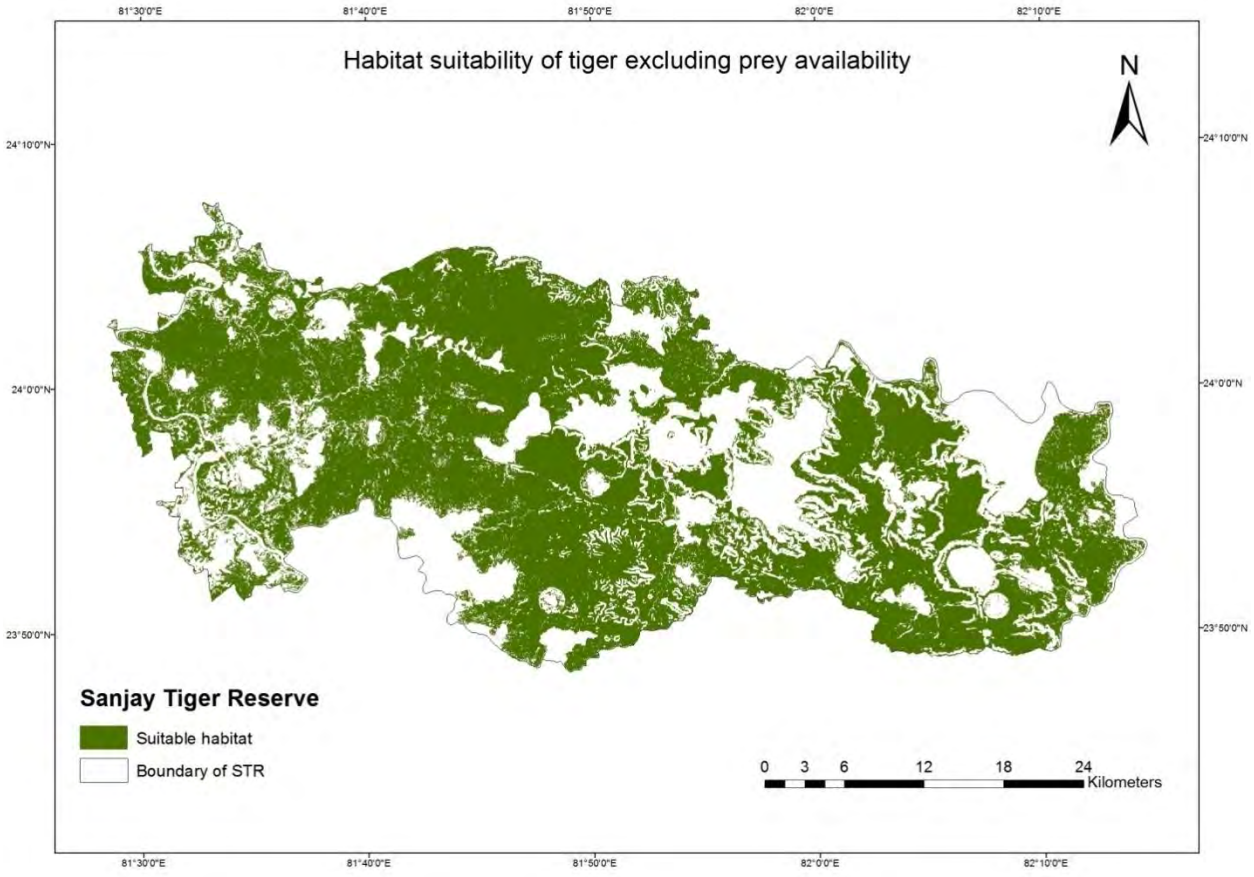

Fig-13: Habitat suitability map of tiger excluding prey availability

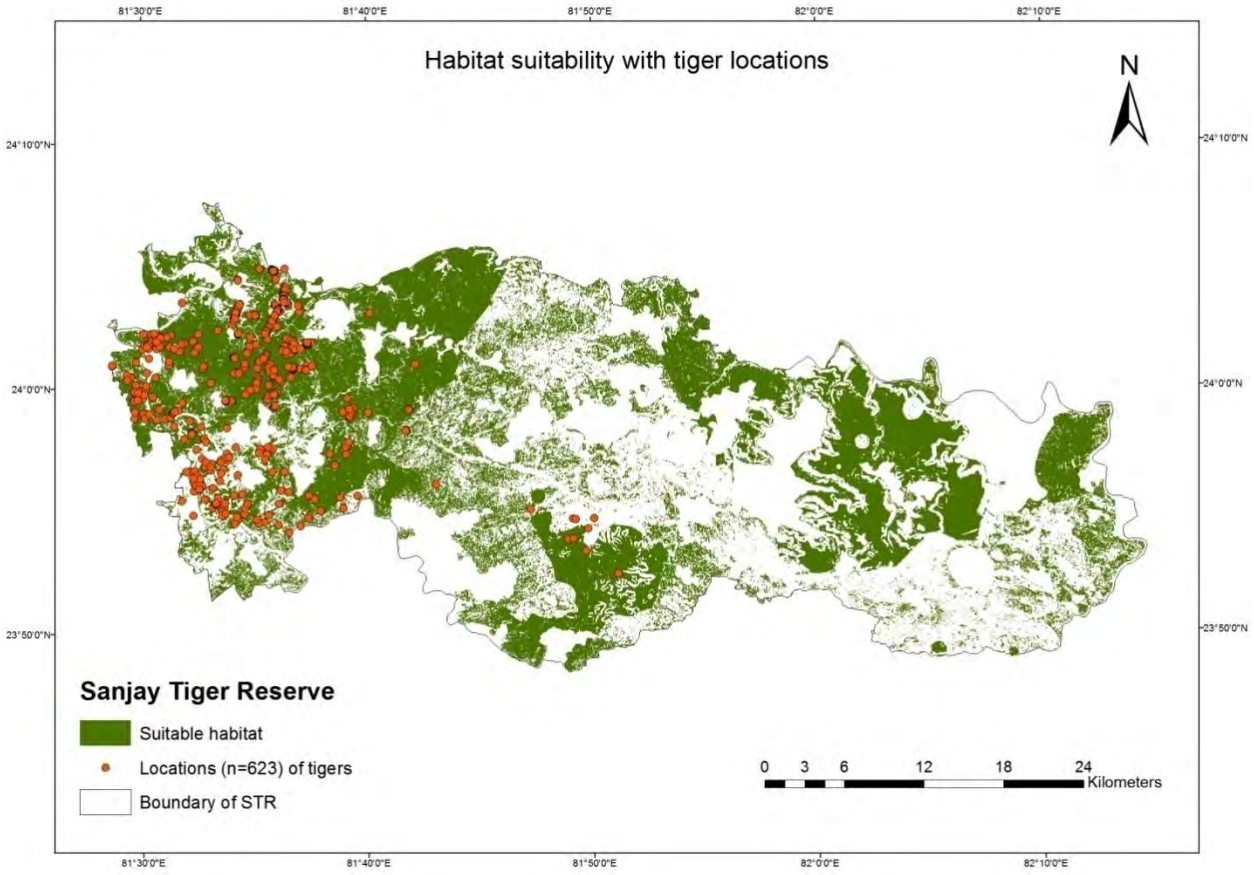

Fig-14: Habitat suitability map of tiger with tiger locations

8. CARRYING CAPACITY AND POPULATION VIABILITY ANALYSIS

Given the availability of large prey (6.84 individuals/ km^2), carrying capacity of tiger in STR was predicted by using the equation developed by Karanth *et al*. (2004)

$$Tj = AUj^b\delta j$$

where A = 0.247 (95% confidence interval 0.181 to 0.336) Uj= prey density/km^2, b= 1 and δj=1**,** derived from the relationship between tiger and prey densities, based on harvest rate by tiger (i.e.50 ungulates per year). Based on the above-mentioned equation, a carrying capacity of 11 tigers (Standard Error 6.81) was worked out for STR.

A population Viability Analysis was performed using VORTEX Program (Version 10.2.7.0; Lacy and Pollack, 2017) to understand the fate of the tigers in terms of population growth and survival probability in the 25 years' time scale.
Population parameters of tiger including life history data were taken from the literature; Smith and McDougal (1991), Bailey (1993), Mazak (1981), Sunquist & Sunquist (2002), Wilkinson & Oregan (2003), Karanth (1999).

Life history data used in the model

Year 1	40%
Year 2	25%
Year 3	25%
Year 4	10%
Cub mortality (%)	50 (in both male and female)
Adult mortality (%)	10 (in both male and female)
Maximum breeding age	15
Start of breeding	4 (males) and 3 (females)
Sex ratio at birth	50%
Adult males in breeding pool	33%
Adult females in breeding pool	50%
Mean progeny per female	2.5 (1 SD)

In addition to the above mentioned population parameters, environment catastrophe (0.2 probability, once in 5 years), inbreeding depression (default value of lethal equivalents=6.29 and percent due to recessive lethal alleles=50) and harvesting in terms of poaching (1 per year) were also considered, in order to obtain the most robust population predictions. Two types of modeling were done based on one hypothetical scenario and the current scenario of the tiger population of STR. A total of nine scenarios were constructed under the two aforementioned broad scenarios and 100 iterations were performed on the population for each scenario to estimate the survival and extinction probability and mean population size.

Hypothetical Scenario: It considers six tigers (two adult males and four adult females) as a founder population.

Scenario 1: Model with only demography parameters and does not include catastrophe, inbreeding depression harvest and supplement

In 100 simulations of the population for 25 years, 53 went extinct and 47 survived, giving a probability of survival 0.47 (0.05 SE) and mean final population was 4.02 (0.41 SE). The mean time to first extinction to occur was 16.06 years (0.84 SE). Across all years, prior to carrying capacity truncation, mean growth rate (r) was 0.041 (0.006 SE). The final observed heterozygosity was 0.58 (0.04 SE). However, this scenario is an ideal one as the environmental stochasticity and other unforeseen loses are likely to happen.

Scenario 2: Model with demography and includes catastrophe and inbreeding

In 100 simulations of the population, 74 went extinct and 26 survived which yielded a probability of survival of 0.26 (0.04 SE). The mean final population size and mean time for first extinction were found to be 1.94 (0.29 SE) and 15.8 years (0.70 SE), respectively. Across all years, prior to carrying capacity truncation, mean growth rate (r) was 0.007 (0.006 SE). The final observed heterozygosity was 0.68 (0.06 SE). Since the extinction probability (0.74, 0.04 SE) is very high in this model, the population would not be viable.

Scenario 3: Model with demography and includes catastrophe, inbreeding and one poaching per year

In 100 simulations for 25 years, 100 went extinct and 0 survived which suggested that removal of individuals at a rate of one per year can easily wipe out the entire population. The mean time to extinction was 5.51 years (0.19 SE). Across all years, prior to carrying capacity truncation, mean growth rate (r) was -0.09 (0.02 SE). This result clearly indicates that poaching must not be tolerated, otherwise it will make all the efforts futile.

Scenario 4: Model with demography and include catastrophe, inbreeding, no poaching and supplement of 2 tiger every three year for three consecutive years, until year 12.

With strict control over poaching and simultaneous supplementation of at least two tigers (one male, equal or greater than 4 years and one female, equal or greater than 3 years) in every three years until year 12, predicted a relatively higher survival probability of 0.65 (0.05 SE) than rest of the scenarios constructed. The mean time to first extinction was 18.53 years (0.76 SE) and the mean final population was 4.79 (0.37 SE). During years of supplementation and across all years, prior to carrying capacity truncation, mean growth rate (r) was found to be 0.068 (0.006 SE). The final observed heterozygosity was 0.90 (0.01 SE). In this scenario, the population will reach its peak in 4th year (10.43), and will begin to decline from 11th year onwards. This suggests that further supplementation may be required only when the prey base and hence the carrying capacity of tiger will be increased at the same time. Carrying capacity played a crucial role even after the supplementations for quite a long period which clearly indicates increasing the prey

base is a must thing for the survival of tigers in STR. The translocated tigers should be from different populations to avoid inbreeding and maintain a good genetic vigor among the progeny.

Current Scenario: It considers the current population of STR, i.e., one adult male and two adult females and one sub-adult male.

Scenario 1: Model with only demography parameters and does not include catastrophe, inbreeding depression harvest and supplement

In 100 simulations of the population for 25 years, 72 went extinct and 28 survived, giving a probability of survival 0.28 (0.04 SE) and mean final population was 2.17 (0.35 SE). The mean time to first extinction to occur was 10.39 years (0.75 SE). Across all years, prior to carrying capacity truncation, mean growth rate (r) was 0.021 (0.008 SE). The final observed heterozygosity was 0.65 (0.05 SE). Although this is one ideal scenario, the probability of survival was found to be much less.

Scenario 2: Model with demography and includes catastrophe and inbreeding

In 100 simulations of the population, 88 went extinct and 12 survived which translated into a very less probability of survival of 0.12 (0.03 SE). The mean final population size and mean time for first extinction were found to be 0.75 (0.17 SE) and 12.52 years (0.71 SE), respectively. Across all years, prior to carrying capacity truncation, mean growth rate (r) was -0.005 (0.008 SE). The final observed heterozygosity was 0.84 (0.06 SE). This is a more realistic scenario but being a very high extinction probability, the population would not be viable at all without taking proper conservation measures.

Scenario 3: Model with demography and includes catastrophe, inbreeding and one poaching per year

In 100 simulations for 25 years, 100 went extinct and 0 survived which suggested that poaching of individuals at a rate of one per year can easily be the cause of extirpation of the entire population. The mean time to extinction was 2.72 years (0.12 SE). Across all years, prior to carrying capacity truncation, mean growth rate (r) was -0.13 (0.03 SE). Once again it was proved that poaching will be a major limiting factor for the population to be survived.

Scenario 4: Model with demography and include catastrophe, inbreeding, no poaching, given a carrying capacity of 22 tigers.

In 100 simulations of the population, 82 went extinct and 18 survived which yielded a very less probability of survival of 0.18 (0.04 SE). The mean final population size and mean time for first extinction were found to be 1.57 (0.36 SE) and 12.06 years (0.75 SE), respectively. Across all years, prior to carrying capacity truncation, mean growth rate (r) was -0.008 (0.007 SE). This model suggested that prey augmentation and increasing of carrying capacity would not be

necessarily adequate to establish a viable population unless a simultaneous supplementation process was performed.

Scenario 5: Model with demography and include catastrophe, inbreeding, no poaching and supplement of 2 tigers every three year for three consecutive years, until year 10, given a carrying capacity of 22 tigers

In situations where poaching does not occur and simultaneously, population is supplemented with at least 2 tigers (one male, equal or greater than 4 years and one female, equal or greater than 3 years) every three years for the initial period, until year 10, of the 100 simulations, only 13 went extinct and 87 survived which translated into a high survival probability of 0.87 (0.03 SE). The mean time to first extinction was 18.92 years (1.65 SE) and the mean final population was 10.67 (0.64 SE). During years of supplementation and across all years, prior to carrying capacity truncation, mean growth rate (r) was found to be 0.049 (0.005 SE). The final observed heterozygosity was 0.88 (0.01 SE). In this scenario, the population will reach its peak in 8th year (17.03, 0.46 SE), and will begin to decline from 10th year onwards. This scenario suggested that with an improved protection, good prey-base and subsequent supplementation programme, the tiger population of STR is the most likely to survive. This scenario was found to be the most plausible one for the long term survival of tiger population in STR, given the prey-augmentation and hence an increased carrying capacity of tiger. Based on this model, all the strategies relevant to improve the prey-base, supplementation and protection would be considered well in advance.

Recommended Actions:

After carefully analyzing the situations, it is recommended that prey-augmentation and subsequent supplementation of tigers are two major steps to secure the long term viability of tiger population in STR. Based on the two broad level scenarios (Hypothetical and Current scenario) and a subset of nine scenarios, it was found that the hypothetical population of six tigers would only be viable if supplementation programmes are carried out simultaneously, given a carrying capacity of 11 tigers. In current scenario, the response of the population towards increased carrying capacity and supplementation was found to be much logical. Hence doubling the current prey-base would invariably increase the carrying capacity of tiger. With subsequent supplementations and improved protection from poaching and other unnatural causes (poisoning etc.), will ensure the long-term survival of the population. It is also suggested that close monitoring of both the resident tigers as well as translocated tigers, be made after performing supplementation programmes.

9. CAPACITY BUILDING OF FOREST STAFF

As a part of this ongoing project, equipping the Forest Department staff with enough technical knowledge and resource is an essential part so that they can continue monitoring of tigers and assessment of its habitat even after the completion of the project. In order to achieve this goal, a number of training programmes throughout the tiger reserve, were organized by the Forest Department with the help of WII as a technical expertise. The programme was initiated at the ranges where movement of tiger is frequent followed by other ranges of core and buffer area of tiger reserve. From November 2015 to April 2017, ten such programmes (Table-14) were organized covering all the core and buffer ranges of STR. These capacity building programmes were attended by staff like chowkidars, Beat Guards, Deputy Rangers, Range Assistants and Range Officers. Sometimes the presence of Assistant Conservator of Forest and Field Director, STR has encouraged the ground level staff in various ways.

The things on which the staff were trained to develop and enhance their capability, were listed below-

1. Use of GPS, compass, range finder while doing field surveys
2. Systematic (grid based) deployment of camera traps
3. Training on the field data collection for animal abundance estimation from direct and indirect evidences (line transect and sign survey)
4. Techniques of monitoring tigers through tracking of radio collared and non-collared individuals with the help of tracking devices, camera traps, and indirect signs (pugmark, scat etc.)

Sl. No.	Date	Staff of the Range/Ranges involved	Topic discussed
1.	November, 2014	Dubari and Beohari	Deployment of camera traps
2.	March, 2015	Pondi and Bastua	Deployment of camera traps
3.	June, 2015	Mohan	Deployment of camera traps
4.	November, 2015	Mohan, Pondi, Bastua, Dubari and Beohari	Handling of equipments and deployment of camera traps
5.	February, 2016	Mohan, Pondi, Bastua, Dubari and Beohari	Line transect, sign survey and deployment of camera traps
6.	April, 2016	Mohan	Line transect, sign survey and handling of equipments
7.	December, 2016	Mohan and Pondi	Laying of line transect, sign survey and deployment of camera traps
8.	December, 2016	Bastua, Dubari and Beohari	Laying of line transect, sign survey and deployment of camera traps
9.	January, 2017	Mohan, Pondi, Bastua, Dubari and Beohari	Use of GPS
10.	April and May, 2017	Bhuimad, Tamsar and Madwas	Deployment of camera traps and use of GPS

Table-14: Details of capacity building programmes organized in STR during 2014 to2017

10. SNTHESIS AND WAY FORWARD

Evaluation of prey availability and habitat suitability of tigers in STR should be seen in the context of sub-optimal habitat. As discussed earlier, availability of prey is one of the key factors which governs the distribution of large carnivores. In STR, prey density was found to be low as a result of immense anthropogenic pressure and fragmented and poor habitat quality. Depletion of prey base causes low density of tigers and other co-predators to occur. In 2015, density estimate of wild ungulate was found to be extremely low (2.83±0.6) which can be attributed to short sampling. However, prey density was observed to increase gradually as a probable result of prey augmentation in terms of translocation of chital from Bandhavgarh Tiger Reserve to STR. Subsequently, village relocation will accelerate the growth of the population of prey species. Hence, village relocation followed by prey augmentation will certainly increase the carrying capacity of tiger in STR. Once the carrying capacity increases, restocking/translocation of tigers from other tiger reserves can be initiated as per the management recommendations given in Chapter-7. Furthermore, intensive monitoring of radio-collared as well as non-collared tigers should be done in a regular basis.

In current situation, movement of tigers was found to be mostly restricted to the eastern most part (Beohari, Dubari and some part of Bastua) of the tiger reserve. However, this study clearly indicates that there are other areas (Mohan and Pondi Range) in STR which can be considered as potentially suitable for tiger but currently not being used. In the absence of tigers, leopard population is flourishing in those areas. Hence prey augmentation in these particular sites followed by relocation of adjacent villages will certainly increase the chance of being occupied those sites by tigers and also provide the suitable release site of tigers to be translocated. In addition to active population recovery efforts, long term monitoring of tigers, its prey and habitat condition will be required to undertake science-based management efforts.

11. ACTIVE RECOVERY AND MONITORING PLAN

Although it is a tiger reserve, the tiger population status is precariously low in STR. Three adult male tigers and two adult tigresses were reported from the reserve and this included one male that was had been translocated from Panna Tiger Reserve (PTR). However, this translocated male died due to fight with other resident male, perhaps after mating with resident female and contributing to gene pool. Currently, the total population size is 11 individuals 1hat include two adult-males, two adult-females (including one translocated semi-wild tigress from BandhavgarhTR), four sub-adult males and three newborn cubs (one month old). However, the major issue is that the habitat and prey species populations require significant improvement/recovery in order to manage this as self-sustaining population. In the absence of a comprehensive habitat, prey and tiger population recovery strategy, it is unlikely to maintain the growth phase and it might lead to serious conflict situations, which will be counterproductive to tiger conservation efforts.

1. Goal and Objectives

The overall goal of the project is to recover habitat, prey populations and tiger population by 2026. The following are the specific objectives;

1. To undertake habitat recovery and prey augmentation towards preparing and enabling suitable core area for tiger recovery including active reinforcement efforts (Action: STR& WII).
2. To ensure demographically, genetically and physically (health-wise) viable population of prey populations, tiger and its offspring, by undertaking population management such as translocation from other suitable sites (Action: STR& WII).
3. To devise and execute monitoring strategy providing security based monitoring of founder individuals and remote monitoring of selected animals involving radio telemetry and GPS-satellite/GSM tracking technology (Action: WII &STR).
4. To study prey-predator relationship and undertake population estimation and monitoring as per NTCA Phase IV monitoring protocol (Action: WII &STR).
5. To undertake conservation education program for local people and capacity building trainings for field staff towards social acceptability and technical skill development respectively for effective implementation of tiger recovery program (Action: STR& WII).

2. Institutional Framework and Core Team Constitution

Tiger Recovery Program is a long-term investment and commitment, and involves multitude of scientific, administrative and political inputs. However, the program will be owned by the State Forest Department, with technical support from Wildlife Institute of India, National Tiger Conservation Authority and other stakeholders. If there is strong institutional mechanism in place, it is very likely that the project will achieve desired outcome. In line with IUCN and

NTCA protocols, a management and technical team with the following members will be constituted to oversee and execute the recovery process;

1. Team Leader
2. Program Coordinator
3. Principal Investigator
4. Co-investigators
4. DIG/AIG, National Tiger Conservation Authority, New Delhi/Nagpur
5. Field Director, Bandhavgarh and Panna Tiger Reserve, Madhya Pradesh
6. Veterinary Officers, Bandhavgarh and Panna Tiger Reserve, Madhya Pradesh

3. Background and Feasibility Analyses

While the Tiger Recovery Program is a long-term strategy in terms of the planning, execution and success evaluation, it needs to be approached in a step-wise process. In order to understand the specific issues, carrying capacity of tiger and future projections, it is necessary to undertake Feasibility Study looking into habitat, prey and habitat integrity including spatial configuration, anthropogenic issues, opportunities and threats. This will essentially decide the future course of action in terms of specific focal areas and actions in a time-bound manner. The feasibility study will focus on the following activities;

a) ***Assessment of Carrying Capacity***: There is already some information regarding prey availability based on the on-going project. Given the availability of large prey (6.84 individuals/ km^2), carrying capacity of tiger in STR was predicted by using the equation developed by Karanth *et al*. (2004)

$$Tj = AUj^{b}\delta j$$

where A = 0.247 (95% confidence interval 0.181 to 0.336) Uj= prey density/km^2, b= 1 and δj=1**,** derived from the relationship between tiger and prey densities, based on harvest rate by tiger (i.e.50 ungulates per year). Based on the above mentioned equation, a carrying capacity of 11 tigers (Standard Error 6.81) was worked out for STR. Carrying capacity of the STR would essentially determine the number of founders to be considered for translocation if need be and what are the preparations need to be done in a phases manner towards achieving the larger goal of establishing viable population in STR. It would also involve detailed mapping process looking into landuse and landcover characteristics in the context of habitat suitability for tigers, which has already been accomplished as a part of the ongoing project. Evaluation of connectivity and landscape permeability for tiger has also to be determined to naturally colonize the STR from other source areas such as Bandhavgarh Tiger Reserve.

b) ***Habitat Suitability and Evaluation of Release Site***: It is apparent that although STR is low-density tiger area, it has significant potential to hold significant tiger population due

to habitat availability in the core and buffer area. Based on the findings of the ongoing project only 46.9% of the total area was found to be suitable, given the current status of prey availability. If prey availability is excluded from the analysis, 61% of the total area was found to be suitable for tiger. This result clearly indicates STR can harbor significant tiger population, provided the prey base has been augmented. Given the connectivity and improved habitat condition, STR can become another important Tiger Reserve, supporting the national and global target of doubling the tiger population. Enhanced protection measures are already accorded to STR and processes are underway to free human occupied areas so that inviolate space could be created for tiger to breed and have sense of security, which are critical elements for population growth. SWOT analyses would be performed to define broad scale and micro-scale issues including staff strength and acceptability level of people for such program.

c) ***Assessment of Founder Individuals***: It is entirely possible that tiger population growth in STR would take place with existing tiger population and with few inflows from other areas including translocation and natural colonization may also be possible if existing corridors were strengthened. However, this may take prolonged period unless credible outcome has been achieved in short span of time. Therefore, it is always important to consider founder individuals which demographically, genetically and behaviorally suitable for tiger recovery program. Information generated based on spatio-temporal movement and occupancy of the tigers from other source areas, a list of suitable animals for translocation would be prepared in consultation with the Field Director of respective Tiger Reserves. This should become basis for selecting animals for translocation and for future reinforcement. However, the dossier of suitable release animals needs to be constantly updated and ready for considering as suitable founder animals. It may also be necessary to radio-collar and monitor selected few animals from the source areas in order to understand the behavior so that adequate response mechanism at release site can be established.

d) ***Population Viability Analysis*:** Population Viability Analysis (PVA) was performed using VORTEX Software Program to understand the performance of founder individuals (naturally colonized as well as translocated) in terms of population growth and survival probability in the 25 years time scale which has been detailed in chapter-7. Two types of modeling were done based on one hypothetical scenario consisting of six founder individuals (two adult males and four adult females) and the current scenario of the tiger population (one adult male, two adult females and one sub-adult male) of STR. A total of nine scenarios were constructed under the two aforementioned broad scenarios and 100 iterations were performed on the population for each scenario to estimate the survival and extinction probability and mean population size. In order to provide a robust estimation of population survival or extinction prediction over 25 years time scale, the knowledge of

life history trait of tiger would be taken into account as it provides the basis for PVA modeling and scenario analyses. In addition to the life history parameters, environment catastrophe, inbreeding and possible poaching will also be considered in the PVA to obtain the most robust and realistic population predictions. After carefully analyzing all the scenarios, it is found that increasing the carrying capacity of tiger by prey-augmentation and subsequent supplementation of tigers are two major steps to secure the long term viability of tiger population in STR. The result suggests that the founder population of six tigers will only be viable (survival probability 0.65, standard error 0.05) if subsequent supplementation is carried out, whereas the current population with a higher carrying capacity and subsequent supplementation showed a much better survival probability (0.87, standard error 0.03). This would provide sound scientific basis for undertaking recovery program in the short as well as long-term after observing the response of the population towards an increased carrying capacity and supplementation programmes.

4. Capture, Transport and Health Issues

Standard protocol of immobilization and transportation has already been established for the reserve, following experiences from Panna Tiger Reserve, Madhya Pradesh and Sariska Tiger Reserve, Rajasthan. It is critical to involve full-time veterinarian in this program. The field team will have to be exposed to enough experience before the capture and such capacity building activity can easily be organized from other experienced places, both in India and abroad, where such capture and translocation are every day activity (e.g. South African Reserves). We also need to equip the field team with sophisticated capture and transport kits, and need to make provision for procuring these items in order to be professional in undertaking this important conservation activity. All the NTCA protocols with respect to reintroductions will have to be adhered to.

It is important to profile each animal in terms of health and behavior. Visual examination, scat samples and biological samples would be used to periodically to measure stress and reproductive hormones, endo/ecto parasites and genetic analysis. Provisions will have to make to procure equipments to measure these in the field without relying on external agencies heavily. The research team of WII would handle this activity and regular update would be done in the field itself. It may be worth profiling individual animals in terms of genetic and reproductive health, in order to effect specific administrative action on timely basis.

5. Release Process

In such program, the precautionary principle demands establishing soft-release facility for (a) enabling the animal to settle down after capture and transportation stress and (b) for monitoring health of the animal after having been chemically immobilized. These are some of the veterinary requirement. However, in the case of STR, both soft release and hard options have been exercised. Therefore, it would be useful to consider maintaining the holding/soft release facility for such purposes, but hard release can be considered as long as the animals are tagged/collared

and proper monitoring strategy are in place. In this program, both these options would be considered for prey augmentation and translocation of founder individuals. It was also possible to understand from the available experience in Panna that release site does not have any effect on movement and habitat choice of the released animals, and thus, there may be not the need for elaborate release site establishment. Such activity can be guided by the ease of operation without much stress to the capture animals and should have consideration for monitoring team, as it is critical to have round the clock monitoring during initial months.

6. Post Release Monitoring Protocol

Post release monitoring is a key for success/failure of such recovery projects and there are enough evidences to back this claim. Therefore, as much as effort or resource invested for the reintroduction program, as much if not more to be allocated for monitoring activities. It is important that all the founder animals and certain dispersing animals are radio-collared with VHF/GPS/Satellite of GSM collars and this should become integral part of the project until the population has reached its carrying capacity or target level as set out by the carrying capacity analysis. The monitoring would involve two types of dedicated teams (1) Security-based Monitoring by the Field Staff using VHF tracking method and (2) Technical-oriented Monitoring by WII team using VHF as well as GPS/Satellite/GSM tracking method. While the former would be done round the clock during initial months until the animals establish home range before switching over to systematic monitoring, the latter would undertake systematic monitoring and would gather all the scientific information to guide the management action as required in the field based on the response of these animals.

As stated above, security based tracking would be undertaken for newly translocated animals until they establish and all the animals would be monitored everyday basis, but the information flow would be through a joint Field Coordinators (one from STR and WII) so that there is no communication gap and that information could be synthesis quickly for understanding the process and management interventions. The information would be synthesizes on fortnightly basis by the field team and a monthly reporting would be done by WII team on the movement and home range of the tracked animals. From the WII team‘s perspective, the entire activity would be structured and dedicated team would be deployed for different purposes such as (1) radio-tracking and monitoring of prey and tiger populations, (2) camera trapping and population estimation of tiger and co-predators, (3) line transect sampling for estimating prey/ungulate abundance across space and time and (4) genetic and reproductive health monitoring. Tiger Recovery Program is a long-term effort and therefore, these activities ought to be visualized in the same time scale, although it may be phases due to resource limitation. Success/failure of the program is linked to proper and effective protection of the released animals and round the clock monitoring and surveillance with co-ordination of WII team and park staff will ensure this. In addition to the monitoring involving radio-collar, regular monitoring involving camera traps should be deployed in order to understand the effect/benefit of tiger recovery in the area. If

resource permits, advanced technology such as Wireless Sensor Network and Un-manned Aerial Vehicle may also be considered for tracking and surveillance purposes.

7. Habitat Recovery Activities and Monitoring Protocol

Village relocation is key management inputs in order to enhance habitat availability. However, the quality of habitat being added through this effort would stem from the way the habitat being management, in addition to dealing with already degraded habitat areas due to excessive exploitation for livelihood activities including grazing. It is therefore proposed that a comprehensive habitat recovery and monitoring strategy would be executed. This entails relocation of villages in entirety, followed by habitat improvement activities that would involve (a) weed removal, (b) removal of un-palatable grass species, (c) planting of suitable grass species and (d) establishment of monitoring activities. There is already process in few of the Tiger Reserves in Madhya Pradesh and a similar model would be executed, along with monitoring of these areas based on Remote Sensing and GIS tools, and field based plots including enclosures/enclosures.

8. Short Term Success Indicators

1. Approval of project concept and resource allocation, and endorsement from key stakeholders
2. Completion of feasibility analyses and development of protocol for habitat recovery and prey augmentation.
3. Establishment of coordination with source population sites and identification of potential candidate animals for translocation.
4. Successful tranquilization, radio collaring and revival of the targeted animal for reinforcement with minimal stress after taking morphological data and biological samples. Successful release of the targeted animal (either hard or soft release depending on the health condition of the animal).
5. Formation of joint tracking team (WII and STR) and coordination mechanism established including reporting arrangement and response strategies during crisis situation. Signing of MoU between STR and WII, and establishment of WII's Field Station for Long-term Research and Training in STR.
6. Assessing demographic characteristic such as sex ratio of the established populations by the end of 2020 and take appropriate decisions of further reinforcement of prey and tiger population by reintroducing more individuals if required.

9. Long term Success Indicators

1. Successfully reaching carrying capacity/target population size, consolidating and safeguarding foundation population and its offspring with sign of population growth.

2. Establishing natural connectivity between STR and other source populations, and ensuring functional connectivity for tiger movement between these sub-populations.
3. Achieving the carrying capacity of tigers in STR (which will likely increase with more village relocations), and maintaining the population and genetic viability in the STR.
4. Securing the threat free environment and well-trained management team for safeguarding of the tigers, possibly supported by technological integration.
5. Understanding their population dynamics, prey-predator relationship and response to disturbance, with constant management inputs for regular and crisis management strategies.

10. People Participation and Livelihood Activities

IUCN Reintroduction Specialist Group and NTCA Protocol lay emphasis on social acceptance for such conservation program, as it involves the species that carries flagship value, but also conflict risk for local dependent communities. In this case, tiger population recovery is likely to increase the interface issues with the human population in the landscape. While general conservation education may be required to share the project need and the outcome, it would be critical to engage the people in the landscape, especially in the notified buffer area. Specific package may be worked out and specific experts from WII and NGOs may be integrated in the project. This will integrate the interests/concerns of the local communities and will be helpful tiger recovery in the immediate and long-term.

11. Ecological Research and Long-term Monitoring

(a) Rationale: Under the larger tiger recovery program, the sub-component will exclusively deal with ecological research and scientific monitoring. This is essential because not only it enables effective information gathering, technical support, documentation and for guiding the management interventions on regular basis and also in crisis situations. The research would focus on home range and movement pattern, predator co-occurrence variations, prey-predator relationship and disturbance factors. The huge efforts placed on the re-building exercise will generate much more knowledge than the movement and home range information, and clearly, it is one of the rare opportunities for understanding several facets of tiger conservation biology, testing traditional and modern methods including estimating low-density population, sensitivity of estimates to population recruitments, and tiger response to local and landscape variables. All these would be critical for developing tiger conservation plan in the long-term. While the information is obtained regularly by the monitoring team and mapped in GIS appropriately, the linkages with various factors need to be understood at the landscape scale. As a follow up, the proposed project in addition to monitoring the radio-collared individuals, would aim to understand the prey-predator relationship, landscape ecology of tiger, and population estimation protocol for tiger and associated species. In addition to the specific objectives mentioned in Section 2 of this project document, following objectives are visualized for scientific management of the tiger recovery program in particular and STR in general.

(b) Specific Objectives: The following are the specific objectives of the project;

1. To undertake post-release monitoring of prey and tiger populations looking into population growth, movement pattern, behavior, genetic structure and physiological profile.
2. To estimate population size of tiger, co-predator and prey species, and model the habitat correlates to understand the species-habitat relationship, and support the ongoing Phase IV monitoring activity.
3. To map landscape composition and configuration, and estimate patch properties, connectivity and landscape permeability within and across the landscape.
4. To quantify human-wildlife interface issues and ecological correlates linked to economics and system services.

***(c) Design and Methods*:** Sampling design would involve hierarchical procedure, with mean home range size of the tiger to be largest cell size and within which habitat types and administrative units such as beat boundary and compartment boundary would be studied. During the feasibility analyses, intensive efforts would be made to quantify prey abundance, habitat quality, carnivore occupancy and abundance, socio-economic assessment of representative population and perception analyses of the people. All radio-collared prey species and tigers would be monitored by VHF tracking involving modified home-in method (occasionally by triangulation) and by GPS telemetry using satellite or GSM tracking process. Data collection would be carried out round the clock in the initial period until the tigers settled down in the area, and thereafter, a sampling strategy targeting data collection at regular interval would be developed. Based on the number of VHF receiver equipment and trained man power, data collection will be done at regular intervals, with specific days for triangulation and home-in, which will be done both round the clock, and at regular intervals (e.g. every three days). The locations would be plotted on GIS map, and estimates would be derived based on home range analysis in ArcGIS Software or in other relevant software.

Grid based sampling would be done for analyzing movement pattern and for estimating population status of predators and prey species. Camera trap would also be done simultaneously to understand the variation associated with low density population estimates of tiger and to estimate population sizes of co-predators on spatio-temporal scale, towards gaining insight on the responses shown by individual species with increasing tiger numbers and movement. The sensitivity of population estimate would also be understood, with variation in the number and movement of target species in the camera locations. Several thematic layers in GIS would be used to study habitat recovery and the landscape ecology of prey and tiger in the landscape, looking into patch size and configurations, surrounding matrix and permeability for animal movement, etc. The study would also target certain human-wildlife interface issues relevant for planning tiger conservation strategies for the Reserve in particular, and the tiger landscapes in

general, possibly for the entire state. Existing collaboration with other technical institutions will also be explored to integrate sophisticated technology for research and management purposes.

***(d) Expected Outcome*:** The project would provide a detailed analysis of the behavior and movement pattern of the tigers in STR and surrounding landscape, and would identify the correlates of positive and negative sensitive areas. Home range estimates and territoriality would be mapped. Identification of local and landscape variables that determine tiger distribution would be done, including the key disturbance elements. Occupancy and abundance estimates for prey and predator, and co-occurrence pattern would be estimated on spatio-temporal scales, and would support the Phase IV activity in terms of capacity building and monitoring. Socio-economic profile of people in and around the area, and issues related to livestock population and use of the area would be provided. The knowledge generated at the landscape scale would offer basis for management of the growing tiger populations and to deal with human-carnivore conflict issues in STR and also in the entire region. Integration of technology would open up new avenue for the wildlife management in STR and also in the rest of the state.

***(e) Review Process*:** The progress of the work, success indicators and other relevant issues would be reviewed periodically, (a) with quarterly report every three months, (b) a high level review either (coinciding with Annual Research Seminar of WII) or end of financial year after completing annual report, and (c) every three months at the field level between Field Director and Principal Investigator of the Project. All concerned would participate and provide inputs in the annual review process. This will be strictly adhered to. Meanwhile, if there is any activity or strategy that is found wanting, it will be addressed on immediate basis. Revision of decision, rescheduling etc., will be undertaken as and when necessary based on the reviews.

(f) Technical Reports and Publications: Annual Technical Report shall be produced by WII, with equal sharing of credit and any publication that may come of the project would be shared equally, with authorship based on inputs/contributions. A mutually agreeable MoU shall also be signed between STR (Field Director) and WII (Principal Investigator).

12. Budgetary Requirement and Commitment

Tiger recovery program is a long-term endeavor, and there is definitive requirement to visualize and make available required resources and commitments of all stakeholders are required. Without such long-term vision and strategy, recovery efforts would not yield desired results and there are ample examples across the country and in other parts of the world, where success of conservation programs have relied on institutional mechanism, long-term commitment of resources, periodic review process and course correction strategies. It is expected that the Madhya Pradesh Tiger Foundation would fund the project or any other resource such as CAMPA that may be sourced locally.

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ANNEXURE-1
Photographic ID of Tigers (2014-2015)

T-001 (Left flank)

T-001 (Right flank)

T-002 (Left flank)

T-002 (Right flank)

T-003 (Left flank)

T-003 (Right flank)

T-004 (Left flank)

T-004 (Right flank)

T-005 (Left flank)

T-005 (Right flank)

ANNEXURE-2
Photographic ID of Tigers (2015-2016)

T-001 (Left flank)

T-001 (Right flank)

T-005 (Left flank)

T-005 (Right flank)

T-006 (Left flank)

T-006 (Right flank)

T-007 (Left flank)

T-007 (Right flank)

T-008 (Left flank)

T-008 (Right flank)

T-009 (Left flank)

T-009 (Right flank)

T-010 (Left flank)

T-010 (Right flank)

T-011 (Right flank)

T-012 (Left flank)

T-012 (Right flank)

ANNEXURE-3

Sample pictures of other animals captured in camera traps

Leopard (*Pantherapardus*)

Sloth bear (*Melursusursinus*)

Hyena (*Hyaenahyaena*)

Indian Wolf (*Canis lupus pallipes*)

Golden jackal (*Canisaureus*)

Indian fox (*Vulpesbengalensis*)

Jungle cat (*Felischaus*)

Palm civet (*Paradoxurushermaphrodites*)

Small Indian civet (*Viverriculaindica*)

Honey badger (*Mellivoracapensis*)

Chital (*Axis axis*)

Sambar (*Rusa unicolor*)

Barking deer (*Muntiacusmuntjac*)

Wild pig (*Susscrofa*)

Nilgai (*Boselaphustragocamelus*)

Chinkara (*Gazellabennettii*)

Four horned antelope (*Tetracerusquadricornis*)

Indian porcupine (*Hystrixindica*)

Black naped hare (*Lepusnigricollis*)

Greylangur (*Semnopithecus entellus*)

Rhesus macaque (*Macacamulatta*)

Indian peafowl (*Pavocristatus*)

ANNEXURE-4

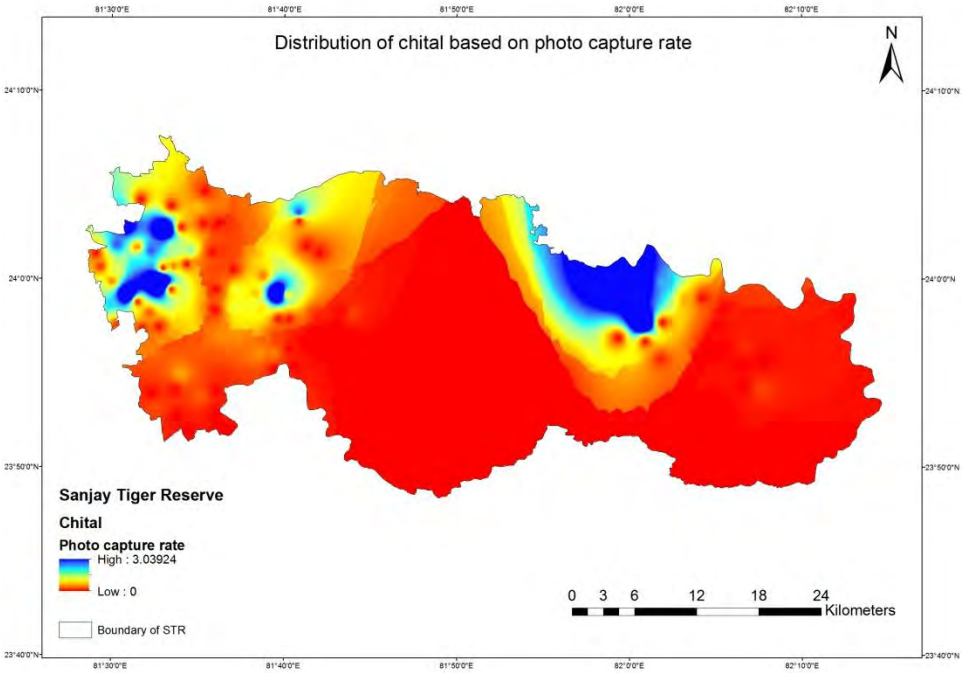
Photographs of capacity building programme

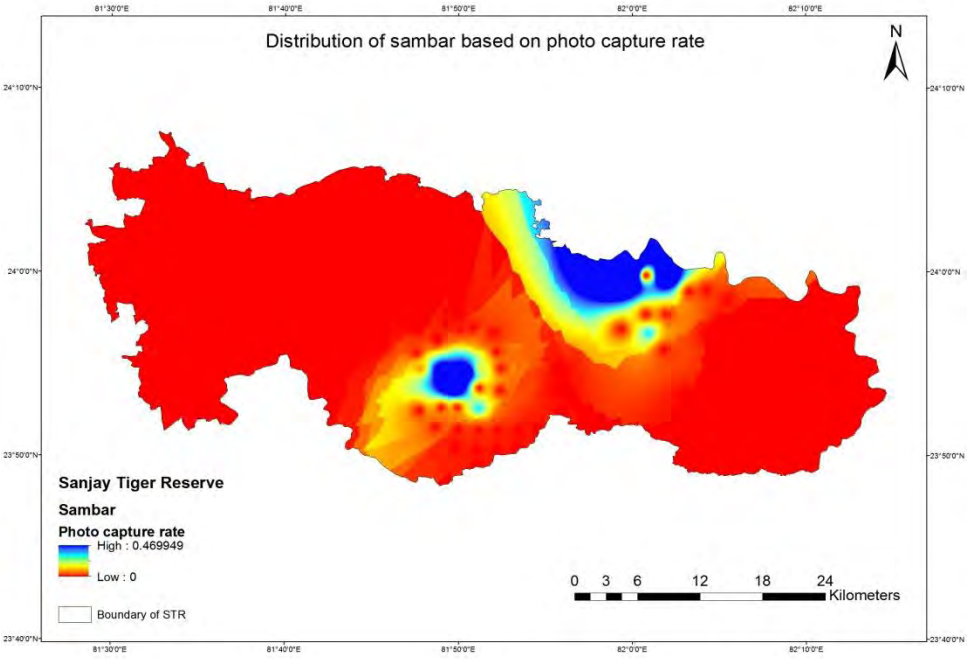
ANNEXURE-5

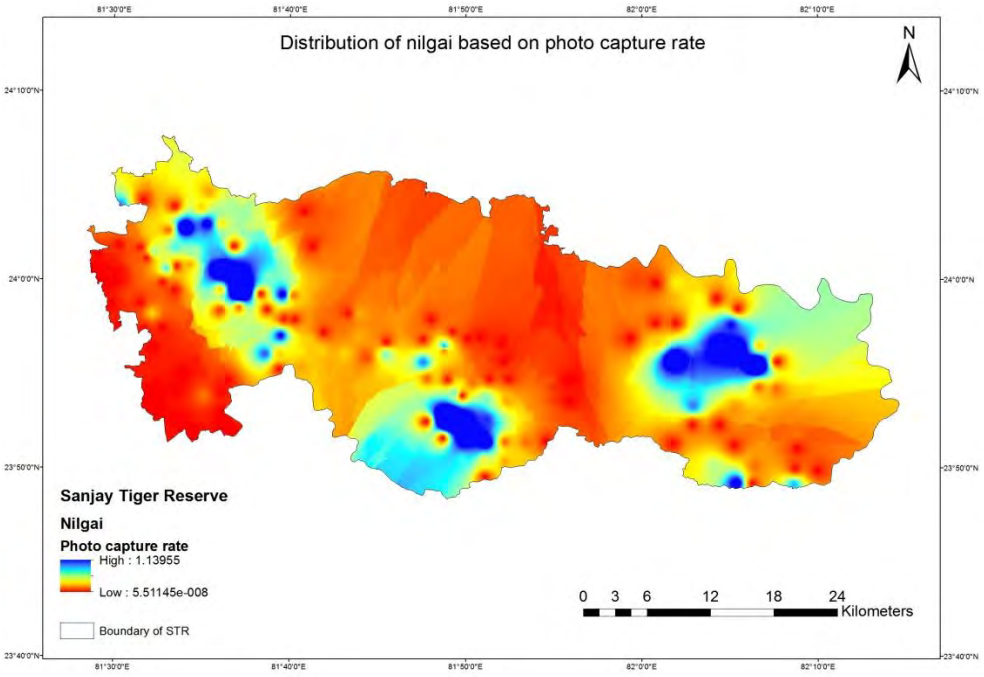
Photographs during radio-collaring of tigers

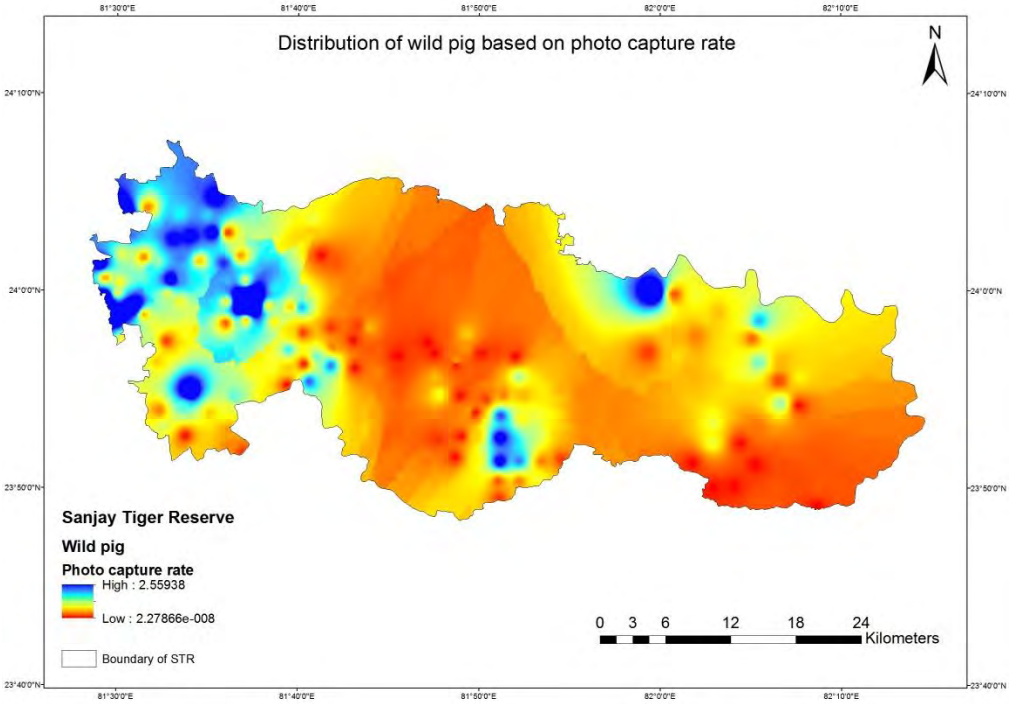
ANNEXURE-6

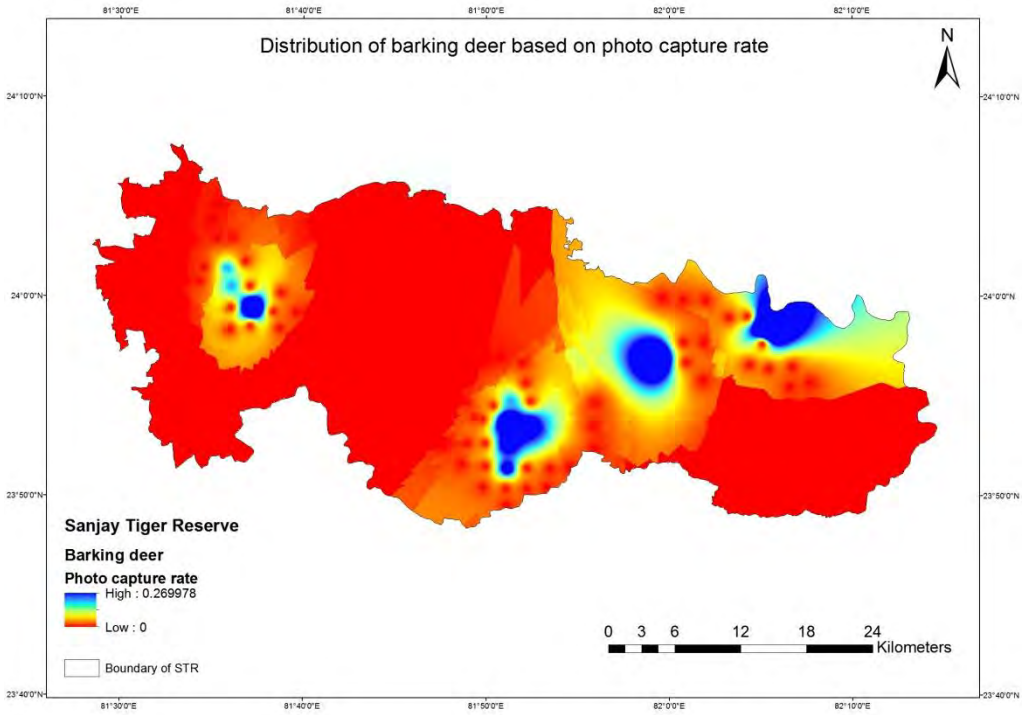
Distribution maps of prey species based on photographic capture rate

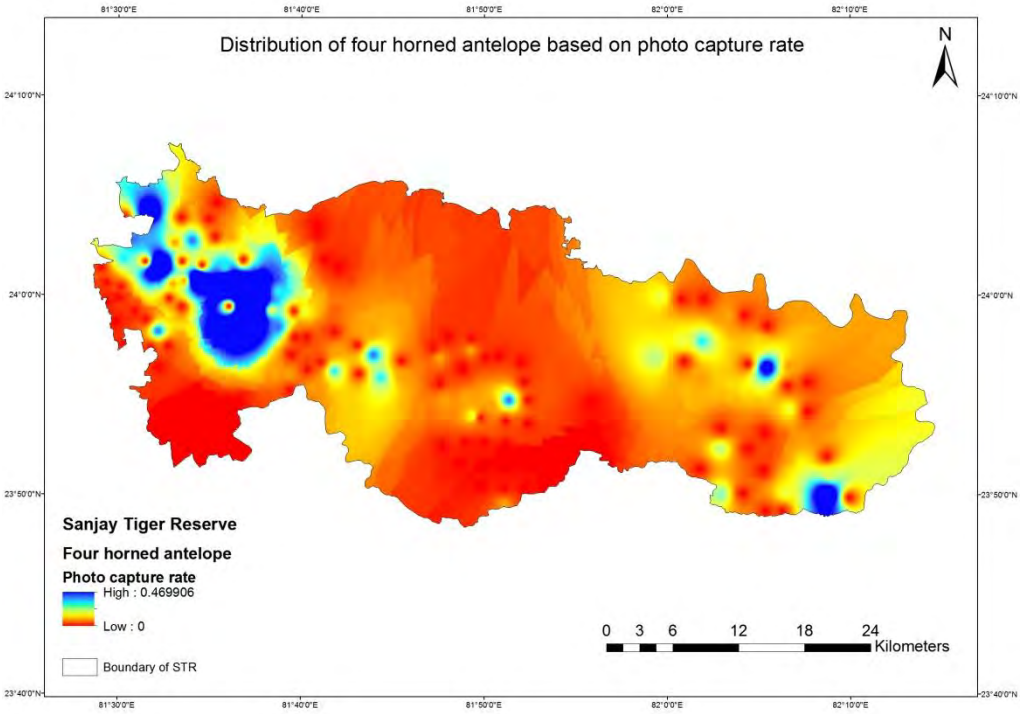


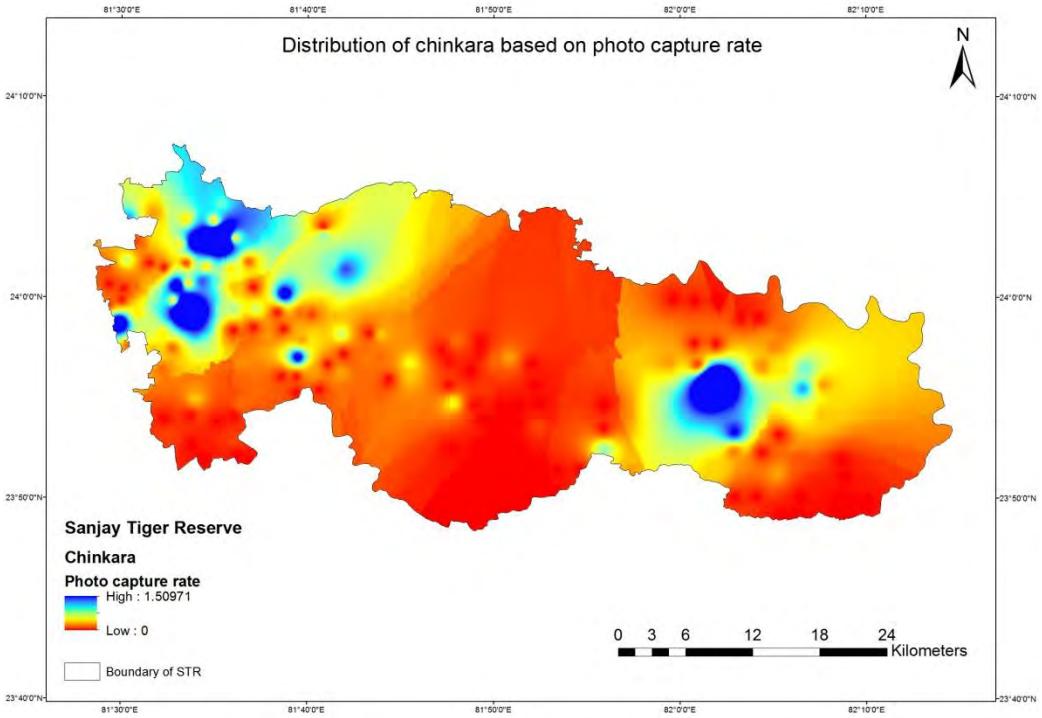


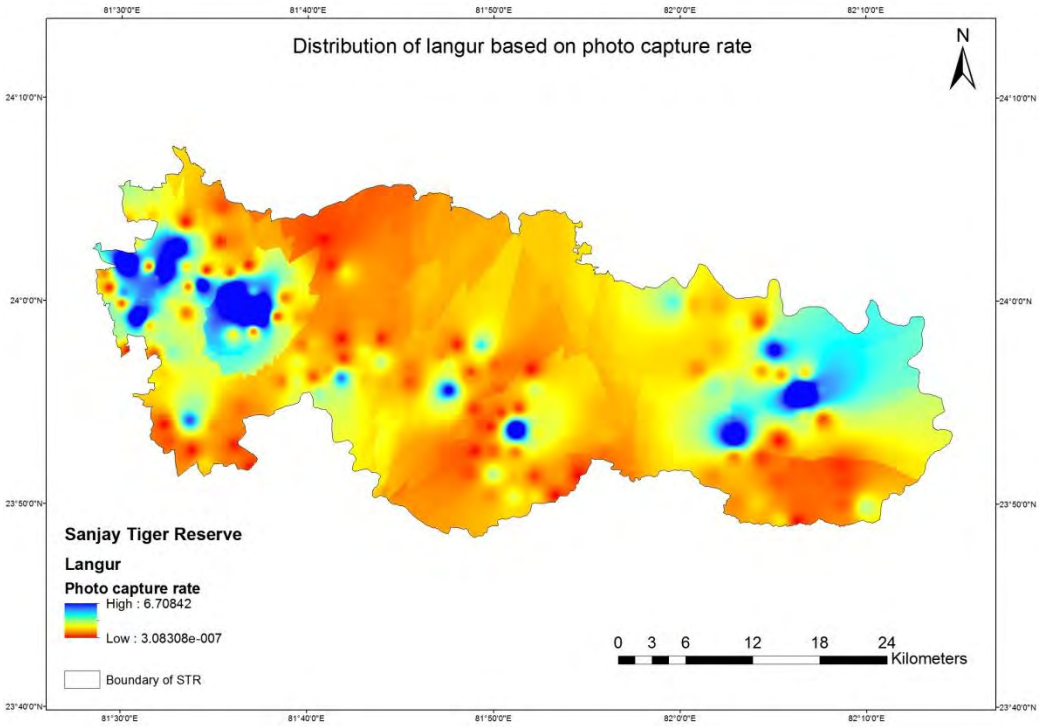

Distribution of nilgai based on photo capture rate
N
81°30'0"E
81°40'0"E
81°50'0"E
82°0'0"E
82°10'0"E
24°10'0"N
24°0'0"N
23°50'0"N
23°40'0"N
Sanjay Tiger Reserve
Nilgai
Photo capture rate
High : 1.13955
Low : 5.51145e-008
Boundary of STR
0 3 6 12 18 24
Kilometers

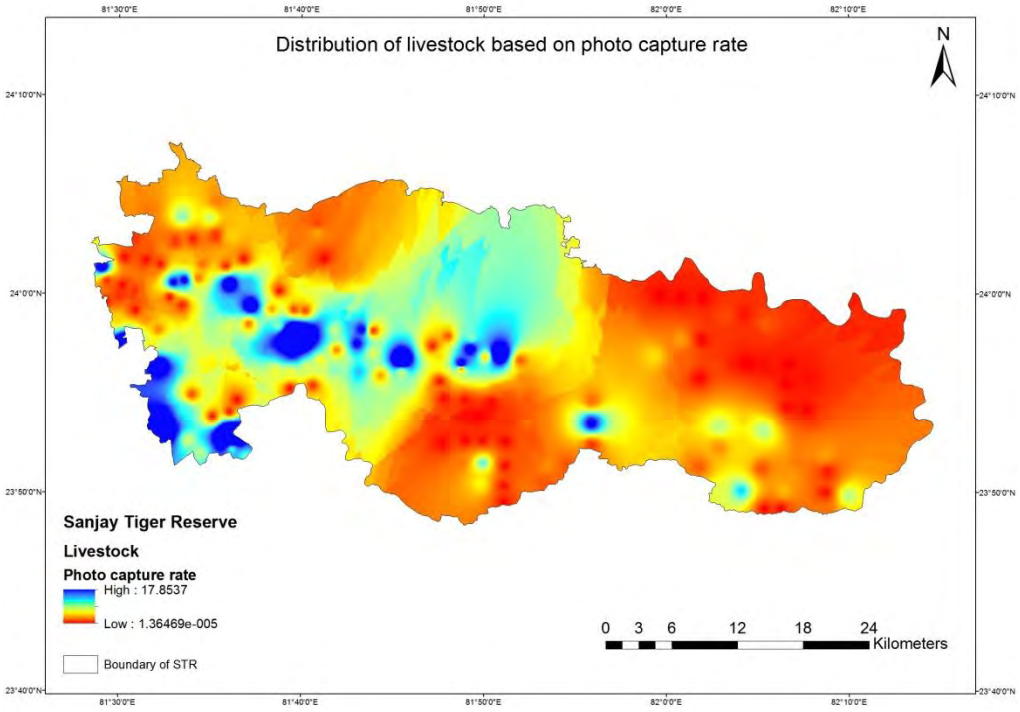

Distribution of wild pig based on photo capture rate
N
81°30'0"E
81°40'0"E
81°50'0"E
82°0'0"E
82°10'0"E
24°10'0"N
24°0'0"N
23°50'0"N
23°40'0"N
Sanjay Tiger Reserve
Wild pig
Photo capture rate
High : 2.55938
Low : 2.27866e-008
Boundary of STR
0 3 6 12 18 24
Kilometers


Distribution of barking deer based on photo capture rate
N
81°30'0"E
81°40'0"E
81°50'0"E
82°0'0"E
82°10'0"E
24°10'0"N
24°0'0"N
23°50'0"N
23°40'0"N
Sanjay Tiger Reserve
Barking deer
Photo capture rate
High : 0.269978
Low : 0
Boundary of STR
0 3 6 12 18 24
Kilometers


Distribution of four horned antelope based on photo capture rate
N
81°30'0"E
81°40'0"E
81°50'0"E
82°0'0"E
82°10'0"E
24°10'0"N
24°0'0"N
23°50'0"N
23°40'0"N
Sanjay Tiger Reserve
Four horned antelope
Photo capture rate
High : 0.469906
Low : 0
Boundary of STR
0 3 6 12 18 24
Kilometers


Distribution of chinkara based on photo capture rate
N
81°30'0"E
81°40'0"E
81°50'0"E
82°0'0"E
82°10'0"E
24°10'0"N
24°0'0"N
23°50'0"N
23°40'0"N
Sanjay Tiger Reserve
Chinkara
Photo capture rate
High : 1.50971
Low : 0
Boundary of STR
0 3 6 12 18 24
Kilometers


Distribution of langur based on photo capture rate
N
81°30'0"E
81°40'0"E
81°50'0"E
82°0'0"E
82°10'0"E
24°10'0"N
24°0'0"N
23°50'0"N
23°40'0"N
Sanjay Tiger Reserve
Langur
Photo capture rate
High : 6.70842
Low : 3.08308e-007
Boundary of STR
0 3 6 12 18 24
Kilometers


Distribution of livestock based on photo capture rate
N
81°30'0"E
81°40'0"E
81°50'0"E
82°0'0"E
82°10'0"E
24°10'0"N
24°0'0"N
23°50'0"N
23°40'0"N
Sanjay Tiger Reserve
Livestock
Photo capture rate
High : 17.8537
Low : 1.36469e-005
Boundary of STR
0 3 6 12 18 24
Kilometers

Check for updates

Research Article

Home range, habitat use and food habits of re-introduced gaur (*Bos gaurus gaurus*) in Bandhavgarh Tiger Reserve, Central India.

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Abstract:

Gaur, which became locally extinct before 1995 in Bandhavgarh Tiger Reserve (BTR), Central India, is an endangered animal per Schedule – I of the Indian Wildlife Protection Act (1972). A re-introduction program was therefore created to rebuild the gaur population in BTR, both to enhance the long-term survival of the species and to restore natural biodiversity. After re-introduction, the home range, habitat use and food habits of gaur (*Bos gaurus gaurus*) were studied in BTR, India, from January 2011 to January 2012. Nineteen gaurs (five males - three radio-collared and 14 females - nine radio-collared) were re-introduced from Kanha Tiger Reserve to Bandhavgarh Tiger Reserve in January 2011. The reintroduced gaurs were monitored periodically through ground tracking and satellite GPS fixes. The mean annual group size of gaur was estimated at 7.3 ± 0.76 (SE). The overall estimated summer, monsoon and winter home ranges of gaur were 290 km^2, 137 km^2 and 155 km^2 (Minimum Convex Polygon) respectively. The overall individual male home ranges varied from 135 to 142 km^2, and overall individual female home ranges varied from 32 to 169 km^2. Radio collared locations were plotted on a classified (LISS III) habitat map of Bandhavgarh Tiger Reserve to evaluate the habitat use and availability in each season. Habitat preference was computed using Bonferroni confidence interval method, compositional analysis and Ivlev's index. In summer, gaur largely preferred grassland ($P<0.0001$), whereas in monsoon and winter, gaur preferred bamboo mixed forest ($P<0.0001$). Gaur avoided open mixed forest ($P<0.0001$) and agricultural land in all three seasons. Data on food habits were collected through opportunistic sightings. In total, gaur fed on 68 plant species. The present study has reported first-time information on ranging patterns of reintroduced gaur and their degree of preferences for different vegetation and terrain types across seasons, which will be very useful to the park administration for future conservation of this endangered species and for habitat intervention.

Key words: Reintroduction, gaur *(Bos gaurus gaurus),* home range, habitat use, food habits, Bandhavgarh Tiger Reserve.

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Introduction

Gaur (*Bos gaurus gaurus*), family Bovidae, is one of the large wild ungulates of Asian jungles. Gaur is an endangered animal per Schedule – I of the Indian Wildlife Protection Act (1972). It is included in Appendix I of the Conservation on International trade in Endangered Species of Wild Fauna and Flora (CITES) and categorized as Vulnerable by the International Union for Conservation of Nature and Natural Resources (IUCN). Gaur is the tallest living ox [1], and one of the four heaviest land mammals (elephant, rhino and wild buffalo are the other three). Adult gaur bulls weigh 600-940 kg and stand 1.6 to 1.9 m at shoulder [2]. The adult cows are about 10 cm shorter in height [3] and weigh about one fourth less than the adult males [4]. Formerly gaur were distributed throughout the forested tracts of India and South Nepal, east to Vietnam and south to Malaya [5]. According to Ranjitsinh [6] the estimated population of gaur in India is between 12,000 and 21,000. Sankar et al. [7] estimated the gaur population in India to be approximately 23,500. Presently gaur occur in 101 existing and 27 proposed Protected Areas (PA's) of India covering 15 states. Tropical Moist Deciduous and Tropical Dry Deciduous forests are the dominant vegetation types within the present distribution limits of gaur [7].

The gaur population in India co-occurs with elephants (*Elephas maximus*) throughout its present distributional range, except in the Central Indian highlands, where elephants have become extinct [8]. Presently gaur are distributed in more or less isolated pockets, largely corresponding to the major mountain systems of the Western Ghats, the Central Indian highlands and the North-Eastern Himalayas, including the hills south of Brahmaputra. As ecosystem landscapers, gaur play an important role in the moist and dry deciduous forests in India, as they have a major impact on the physical structure of habitats, rates of ecosystem processes and the diversity of communities [9]. Also, mega-herbivores like gaur are important modifiers of ecosystem structure and function because they can trigger trophic cascades [10-11], increase spatial heterogeneity, accelerate successional processes [12] and influence nutrient cycling and primary productivity [13].

The last small population of gaur (30 to 32 individuals) migrated out of the Bandhavgarh Tiger Reserve (BTR) in 1995. This population was considered to be the only population north of the Narmada River, in Central India. The local extinction of gaur from the park also resulted in loss of biodiversity and decline in tourist numbers in the park [14]. Since BTR also has a considerable population of tigers (n~50), it was important to have gaur in the park as a prey species of tiger [14].

For the last two decades, captive breeding, reintroduction and translocation programs have become increasingly important conservation tools [15-16], although there are two important obstacles to re-establishing species: first, understanding the fundamental ecological requirements and life histories of species of concern [17], and second, identifying appropriate areas for reintroduction or restoration, given that degradation or modification can render native habitats unsuitable [18-19]. A study [20] showed that young rhino males do not adapt quickly to a new environment and hence are susceptible to high mortality, whereas adult and near adult males and females adapt faster. Another factor in the success of reintroductions is whether animals remain where they are released [21]. There are few reintroductions of mega-herbivores and herbivores reported, *viz.,* reintroduction of bison (*Bison bison*) into the rocky mountain parks of Canada [22], elk (*Cervus canadensis*) in America [23], reindeer (*Rangifer tarandus*) in Finland [24], white rhinoceros (*Ceratotherium simum*) in Botswana [25] and Asiatic One-horned Rhinoceros (*Rhinoceros unicornis*) in Dudhwa Tiger Reserve, Uttar Pradesh [26].

The re-introduction program to re-build the gaur population in Bandhavgarh Tiger Reserve (BTR) translocated and reintroduced an initial population of 20 animals, with subsequent supplementation of 30 more animals; the sex ratio was 60% females and 40% males. The simulations of gaur population viability analysis (PVA) showed that the probability of survival of reintroduced gaur in BTR is 0.9400

(0.023 SE). This program is the first successful mass trans-location of gaur in its entire distributional range. Following re-introduction of gaur in BTR, the present study was conducted from January 2011 to January 2012 with the following objectives: a) to estimate the home ranges of gaur in different seasons, b) to understand the habitat use and habitat preference of gaur in different seasons and c) to estimate the food habits of gaur.

Methods

Study area

Bandhavgarh Tiger Reserve lies on the extreme north-eastern border of the Madhya Pradesh state and the northern flanks of the eastern Satpura Mountain range (23°30' 08" to 23°47'05" N and 80°11'43" to 80°47'05" E). BTR consists of two conservation units: Bandhavgarh National Park (442.842 km^2) and the Panpatha Wildlife Sanctuary (245.842 km^2). The altitude of the park varies between 410 m and 811 m. The terrain is of rocky hills rising sharply from the swampy and densely forested valley in the low land. BTR lies within the tropical zone, having three distinct seasons. The area is characterized by well-defined winter (November-February), summer (March- June) and monsoon-post monsoon (July- October). During the study period, the lowest temperature reported was 2.2 °C in winter, and the highest was 44 °C in summer. Average rainfall is 1,173 mm, most of which occurs during the monsoon [27].

Vegetation of BTR falls under five categories [28]: moist peninsular low level sal (*Shorea robusta*) forest ($3C/C_{2e}$), northern dry mixed deciduous forest ($5B/C_2$), dry deciduous scrub (DS_1), dry grassland ($5/DS_4$) and West Gangetic moist mixed deciduous forest ($3C/C_{3a}$). Wild herbivores found are chital (*Axis axis)*, sambar (*Rusa unicolor)*, barking deer (*Muntiacus muntjak)*, nilgai *(Boselaphus tragocamelus)* and chinkara (*Gazella bennettii)*; large carnivores are tiger *(Panthera tigris)* leopard *(Panthera pardus*) and dhole (*Cuon alpinus*). The scavengers/ omnivores consist of striped hyena *(Hyaena hyaena)*, golden jackal (*Canis aureus*), wild pig *(Sus scrofa)* and sloth bear *(Melursus ursinus)*. Other small carnivores such as jungle cat (*Felis chaus*), rattle (*Mellivora capensis*), common mongoose *(Herpestes edwardsi*), ruddy mongoose (*H. smithi*), palm civet (*Paradoxurus hermaphroditus*) and small Indian civet (*Viverricula indica*) are also found. Primates such as common langur *(Semnopithecus entellus)* and rhesus monkey *(Macaca mulatta)*, and rodents/lagomorphs such as porcupine (*Hystrix indica)* and rufous-tailed hare *(Lepus nigricollis ruficaudatus)* occur in the park.

There are 15 villages (with human population of 6160 and livestock population of 11042) located inside the Tiger Reserve, of which seven are located in National Park and are due for relocation. Large numbers of domestic buffaloes (*Bubalus bubalis*) and a few domestic brahmini cattle (*Bos indicus*) are kept in the villages.

Capture and translocation of gaur

The action plan was prepared by the Madhya Pradesh Forest Department which envisaged capture and reintroduction of 20 gaur (15 adult females and 5 adult males) from KTR to BTR, Madhya Pradesh. It was proposed that after careful monitoring of the initial reintroduced stock, reintroduction of 30 more gaur to Bandhavgarh would be undertaken within two years to maintain a viable population of approximately 50+ animals [14].

Nineteen gaur, five males (three sub adults, two adults) and 14 females (one yearling, six sub adults, seven adults) were captured from KTR between 21st January and 27th January 2011 and re-introduced into BTR. Of these, 12 animals were fitted with radio collars: two adult males with GPS/satellite collars

and 10 individuals with VHF collars (one male and nine females). A holding Boma (enclosure for large herbivores; *Swahili* term, Mozambique) was designed at KTR where the immobilized animal would be released before eventually being loaded in the transport truck. The Boma was constructed of steel sections 2.5 m high by 3 m long made out of 50 mm x 75 mm x 3 mm rectangular hollow tubes. The Boma had three sliding gates 1.5 m wide and 2.5 m high sliding on a 3 m rail. The Boma had a loading ramp, which was a 3 m section made of solid pressed steel at 2.5 m height. The steel sections of the Boma beyond the sliding gate were covered with agri-mesh all the way up to the entrance of the truck. Since gaur are forest dwelling animals, this was done to give them a sense of having a space to hide in. Branches with foliage were hung on the wires running across the Boma. The Boma was divided into two compartments using bamboo mats and sliding gate, providing food, water and salt in the last compartment. Transport trucks and containers were designed according to the animals' needs. A stretcher was specially designed for carrying immobilized animals from the site of capture to the vehicle. A suitable site with good vegetation, cover and water was selected for the soft release of gaur at the borders of Tala and Magdhi ranges at BTR. The reintroduced gaur were released in a power-fenced 50 hectare plot in BTR. On 20th March 2011 the reintroduced gaur were released into the wild.

Home range

The radio-collared gaurs were monitored periodically through ground tracking, using "homing in" and "triangulation" techniques [29-31]. The satellite data up-link in both the satellite collars ceased functioning, one in August 2011 and the other in October 2011. Thereafter the gaur were tracked by VHF signals (ground tracking). The Minimum Convex Polygon (MCP) technique was used to determine the home-ranges of the gaur [32-34]. The interpretation and comparison of home-range size were measured by 100% MCP. The use of MCP was justified because of the sample size in a one year study period, and the temporally clustered nature of fixes that resulted in autocorrelation of results [35]. Accurate analyses using Fixed Kernel methods would not be suitable with this data set because they generally require larger samples with a more even distribution of the locations to maintain accuracy [36]. Minimum Convex Polygon (MCP) technique is one of the oldest techniques for home range estimation, comparable among species globally, and its inclusion as one or more methods of range calculation is therefore valuable [32-34]. Program CALHOME [37] and ArcGIS 9.2 (ESRI 2006) were used to estimate the home ranges of gaur. Home ranges of each individual in different seasons were estimated in the present study. Since gaur is a group living animal, the home ranges were also grouped by males and females to understand their overall seasonal home ranges.

Habitat use

All the radio telemetry locations from 12 radio-collared gaur were analyzed to evaluate the habitat use patterns. Season-wise gaur locations were plotted on the classified Landsat ETM+ imagery of BTR. On each collared location, the major vegetation and terrain type were recorded. Seven vegetation types were classified from Landsat ETM+ imagery: sal (*Shorea robusta*) forest, bamboo forest, open mixed forest, mixed forest, riparian forest, grassland and agriculture land [38]. Three major terrain types were categorised in the study area, *viz.,* flat, gentle slope and steep slope. Habitat use by gaur was estimated as the percent of locations found in each vegetation and terrain type. The 100% MCP home range represents the total area within which an animal has the opportunity to choose different vegetation types. Therefore, the availability of different vegetation types (percentage area) to a gaur was computed within its 100% MCP home range in a GIS domain [39]. Subsequently, habitat use (vegetation and terrain) of gaur in each season was computed using Bonferroni simultaneous confidence intervals and

Chi-square test [40], and the result was further validated by the preference rank of different vegetation types through compositional analysis [38] and Ivlev's electivity Index [41]. The analytical methods (Bonferroni simultaneous confidence intervals and compositional analysis) were conducted using the program RSW (Resource Selection Analysis Software for Windows) [42]. Each gaur was considered as a sample for statistical analysis [43].

Food habits

Data on food habits of gaur were collected by opportunistic sightings in all seasons whenever the animals were located using radio-telemetry. After direct observation through binoculars (8 X 40), on-site inspections were made to identify the food plants and parts eaten by gaur in the field. Total time spent for recording food habits data was 146 hrs in summer, 139 hrs in monsoon and 161 hrs in winter.

Results

Group size and composition

The group size of gaur varied from 1 to 19 individuals. The two gaur bulls (GM3 and GM5) were found solitary on many occasions (n=138) in all seasons (summer, monsoon and winter) and would join the family groups for a span of 10-15 days. The mean annual group size of gaur was estimated as 7.3 ± 0.8 (SE). The mean group size of gaur in summer was 9.5 ± 0.8 (SE), in monsoon 7.6 ± 1.4 (SE) and in winter 5.3 ± 1.2 (SE).

Home range of gaur

In total, 3972 locations of radio collared gaur were obtained, of which 1579 locations were males and 2393 locations were females (March 2011 to January 2012). The number of radio collared locations obtained and home ranges of individual gaur are given in Appendix 1. The month-wise utilized area (in km^2) by the gaur is given in Fig. 1.

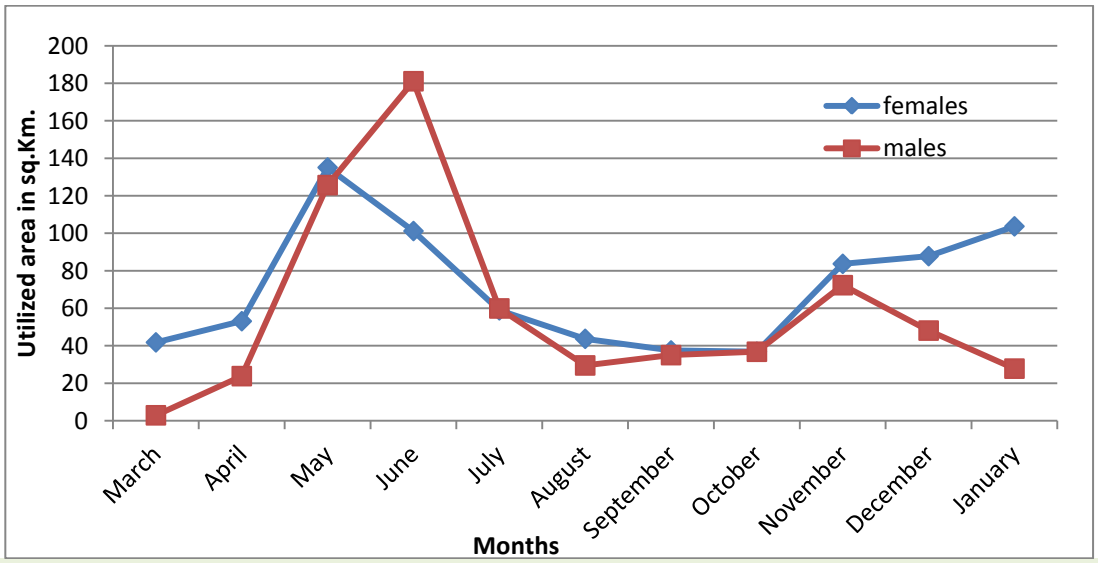

Fig. 1. Month-wise area of utilization of gaur in Bandhavgarh Tiger Reserve (March 2011- January 2012).

The estimated summer, monsoon and winter home ranges of the gaur were 290 km^2, 137.1 km^2 and 155 km^2 respectively. The overall home ranges of the males and females during the study period (March 2011 to January 2012) were 255 km^2 and 200 km^2, respectively, and the home-range overlap was 186 km^2 (Fig. 2). The summer (March 2011-June 2011) home ranges for males (n= 559) and females (n= 1338) were 231 km^2 and 161 km^2, respectively. In monsoon and post-monsoon (July 2011 to October 2011) the home ranges of males (n= 607) and females (n= 828) were 111 km^2 and 136 km^2 respectively. In winter (November 2011 to January 2012) the home ranges of males (n= 227) and females (n= 413) were 98 $km^2$and 152 km^2 respectively (Fig. 3). The overall individual male home ranges varied from 135 to 142 km^2 and overall individual female home ranges varied from 32 to 169 km^2.

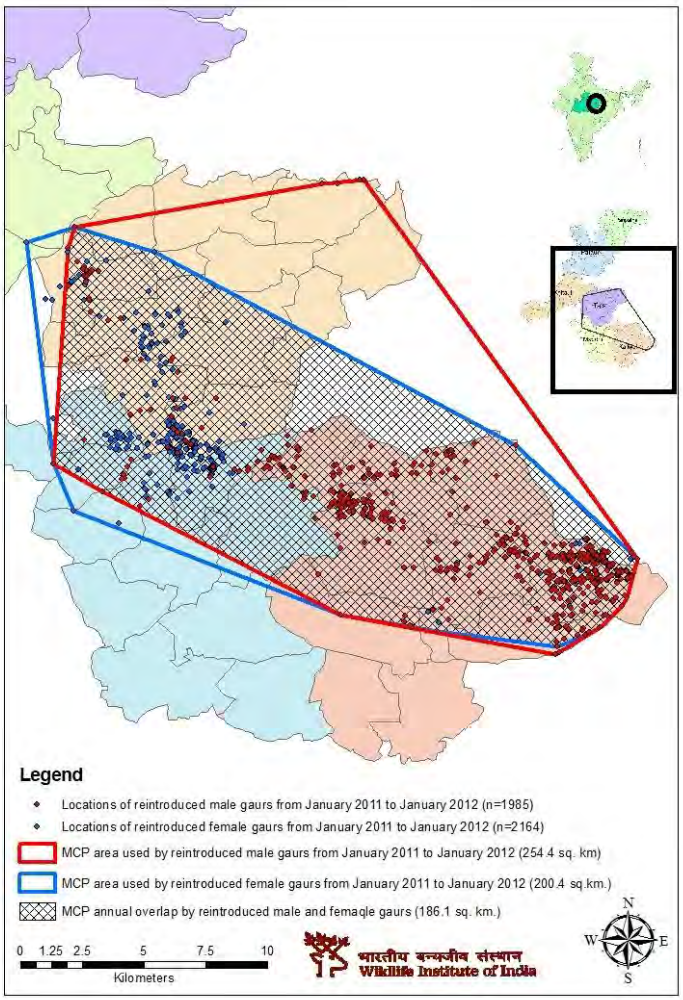

Fig.2. Overall home range of male and female gaur and their area of overlap in Bandhavgarh Tiger Reserve (March 2011- January 2012).

Natality and Mortality

There were four births during the study period, of which three calves survived. In total four animals died, of which two were collared females that died naturally. A sub-adult female was killed by a tiger on 4th June 2011. An un-collared female went missing from the park on 27th March 2011.

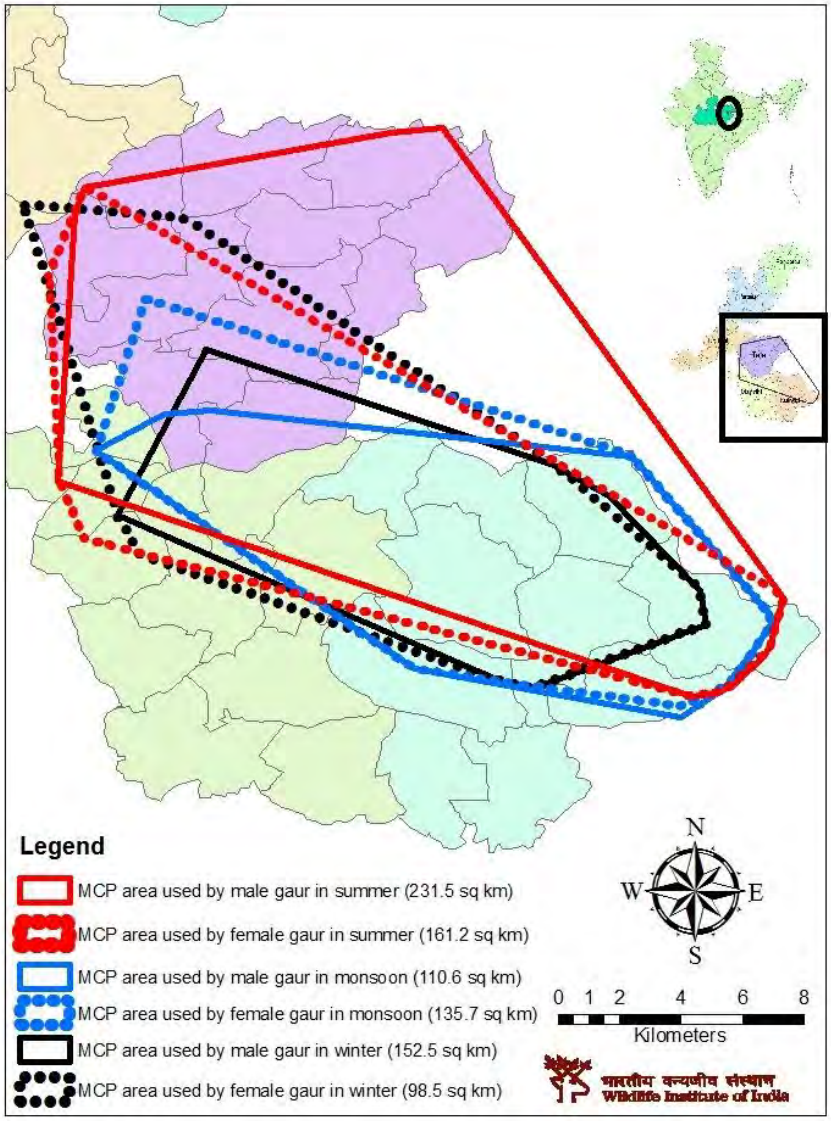

Fig. 3. Locations and home range of gaur season-wise (summer, monsoon and winter) in Bandhavgarh Tiger Reserve.

Habitat use by gaur

In summer, gaur used grassland ($P<0.001$) and sal forest ($P<0.001$) habitats more than their is availability; mixed forest ($P<0.001$), open mixed forest ($P<0.001$) and agricultural land ($P<0.001$) were less used than their availability; bamboo forest and riverine forest were used in proportion to their availability ($X^2=62.6731$, df= 6, $P<0.0001$, $\lambda= 0.0054$; Bonferroni simultaneous confidence intervals and Chi-square test) (Appendix 2). The summer habitat preference of gaur was in the following order: grassland> sal forest> bamboo forest> riparian forest> mixed forest> agricultural land> open mixed forest. In monsoon, gaur used bamboo forest ($P<0.001$) more than its availability; mixed forest ($P<0.001$), open mixed forest

(P<0.001) and agricultural (P<0.001) land less than their availability; grassland, sal forest and riparian forest were used in proportion to their availability (X^2=54.2351, df= 6, P<0.0001, λ= 0.028; Bonferroni simultaneous confidence intervals and Chi-square test) (Appendix 2). The monsoon habitat preference of the gaur was in the following order: bamboo forest >grassland> sal forest> mixed forest> riparian forest> open mixed forest> agricultural land. In winter, gaur used bamboo forest (P<0.001) more than its availability; grassland (P<0.001), sal forest (P<0.001), open mixed forest (P<0.001) and agricultural land less than their availability; mixed forest and riparian forest were used in proportion to their availability (X^2=33.0898, df= 6, P<0.0001, λ= 0.016; Bonferroni simultaneous confidence intervals and Chi-square test) (Appendix 2). The winter habitat preference of gaur was in the following order: bamboo forest> mixed forest> riparian forest> sal forest> grassland> open mixed forest> agricultural land. Ivlev's electivity Index provided identical results as compositional analysis for ranking of preference of different habitats by gaur in BTR (Appendix 3).

Gaur mostly used flat terrain (65%) compared to gentle slope (28%) and steep slope (7%). The use of undulating terrain by gaur increased in monsoon and winter compared to summer. The use of terrain with a gentle slope went up from 25% in summer to 45% in winter. Gaur used flat terrain mostly in summer (71%) followed by monsoon (63%) and winter (51%). The steep slope was used by gaur mostly in monsoon (12%) followed by winter (4%) and summer (4%).

Food habits

In total 68 plant species were consumed by gaur (Appendix 4). Among the food plants eaten the number of tree species were maximum (n=28) followed by grass (n=21), herbs (n=10), shrubs (n=6) and climbers (n=3). The number of tree species in the diet of gaur was considerably higher in summer (n=22) than in monsoon (n=11) and winter (n=9). On the other hand, the number of grass species consumed by gaur was higher in monsoon (n=14) than in summer (n=10) and winter (n=9). Five incidences of de-barking of sal (*Shorea robusta*) and three incidences of de-barking of mahuwa (*Madhuca indica*) by the gaur were recorded in peak summer.

Discussion

The group size of gaur may range from 1 to 16 animals [1, 7, 44-46] and occasionally up to 40 individuals [47-48]. In Pench Tiger Reserve the observed mean group size of gaur was highest in winter (5.6 ± 0.42), followed by monsoon (4.6 ± 0.29) and summer (3.9 ± 0.14), and significant differences in the group sizes between summer and monsoon were reported [7]. In Mudumalai Tiger Reserve, the overall mean group size of gaur was 9.8 ± 7.6, while in dry season it was 8.7 ± 6.2 and in wet season it was 10.2 ± 7.9 [49]. In Parambikulam Wildlife Sanctuary the mean group size of gaur was 6.0 [50]. In the present study there was no significant difference observed in the gaur group size in different seasons. Hence, it can be assumed that different seasons played a negligible role in determining group size of gaur in BTR.

It was observed that the relocated gaur initially (March 2011 to June 2011) utilized an area of 290 km^2 after their reintroduction, and subsequently their ranges were reduced to 160 km^2 after exploration of new areas. In Pench Tiger Reserve, the home range of male gaur was 12.6 km^2 and 7.6 km^2 in summer and monsoon respectively, while in the present study, the home ranges of male gaur were much larger. The home ranges of female gaur in Pench Tiger Reserve were 7.2 km^2 and 13.8 km^2 in summer and monsoon respectively, while in the present study, the home ranges of female gaurs were much higher. The observed smaller home ranges of gaur males and females in all seasons in Pench Tiger Reserve may be attributed to the availability of food resources and water through the year [7]. In BTR, gaur were found to utilize grasslands more during summer and bamboo forest more in monsoon and winter. Gaur

is a generalist feeder but prefers to browse in dry season and predominantly graze in monsoon [49]. Riparian forest was used by the gaur according to its availability in all the seasons, because a number of perennial streams and artificial waterholes are found in riparian forests which serve as the major source of water in the Park. Open mixed forest was avoided by gaur in all seasons, as it lacks food resources and water. Agricultural land was avoided by gaur in all seasons because of anthropogenic disturbance. In Kanha Tiger Reserve gaur frequently used the meadows and low-lying areas during most part of the year except monsoon, when the animals moved up and dispersed into the hills [47]. In Bandhavgarh also the gaur used areas with steep slope more in monsoon than in summer and winter.

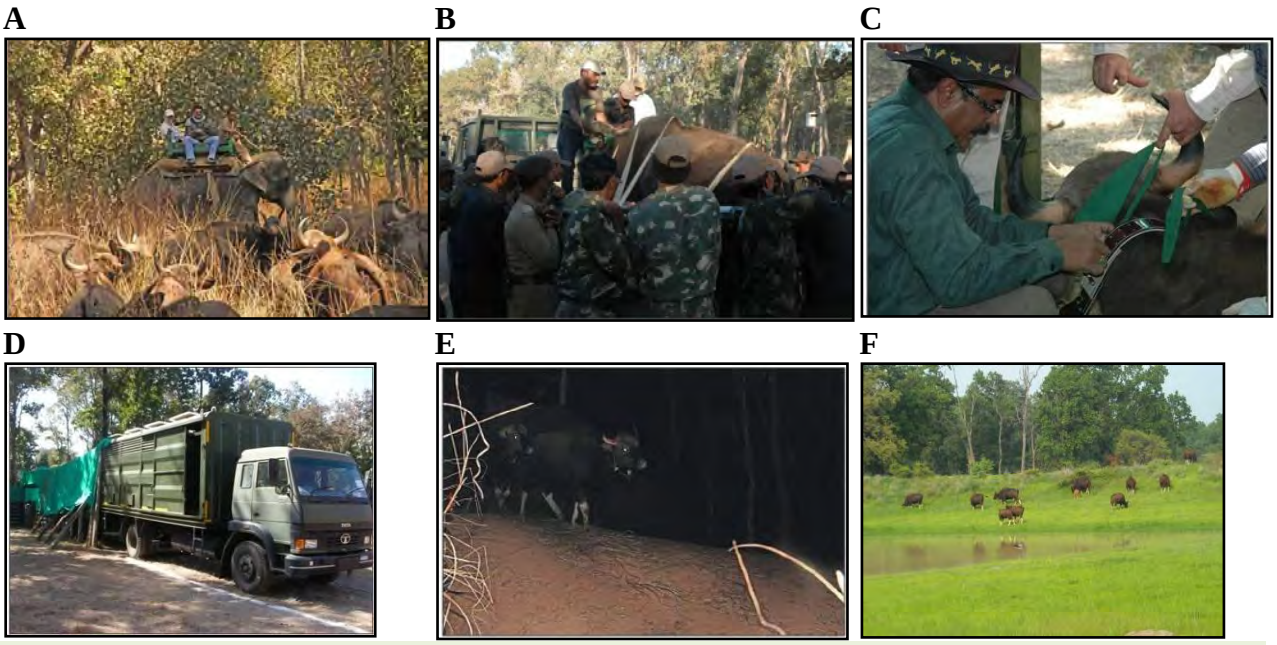

Fig. 4. A: Gaur Capture in Kanha Tiger Reserve; B: Gaur shifting into a small truck in Kanha Tiger Reserve; C: Fitting of radio-collar on gaur at Kanha Tiger Reserve.; D: Truck used to transport gaur from Kanha TR to Bandhavgarh TR.; E: Gaur released in an enclosure at Bandhavgarh Tiger Reserve; F: A herd of free ranging gaur in Bandhavgarh TR. PHOTO CREDITS – By Authors

Gaur have been reported to feed on the bark of trees such as *Adina cordifolia* and *Tectona grandis* in many areas throughout central India [47, 51]. In dry seasons, a high fibrous diet increases digestive efficiency by increasing the retention time of food in the gut [52] and also by increasing the turnover rate of the rumen content [53]. Incidences of de-barking of trees by gaur were rare in BTR, perhaps because even in summer considerable green foliage (trees/shrubs/bamboo) is available in the park.

Village relocation plays a major role in reducing the anthropogenic pressures on the forest area and is highly beneficial to wild animals [54]. In BTR there are 15 villages with large livestock populations located inside the National Park. Two villages in Kallwah range (Kallwah and Kumuruwah) from the National Park were successfully relocated in June 2011, which can set an example to expedite relocation of the remaining villages. Since August 2011, gaurs have been observed using these relocated village sites and hence creation of more such vacated habitats is vital for conservation of this species. Gaur are highly susceptible to transmission of infections from domestic livestock, and there are many records of populations of gaur succumbing to epidemics of foot and mouth disease (FMD), rinderpest and anthrax

in various parts of its distributional range [55]. There is a need to implement a wide vaccination program for the domestic livestock in and around BTR, to prevent the transmission of livestock diseases to gaur.

Implications for Conservation

The known extinction of gaur from three protected areas in India (Thattakad Wildlife Sanctuary, Kerala; Bhandhavgarh Tiger Reserve and Kanger Valley National Park, Madhya Pradesh) in the last two decades shows that this species is losing ground very fast and urgent measures are required to stem the process. Therefore, conservation requires active programs like reintroduction and reestablishment of important species in the areas where they have been recently lost, with or without habitat related interventions. Hence, the gaur reintroduction program in Bandhavgarh Tiger Reserve is an important attempt to re-establish a gaur population in an area that was once part of its historical range, from which it was locally extirpated in the recent past (Fig. 4). The present study takes a successful step towards the conservation of this large bovid, providing first-time information on ranging patterns of gaur and their degree of preferences for different vegetation and terrain types in different seasons. Such information will be very useful to the park administration for conservation of this endangered species and for habitat intervention, if needed. Per the proposed supplementation plan, 31 more gaur (nine males and 22 females) were reintroduced in BTR during March 2012 to establish a viable population of 50 animals.

A long-term study on ecological aspects such as ranging pattern, habitat use, food habits and predation of the reintroduced gaur in BTR will be crucial for the conservation and management of this endangered bovid. Also, the protocol prepared for gaur capture, chemical immobilization and transportation [14] will be highly useful for managers and conservationists in planning and execution of similar reintroduction program of mega-herbivores in their entire distributional range.

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Appendix 1. Home ranges of individual gaur in different seasons (summer, monsoon and winter) in Bandhavgarh Tiger Reserve.

Gaur ID	Summer	Monsoon	Winter			
	Home range (km^2)	Number of locations	Home range (km^2)	Number of locations	Home range (km^2)	Number of locations
GF1	44.5	196	108.7	207	83.4	81
GF3	44.5	194	108.7	207	95.9	81
GF5	33.1	119	xx	-	-	-
GF6	110.4	106	^^	-	45.8	86
GF7	106.5	106	xx	-	-	-
GF8	106.5	164	108.7	207	95.9	81
GF9	110.6	139	^^	-	^^	-
GF10	44.5	178	108.7	207	95.9	84
GF14	123.6	136	^^	-	^^	-
GM1	44.5	196	108.7	207	95.9	81
GM3	45.2	196	108.7	207	87.7	79
GM5	231.5	167	110.6	193	95.3	67

Note: GF= Gaur female; GM= Gaur male; 'xx'= animal dead; '^^'= animal was kept inside enclosure.

Appendix 2. Preference of different vegetation types by gaur in Bandhavgarh Tiger Reserve as shown by Bonferroni simultaneous confidence interval analysis.

Habitat types	Proportion use		Proportion available	Preference	Significance
	Lower limit	Upper limit			
Summer					
Agriculture land	0.0000	0.0112	0.0148	Used less than availability	
Bamboo forest	0.1412	0.1996	0.1862	Used in proportion to availability	
Grassland	0.3573	0.4332	0.0935	Used more than availability	P < 0.0001
Mixed forest	0.1406	0.1989	0.4535	Used less than availability	P < 0.0001
Open mixed forest	0.0087	0.0301	0.0659	Used less than availability	P < 0.0001
Riparian forest	0.0079	0.0287	0.0278	Used in proportion to availability	
Sal forest	0.1893	0.2537	0.1582	Used more than availability	P < 0.0001
Monsoon					
Agriculture land	0.0000	0.0000	0.0134	Used less than availability	
Bamboo forest	0.3525	0.4523	0.1758	Used more than availability	P < 0.0001
Grassland	0.0757	0.1386	0.0942	Used in proportion to availability	

Mixed forest	0.2556	0.3490	0.4745	Used less than availability	P < 0.0001
Open mixed forest	0.0000	0.0000	0.0557	Used less than availability	P < 0.0001
Riparian forest	0.0087	0.0401	0.0398	Used in proportion to availability	
Sal forest	0.1261	0.2014	0.1466	Used in proportion to availability	
Winter					
Agriculture land	0.0000	0.0000	0.0142	Used less than availability	
Bamboo forest	0.3201	0.4117	0.2035	Used more than availability	P < 0.0001
Grassland	0.0094	0.0386	0.0976	Used less than availability	P < 0.0001
Mixed forest	0.4248	0.5198	0.4314	Used in proportion to availability	
Open mixed forest	0.0000	0.0000	0.0494	Avoided	P < 0.0001
Riparian forest	0.0062	0.0323	0.0245	Used in proportion to availability	
Sal forest	0.0878	0.1493	0.1795	Avoided	P < 0.05

Appendix 3. Preference of different habitat types by reintroduced gaur in Bandhavgarh Tiger Reserve as shown by Ivlev's Selectivity Index analysis.

	Summer			Monsoon			Winter		
	Use	Availability	Ivlev's Index	Use	Availability	Ivlev's Index	Use	Availability	Ivlev's Index
Agriculture land	6.55	17.61	-0.45778	0	9.37	-1	0	11.39	-1
Bamboo forest	204.44	221.76	-0.04064	281.68	123.09	0.391803	292.71	162.77	0.285281
Grassland	474.29	111.39	0.619622	75.03	65.94	0.064482	19.2	78.09	-0.6053
Mixed forest	203.73	340.06	-0.45218	211.6	332.2	-0.22177	377.87	345.09	0.045341
Open mixed forest	23.26	78.53	-0.54298	0	38.96	-1	0	39.49	-1
Riparian forest	21.92	33.06	-0.20262	17.08	27.87	-0.24004	15.38	19.57	-0.11989
Sal forest	265.8	188.38	0.170461	114.61	102.61	0.055244	94.86	143.59	-0.20436

Appendix: 4. Food plants and parts eaten by gaur in Bandhavgarh Tiger Reserve (January 2011 to January 2012).

Family	Species	Parts eaten	Season
Trees			
Rutaceae	*Aegle marmelos*	Le	S
Leguminoseae	*Albizzia procera*	Le	S
Combretaceae	*Anogessus latifolia*	Le	S
Leguminoseae	*Bauhinia Racemosa*	Le	S
Burseraceae	*Boswellia serrata*	Le	M, W
Euphorbiaceae	*Bredelia retusa*	Le	S
Anacardiaceae	*Buchanania lanzan*	Le	M
Leguminoseae	*Butea monosperma*	Le	S, M, W
Meliaceae	*Chlorozylon swetiena*	Le	W
Fabaceae	*Cassia fistula*	Le	M
Poaceae	*Dendro calamus strictus*	Le	S, M, W
Ebenaceae	*Diospyros melanoxylon*	Le	S, M
Moraceae	*Ficus hispida*	Le	S
Bixaceae	*Flacourtia ramontchi*	Le	S, M
Tiliaceae	*Grewia tiliifolia*	Le	S
Apocynaceae	*Holarrhena antidysenterica*	Le	S
Sapotaceae	*Madhuca indica*	Le, Fu, Fl	S, M, W
Rubiaceae	*Mitragyna parviflora*	Le	S
Euphorbiaceae	*Phyllanthus emblica*	Le, Fu	S
Dipterocarpaceae	*Shorea robusta*	Le, Br	S, M, W
Myrtaceae	*Syzygium cumini*	Le, Fu	S, M
Combretaceae	*Terminalia chebula*	Le	W

Family	Species	Parts eaten	Season
Combretaceae	*Terminalia arjuna*	Le, Br	S
Combretaceae	*Terminalia tomentosa*	Le	S
Labiateae	*Vitex sps.*	Le	S
Apocynaceae	*Wrightia tinttoria*	Le	W
Rhamnaceae	*Zizyphus mauritiana*	Le, Fu, Br	S, M, W
Rhamnaceae	*Zizyphus xylopyra*	Le, Fu	S
Shrubs			
Colchicaceae	*Gloriosa sps.*	Le	M, W
Verbinaceae	*Lantana camara*	Le	S, M
Fabaceae	*Mimosa hamata*	Le	M
Arecaceae	*Phoenix acaulis*	Le	S
Rubiaceae	*Randia dumetorum*	Le	S
Lytharaceae	*Woodfordia floribunda*	Le	S, M, W
Herbs			
Asparagaceae	*Asparagas racemosus*	Sh	S
Cyperaceae	*Bulbostylis barbata*	Sh	M, W
Leguminoseae	*Cassia tora*	Sh	S, M
Cyperaceae	*Cyperus sps.*	Sh	M, W
Leguminosae	*Desmodium heterocarpus*	Sh	M, W
Fabaceae / Leguminosae	*Desmodium pulchellum*	Sh	M, W
Euphorbiaceae	*Euphorbia hirta*	Sh	S
Lamiaceae	*Leucas aspera*	Sh	M
Lamiaceae	*Leucas biflora*	Sh	M, W
Lamiaceae	*Ocimum tenuiflorum*	Sh	M
Grasses			
Amaranthaceae	*Achyranthes aspera*	Sh	M, W
Poaceae	*Andropogon sps.*	Sh	S

Family	Species	Parts eaten	Season
Poaceae	*Apluda mutica*	Sh	S
Poaceae	*Aristida sps.*	Sh	S
Poaceae	*Chloris dolichostachya*	Sh	S, M, W
Poaceae	*Cynodon dactylon*	Sh	S, M, W
Poaceae	*Dicanthium sps.*	Sh	S
Poaceae	*Digitaria setigera*	Sh	M, W
Poaceae	*Eragrostis tenella*	Sh	M
Poaceae	*Heteropogon contortus*	Sh	M, W
Cyperaceae	*Lipocarpha chinensis*	Sh	M
Poaceae	*Oplismenus sps.*	Sh	S
Poaceae	*Paspalidium flavidum*	Sh	M
Poaceae	*Saccharum spontaneum*	Sh	M, W
Poaceae	*Setaria glauca*	Sh	M
Poaceae	*Seteria pumila*	Sh	M
Poaceae	*Sorghum halepense*	Sh	S
Poaceae	*Sporobolous pulchelus*	Sh	W
Poaceae	*Themeda triandra*	Sh	S, M, W
Gramineae	*Thysanolaena maxima*	Sh	M
Poaceae	*Vetiveria zizanioides*	Sh	S, M, W
Climbers			
Rhamnaceae	*Zizyphus oenopila*	Le, Br	W
leguminoseae	*Butea supreba*	Le, Br	W
Fabaceae	*Bauhinia vahlii*	Le, Br	S, M, W

Le-Leaves; Br-Bark; Fr- fruits; Fl- Flowers; Sh- Shoot; S -Summer; M - Monsoon; W – Winter.

Home Range & Space Use:
10 Years of Monitoring of Sariska Tigers

2008 - 2018

भारतीय वन्यजीव संस्थान
Wildlife Institute of India

Rajasthan Forest Department

Home Range & Space Use: 10 Years of Monitoring of Sariska Tigers

NTCA Funded Project Titled “Monitoring of Re-Introduced Tigers *Panthera tigris tigris* in Sariska Tiger Reserve, Rajasthan”

2008 - 2018

भारतीय वन्यजीव संस्थान
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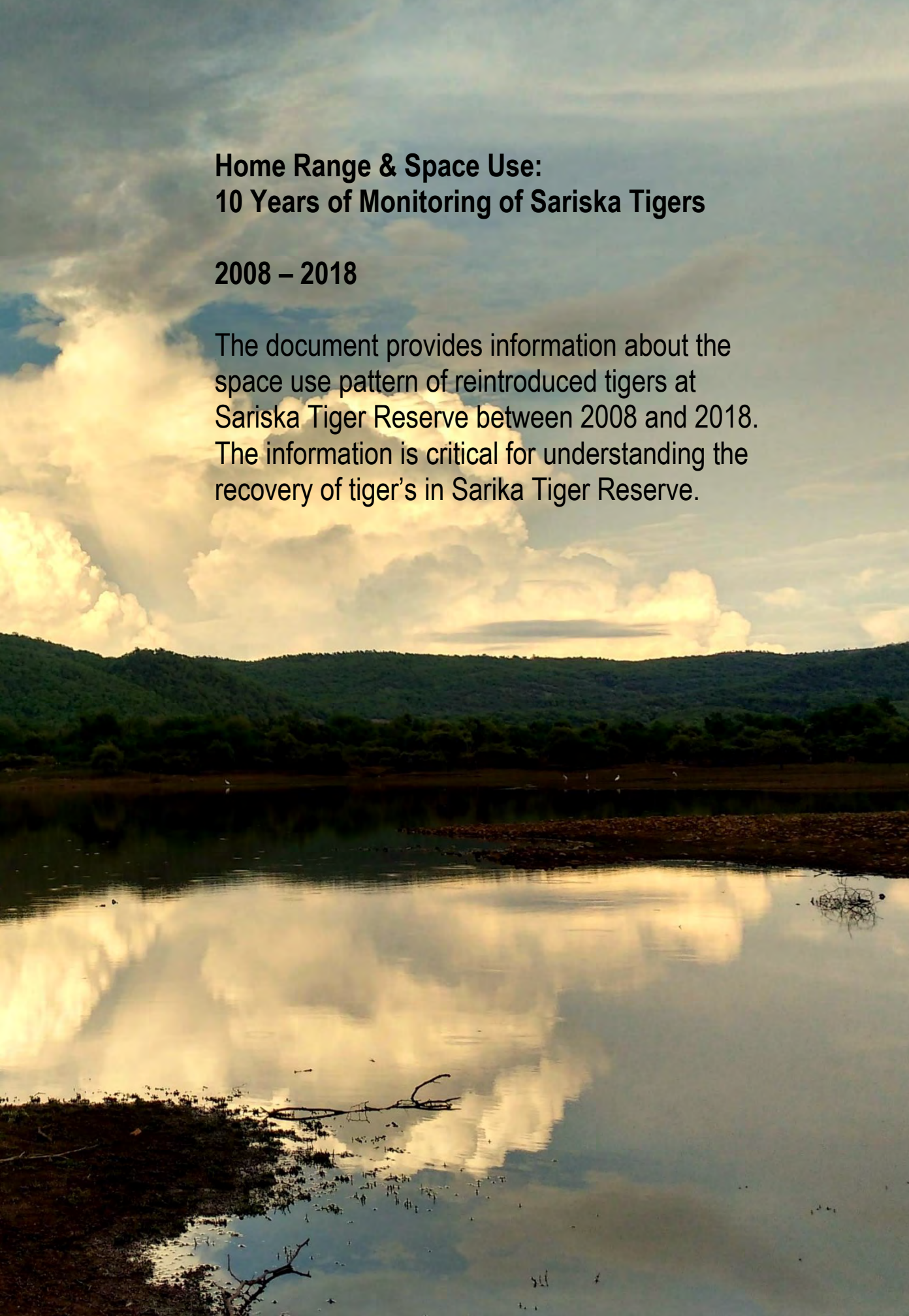


Home Range & Space Use:
10 Years of Monitoring of Sariska Tigers

2008 – 2018

The document provides information about the space use pattern of reintroduced tigers at Sariska Tiger Reserve between 2008 and 2018. The information is critical for understanding the recovery of tiger's in Sarika Tiger Reserve.

Sariska Tiger Reserve

Sariska Tiger Reserve, nestled in the oldest hill range of the Indian sub-continent, the **Aravalli** is home to variety of fauna and flora. The Reserve is situated in the North Eastern province of Rajasthan and has been the western-most limit of tiger occupancy in the country. The protected area comprises of scrub-thorn arid forests, rocky landscapes, dry deciduous forests, rocks, grasses, valleys and hilly cliffs that represent the Northern tropical dry deciduous forest and northern tropical thorn forest (Champion & Seth, 1968).

Spread across 1200 km^2, the reserve has a habitat matrix of protected area interspersed with human agricultural landscapes.

Pre-independence: Game Reserve of the Maharaja of the erstwhile state of Alwar (Johari, 2003).

7th November 1955: Sariska declared as a Wildlife Reserve under the Rajasthan Wild Animals and Birds Protection Act, 1951 and upgraded to a Sanctuary in 1958.

1978: Declared Project Tiger Reserve (11th TR) by the Govt. of India.

1982: An area of 274 km^2 declared, as Sariska National Park vide preliminary notification No. F11 (22) Raj-8/78 Jaipur dated 27 August 1982 under the Wild Life Protection Act, 1972 (Central Act No. 53) section 35 (1).

The reserve encompasses an area of 1200 km^2 and includes 881.11 km^2 core and 383.11 km^2 buffer (TCP, 2016).

400.11 km^2 National Park, 492 km^2 Sariska Wildlife Sanctuary (proposed National Park) and 383.11 km^2 of other forests (Reserved, unclassed and protected forests) (Jhala, 2011).

Note: 394.00 km^2. of Sariska Wildlife Sanctuary is overlapping with area of Sariska National Park.

Champion, S. H., & Seth, S. K. (1968). A revised survey of the forest types of India. A revised survey of the forest types of India.

Johari R (2003). Of sanctions and sanctuary-making: the cultural politics of nature in Sariska Tiger Reserve, Rajasthan, India, 1850–2000 Unpublished MS thesis, York University, Canada

Jhala, Y., Qureshi, Q., & Gopal, R. (2011). Can the abundance of tigers be assessed from their signs?. Journal of Applied Ecology, 48(1), 14-24

Sankar, K., 1994. The ecology of three large sympatric herbivores (chital, sambar, nilgai) with special reference for reserve management in Sariska Tiger Reserve, Rajasthan. PhD Thesis. University of Rajasthan.

Tiger Conservation Plan 2016 – Sariska Tiger Reserve

VEGETATION / FAUNA

Anogeissus pendula is the dominant tree species covering over 40 per cent area of the forest. *Boswellia serreta* and *Lannea coromandelica* grow on rocky patches while *Acacia catechu* and bamboo are common in the valleys besides *Butea monosperma and Zizyphus mauritiana. Albizia lebbeck, Diospyros melanoxylon, Holoptepia integrifolia* and *Ficus spp*. are mainly found in moist areas of the Reserve (Sankar, 1994).

Sariska has a rich faunal diversity that includes the chital (*Axis axis*), sambar (*Rusa unicolor*), nilgai (*Boselaphus tragocamelus)* wild pig (*Sus scorfa)* and jackal *(Canis aureus) as the major herbivores*. The large carnivores include tigers (*Panthera tigris*), leopard (*Panthera pardus*), striped hyaena *(Hyaena hyaena)* besides small carnivores including caracal (*Caracal caracal*), jungle cat (*Felis chaus*), common mongoose *(Herpestes edwardsi*), small Indian mongoose (*H. auropunctatus*), ruddy mongoose (*H. smithi*), palm civet (*Paradoxurus hermaphroditus*), small Indian civet (*Viverricula indica*) and ratel (*Mellivora capensis*). Rhesus macaque (*Macaca mulatta*) and common langur (*Semnopithecus entellus*) are the two primates. Procupine (*Hystrix indica*), rufous tailed hare (*Lepus nigricollis ruficaudatus*) are also found in the Reserve. Sariska also holds rich diversity of birds including some winter migrants. A total of 211 species of birds have been recorded, of which 120 are resident, 73 migrant visitors and 18 vagrants.

CULTURAL VALUES

STR has a rich cultural and archaeological values. The Pandupole temple, which is one of the major attractions to the tourists, is one of the few Hanuman (Monkey God) temple in the country with a lying deity. Another attraction is the Kankwadi fort that was built by Maharaja Jai Singh II of Jaipur, and later conquered by Mughal Emperor Aurangzeb, where he imprisoned his eldest brother Dara-Shikoh during the struggle for succession of the throne. Neelkanth temple perched on a plateau above the hills near Rajgarh village is an abode of Lord Shiva located in the buffer zone of Reserve has a fairly high tourist fall. The temples are overlooked by the silhouette of Rajorgarh Fort. Located on the outskirt of STR is the Bhangarh Fort built in the 17th century Sh. Man Singh I, for his son Madho Singh I with historic importance.

Sariska lost all its tigers in 2004 due to poaching. As a population building exercise and to ensure integrity of the habitat, an initiative of repopulating tigers in the reserve was undertaken jointly by the Rajasthan Forest Department, National Tiger Conservation Authority and the Wildlife Institute of India. A ‘Species Recovery Plan for Tigers’ was prepared in 2005 and eight tigers were successfully reintroduced from Ranthambore Tiger Reserve between 2008 and 2013.

Sariska: Road to Recovery

2008
- 28th June 2008: Adult Male ST 1
- 4th July 2008: Adult Female ST2

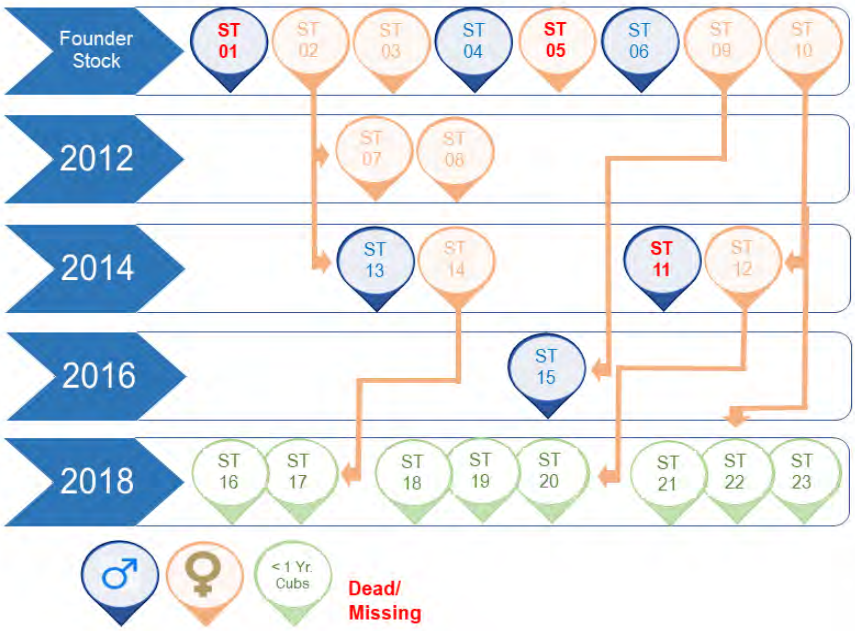
2009
- 25th February 2009: Adult Female ST3

2010
- 20th July 2010: Adult Male ST4
- 28th July 2010: Adult Female ST5

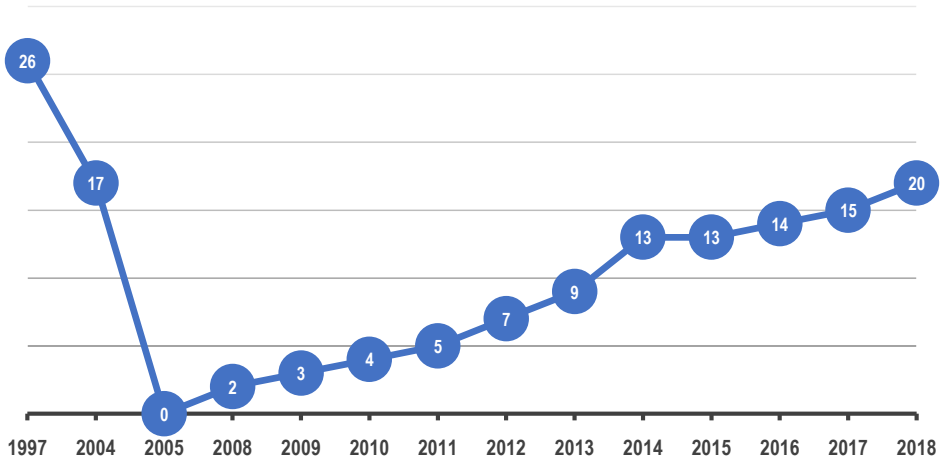
2011
- 23rd February 2011: Adult Male ST6

2013
- 22nd Jan. 2013: Young Adult female ST 9
- 23rd Jan. 2013: Young Adult female ST10

Details of Tiger Litters in Sariska Tiger Reserve

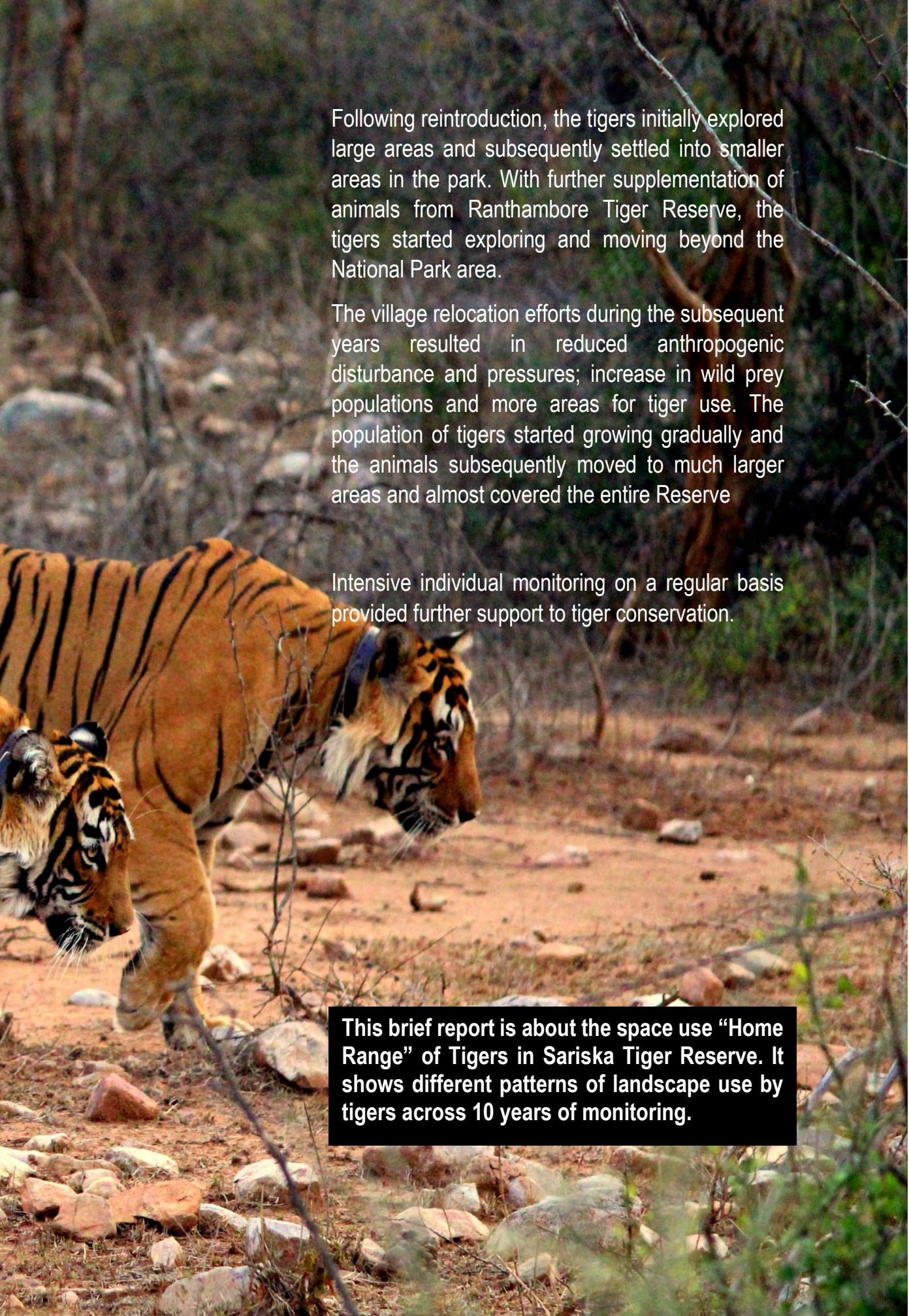


Tiger Population in Sariska Tiger Reserve from 2005 - 2018



The home range is described as the area traversed by an animal in its normal activities of gathering food, caring for young and in search of mate and related to the concept of an animal's territory that is actively defended.

The areas of animal activity plays an important role in ecological studies. Defining the size, shape and pattern of utilization of an animal's home range, is important for studying habitat selection and spacing of individuals.



Following reintroduction, the tigers initially explored large areas and subsequently settled into smaller areas in the park. With further supplementation of animals from Ranthambore Tiger Reserve, the tigers started exploring and moving beyond the National Park area.

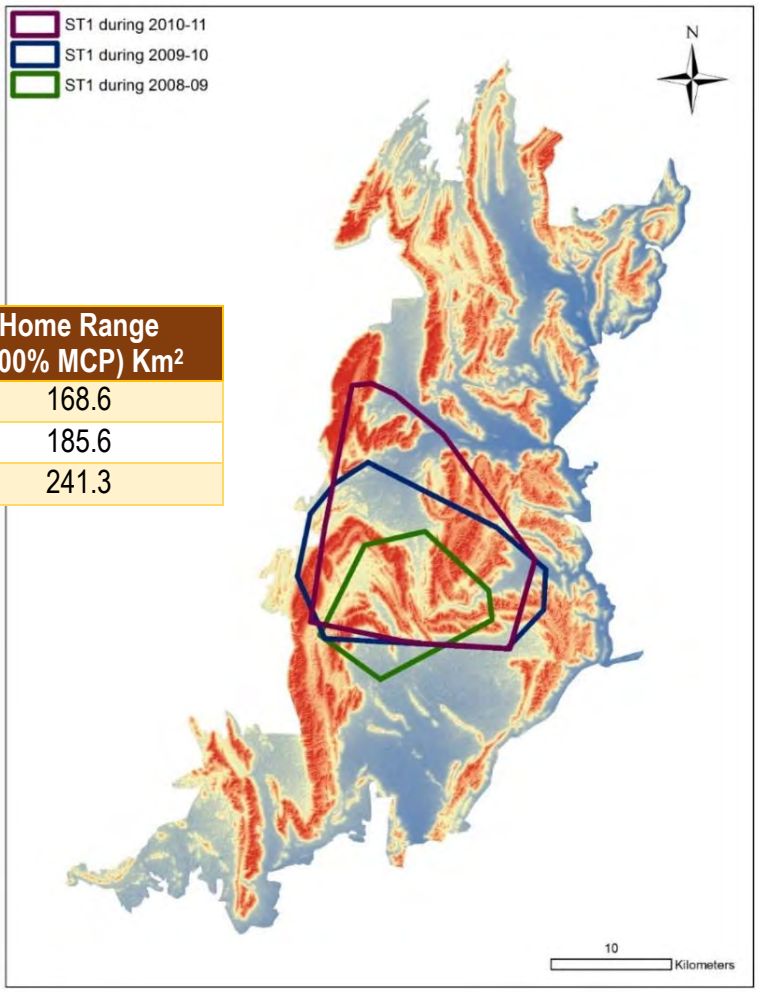
The village relocation efforts during the subsequent years resulted in reduced anthropogenic disturbance and pressures; increase in wild prey populations and more areas for tiger use. The population of tigers started growing gradually and the animals subsequently moved to much larger areas and almost covered the entire Reserve

Intensive individual monitoring on a regular basis provided further support to tiger conservation.

This brief report is about the space use "Home Range" of Tigers in Sariska Tiger Reserve. It shows different patterns of landscape use by tigers across 10 years of monitoring.

ST 01
Male

ST1 was the first tiger, captured, collared and translocated from Ranthambore TR to Sariska TR by air on 28th June 2008. The animal was subsequently re-collared on 23th June 2009. Being the only male at that period, ST1 moved large areas however succumbed to organophosphate poisoning on 14th November 2010 at Kalakhet area inside the Tiger Reserve

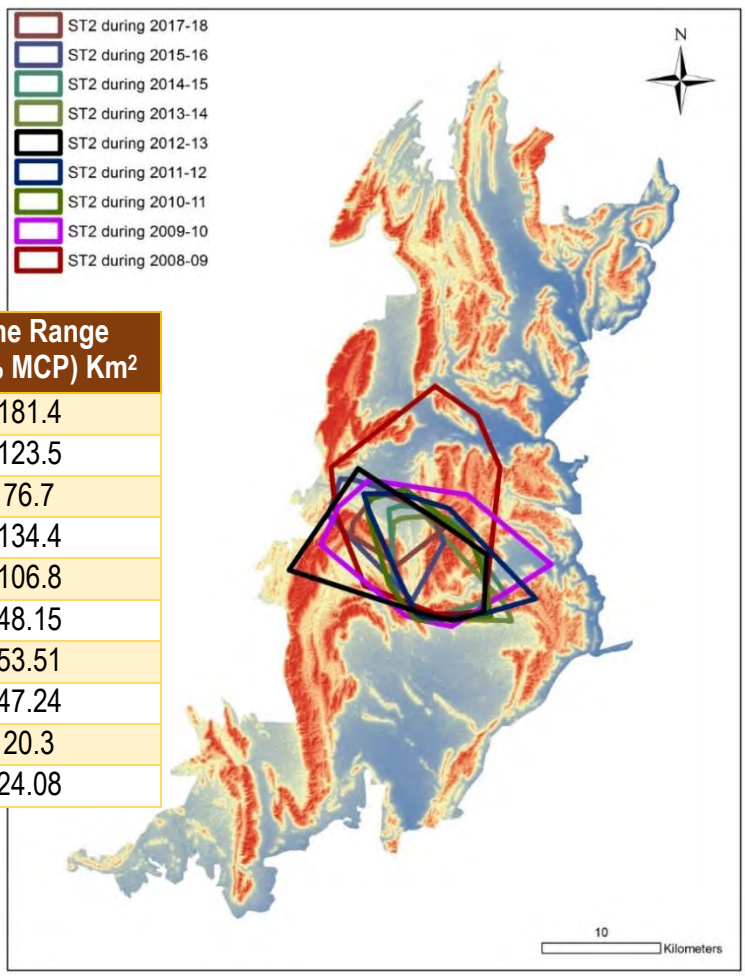


Year	Home Range (100% MCP) Km²
2008-09	168.6
2009-10	185.6
2010-11	241.3

ST 02
Female

The ST2 female was translocated from Ranthambore TR by air on 4th July 2008. ST2 was approximately 3 years of age at the time of translocation. The animals is around 13 years as on June 2018 and has a non-functional collar since 2011.

ST2 uses the area of Sadar, Karnakawas and Tarunda. ST2 has littered twice, ones in March 2012, when ST7 and ST8 tigress were born and then in February 2014 when ST13 tiger and ST14 tigress were born.

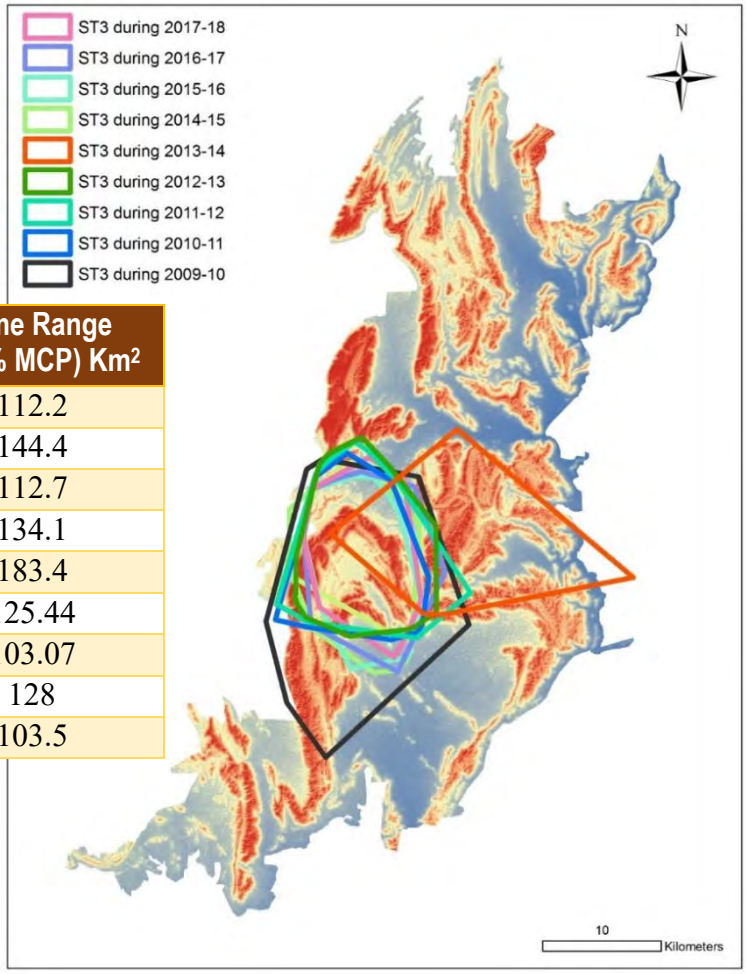


Year	Home Range (100% MCP) Km²
2008-09	181.4
2009-10	123.5
2010-11	76.7
2011-12	134.4
2012-13	106.8
2013-14	48.15
2014-15	53.51
2015-16	47.24
2016-17	20.3
2017-18	24.08

ST 03
Female

The ST3 tigress also known as 'Bhagani ki Rani' was air lifted from Ranthambore on 25th February 2009 when she was approximately two and half years of age. ST3 is around twelve years as on June 2018. ST3 was first collared on 25th February 2009 and subsequently re-collared on 23rd December 2013 and 9th February 2016.

ST3 uses the area of Ghanka, Sadar, Haripura, Fhatyakhora, Kankwadi, Garh and Rajod.

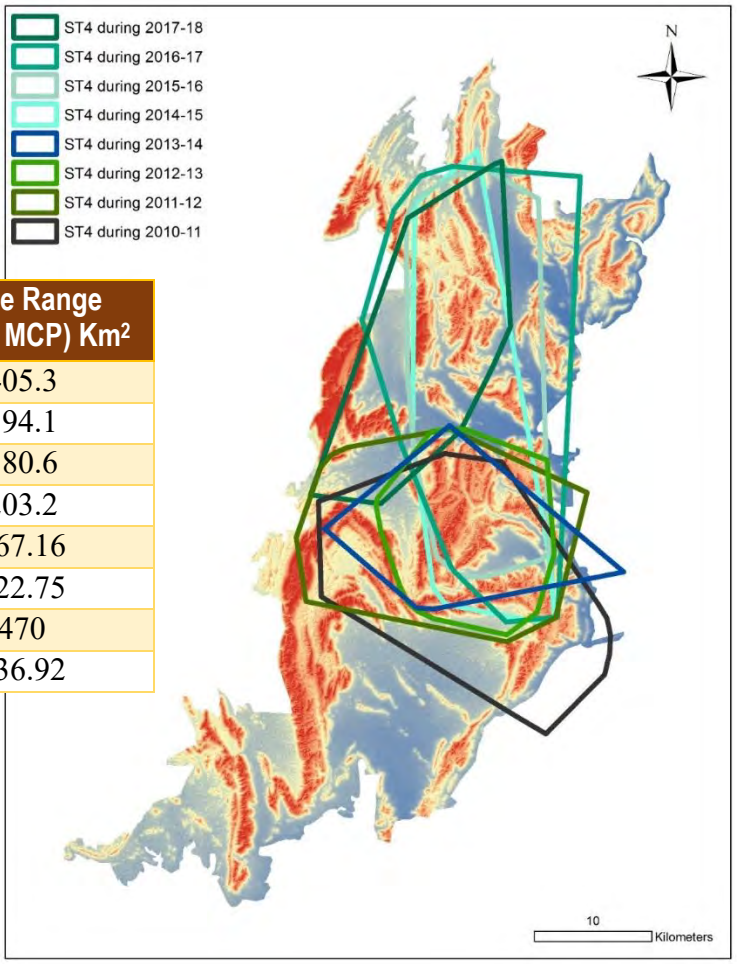


Year	Home Range (100% MCP) Km²
2009-10	112.2
2010-11	144.4
2011-12	112.7
2012-13	134.1
2013-14	183.4
2014-15	125.44
2015-16	103.07
2016-17	128
2017-18	103.5

ST 04
Male

ST4 tiger was translocated from Ranthambore TR on 20th July 2010 by road when it was around five and half years. ST4 is the oldest tiger in Sariska with an age of about thirteen years and seven months as on June 2018. It was first collared on 20th July 2010 and again collared on 30th November 2015.

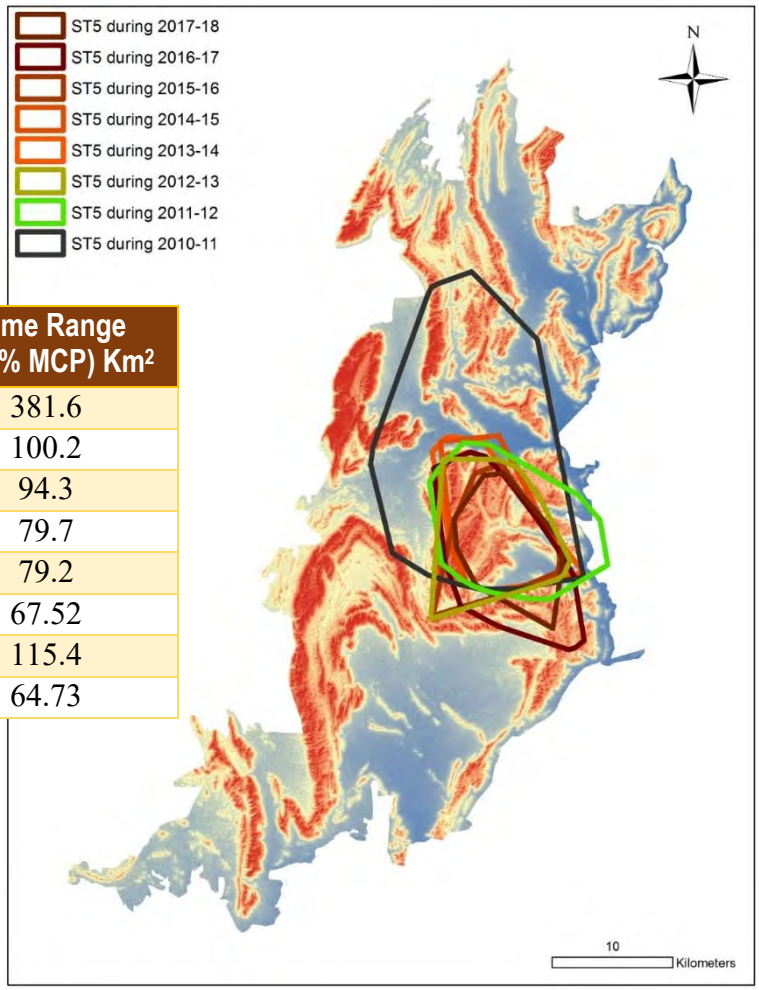
Presently, ST4 uses the northern part of Sariska TR in Talvriskh and Alwar Buffer Range.



Year	Home Range (100% MCP) Km²
2010-11	405.3
2011-12	194.1
2012-13	180.6
2013-14	203.2
2014-15	367.16
2015-16	322.75
2016-17	470
2017-18	236.92

ST 05
Female

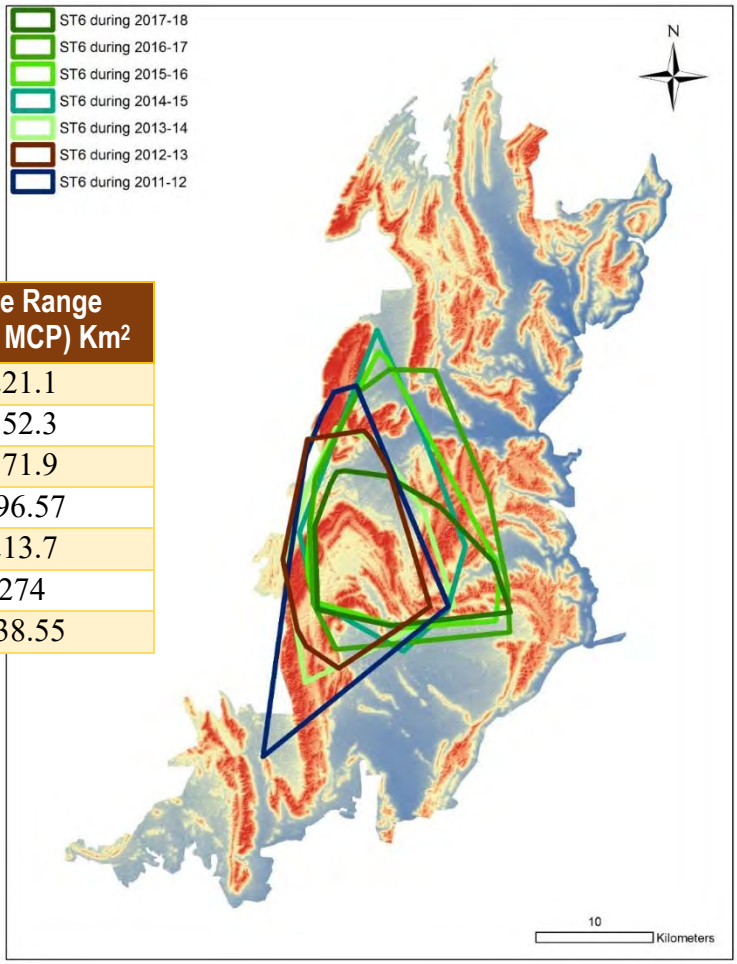
The ST5 tigress was brought from Ranthambore National Park on 27th July 2010 by road when she was approximately three years of age. As on January 2018, ST5 aged around ten years and seven months. ST5 was first collared on 28th July 2010 and subsequently re-collared on 21st December 2015. The collar of ST5 ceased functioning on 7th February 2018. ST5 was extensively using the area of Kiraska, Sukola, Rotkyala, Umri, Dabli and Kalakhadi and other beats of Akhbarpur range.



Year	Home Range (100% MCP) Km^2
2010-11	381.6
2011-12	100.2
2012-13	94.3
2013-14	79.7
2014-15	79.2
2015-16	67.52
2016-17	115.4
2017-18	64.73

ST 06
Male

The ST6 tiger originally from Ranthambore was translocated from Keoladeo National Park on 23rd February 2011 at approximately four and half years of age. As on June 2018, ST6 is around twelve years of age. ST6 was first collared on 23rd February 2011 and subsequently re-collared on 24th December 2012 and 17th May 2015. ST6 uses the whole Sariska Range, Kankwadi, Bhagani and Garh. ST6 is also the most sighted tiger in Sariska TR.

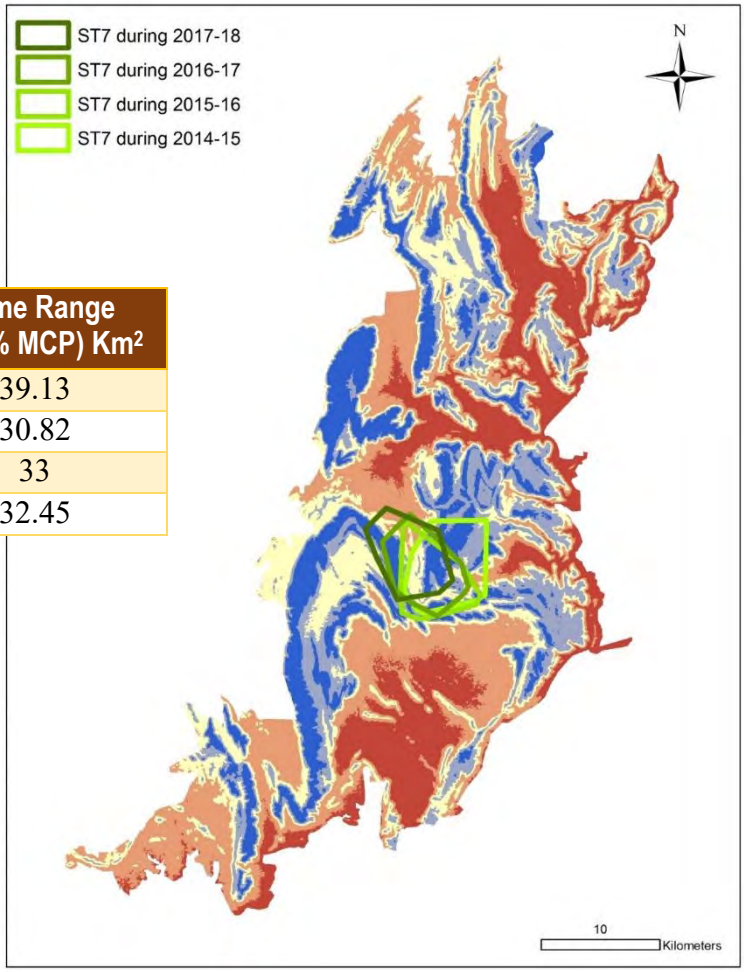


Year	Home Range (100% MCP) Km²
2011-12	221.1
2012-13	152.3
2013-14	171.9
2014-15	196.57
2015-16	213.7
2016-17	274
2017-18	138.55

ST 07
Female

ST7 tigress is from the first litter of ST2 tigress born around March 2012 at Sariska. The animal is around six years and four months as on June 2018. Its uses a very small area of Kalighati, Tarunda, Slopka and Pandupol. ST7 is not collared and monitoring is based on camera trapping and daily patrolling.

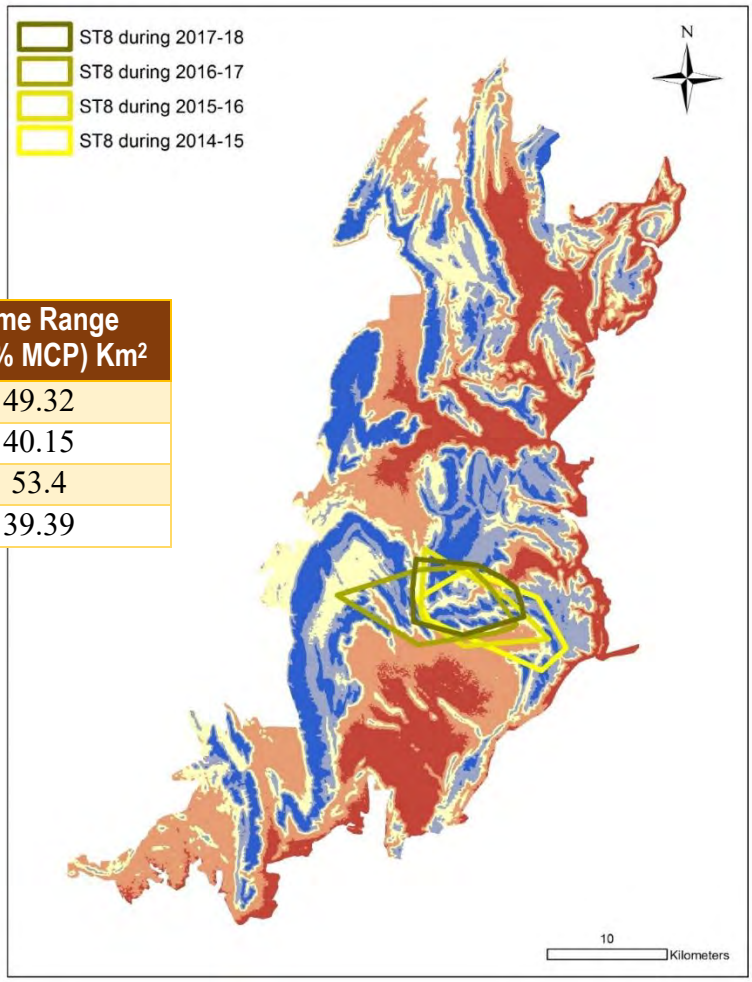
Year	Home Range (100% MCP) Km^2
2014-15	39.13
2015-16	30.82
2016-17	33
2017-18	32.45



ST 08
Female

ST8 tigress is from the first litter of ST2 tigress and sibling of ST7 born around March 2012. It uses the area of Kalighati, Slopka, Pandupol, Umri and Bhagani. ST8 is not collared and monitoring is based on camera trapping and intensive patrolling.

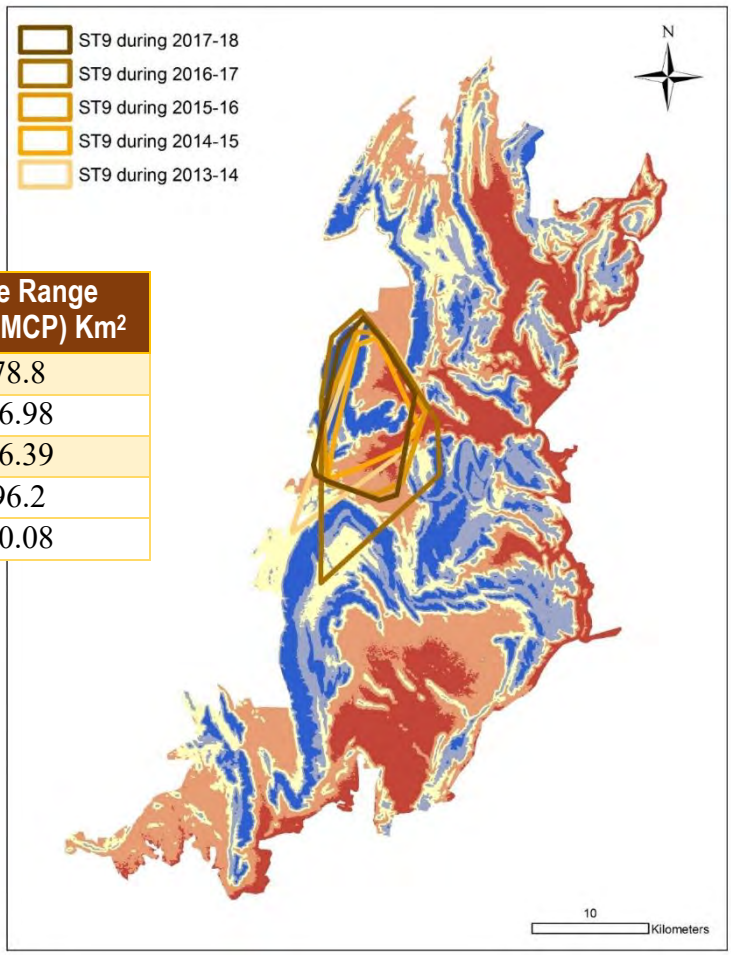
Year	Home Range (100% MCP) Km^2
2014-15	49.32
2015-16	40.15
2016-17	53.4
2017-18	39.39



ST 09
Female

ST9 tigress was translocated from Ranthambore on 22nd January 2013 at about two and half years of age. ST9 was first collared on 22nd January 2013 and subsequently on 13th May 2018. The animal uses a rugged terrain of Sadar, Indok, Berawas, Rekhamala, Duharmala and Bani and has littered one male cub (ST15) during December 2015

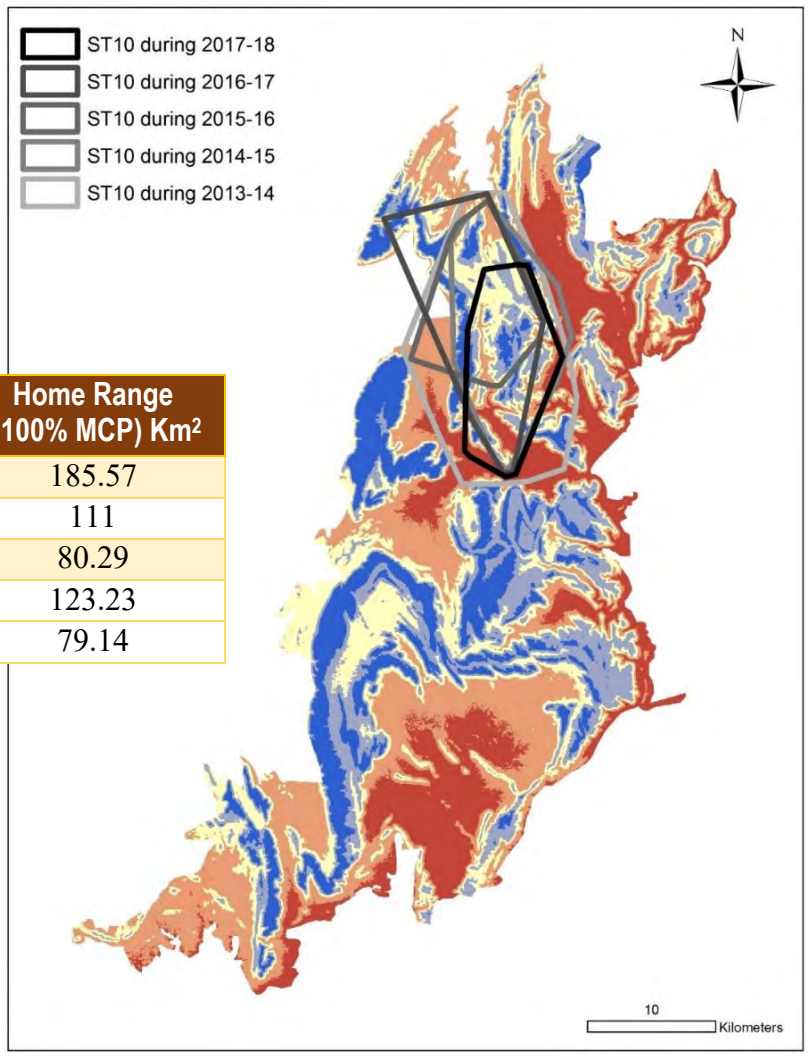
Year	Home Range (100% MCP) Km²
2013 -14	78.8
2014-15	46.98
2015-16	76.39
2016-17	96.2
2017-18	80.08



ST 10
Female

ST10 a sibling of ST9 and brought from Ranthambore on 23rd January 2013 at around two and half year of age. ST10 is around eight years as in June 2018.

ST10 littered two cubs (ST11 and ST12) during May 2014. The animal uses the northern part of Sariska, Lodge, Nathusar, Panidhal, Rampur I, II and III, Binak and few parts of Alwar buffer.

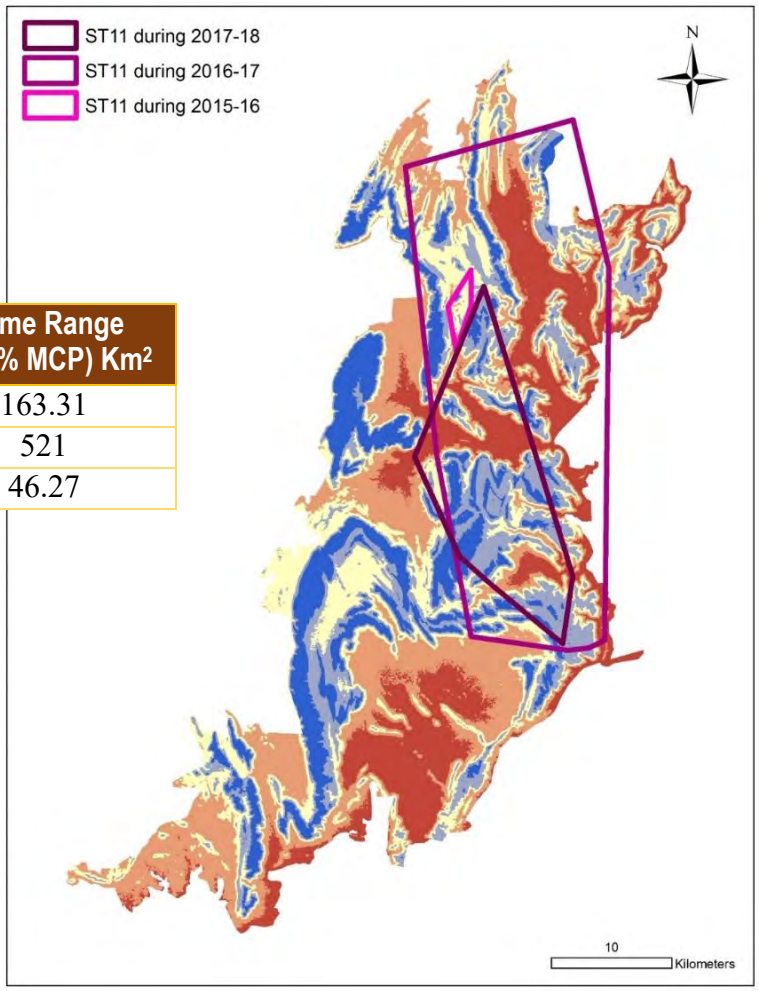


Year	Home Range (100% MCP) Km²
2013 -14	185.57
2014-15	111
2015-16	80.29
2016-17	123.23
2017-18	79.14

ST 11
Male

ST11 is the male cub from the litter of ST10 tigress born around May 2014. As on June 2018, ST11 is nearly four years and two months old. ST11 was collared on 24th April 2017 at Khetra Jungle, Umri. The animal died on 19th March 2018 due to strangulation by a snare at Indok beat in Sariska Range. ST11 used the area of Lilunda, Naldeshwar, Deora, Boh, Kiraska, Sukola, Rotkela, Umri and Pandupole.

Year	Home Range (100% MCP) Km^2
2017-18	163.31
2016-17	521
2015-16	46.27

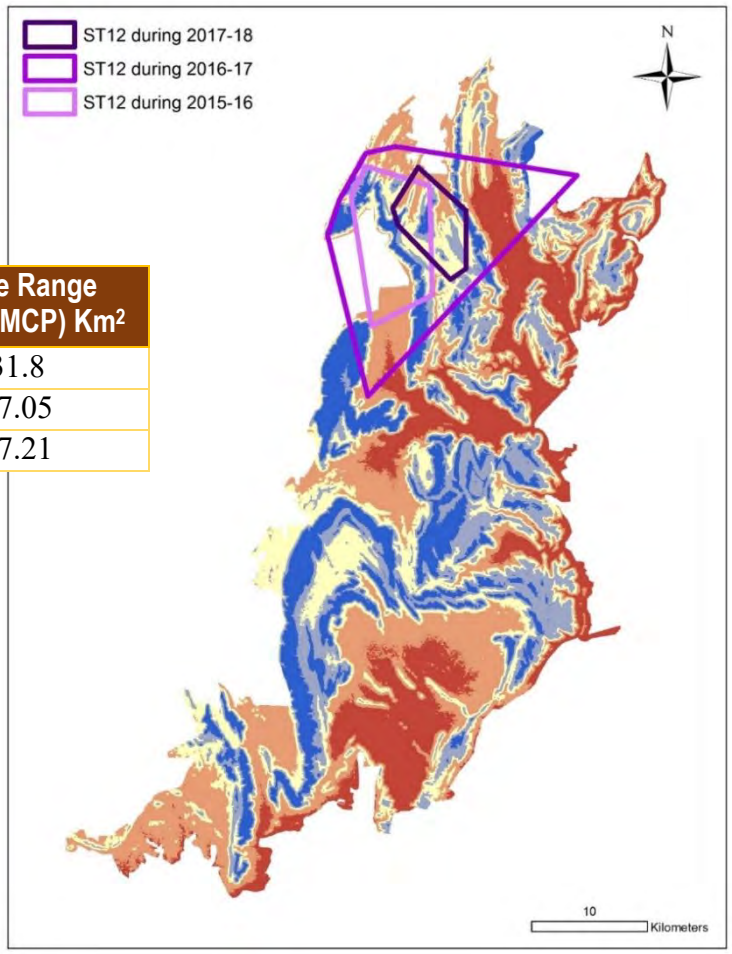


ST 12
Female

ST12 tigress, a sibling of ST11 from ST10 tigress was born around May 2014. ST12 is around four years and two months as on June 2018. ST12 is not collared, and the monitoring is carried out by camera trapping and intensive patrolling.

ST12 uses the area of Rampur I, II and III, Nathusar and Lodge.

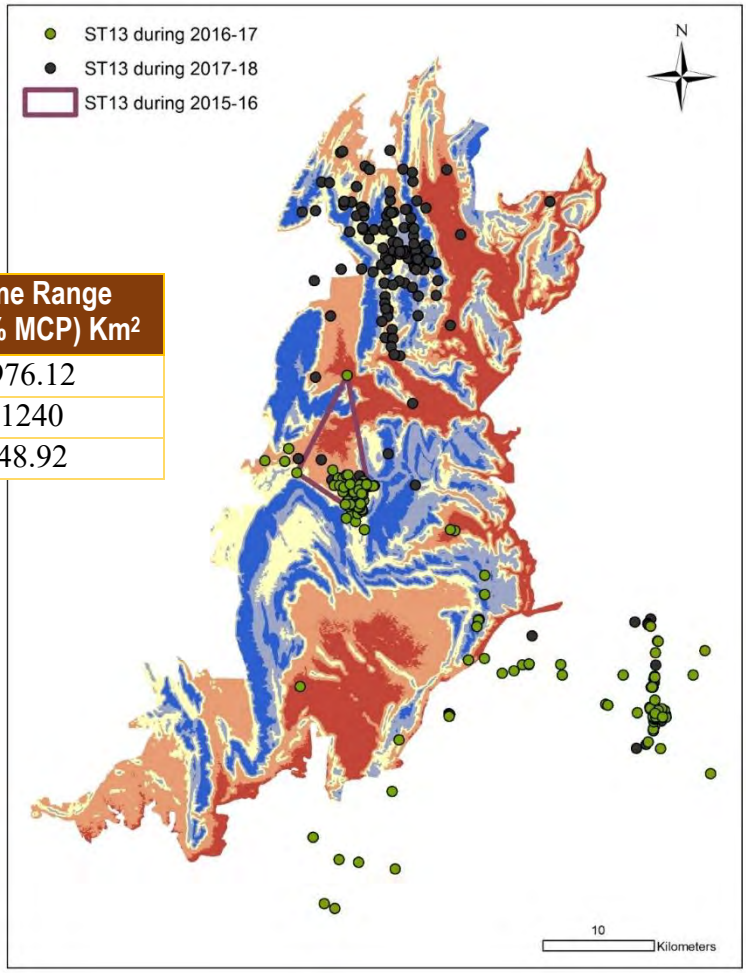
Year	Home Range (100% MCP) Km^2
2017-18	31.8
2016-17	87.05
2015-16	57.21



ST 13
Male

ST13 is the male cub of ST2 from her second litter born during February 2014. ST13 initially used the natal area and subsequently moved towards human dominated area of Rajgarh (Alwar Div.) for almost seven months (November 2016 to June 2017). The animal was captured, collared and shifted to the Nayapani tiger enclosure on 26th June 2017 to ensure its safety. The animal was subsequently released and has been using the areas of both ST10 and ST12 in the northern parts of Sariska TR.

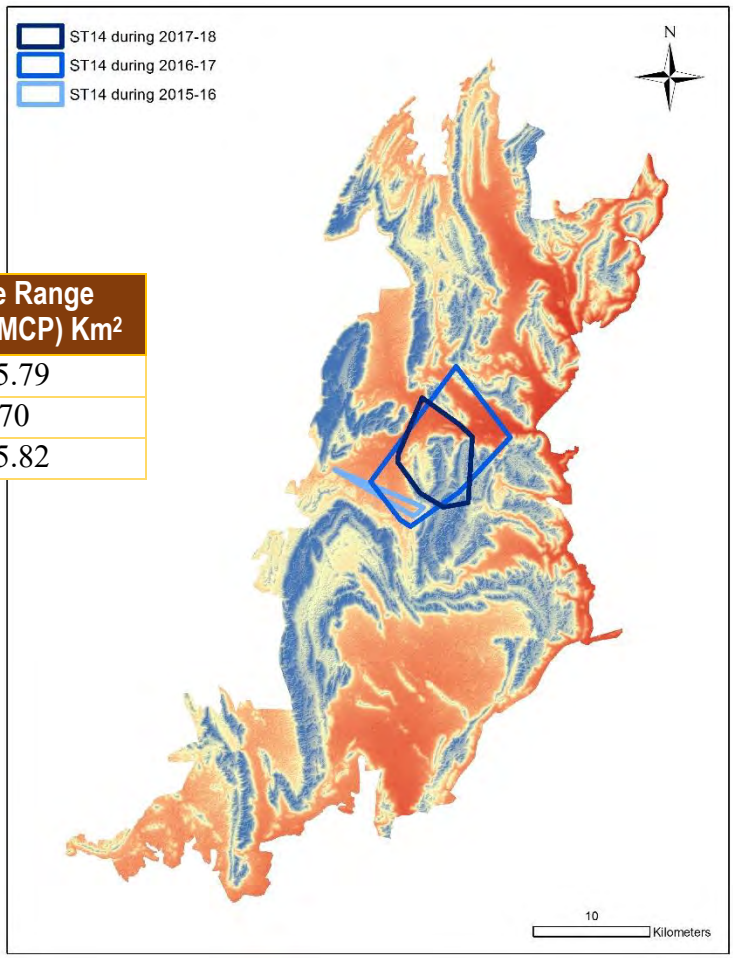
Year	Home Range (100% MCP) Km²
2017-18	976.12
2016-17	1240
2015-16	48.92



ST 14
Female

ST14 is the female cub of ST2 from her second litter and was born around February 2014. ST14 was using the natal area, initially but moved to Lilunda, Naldeshwar, Kiraska and Sukola. ST14 is around four years and five months as on June 2018. Camera trap photograph revealed the animal to be with two cubs (ST16 & ST17) on 6th April 2018 at Kiraska.

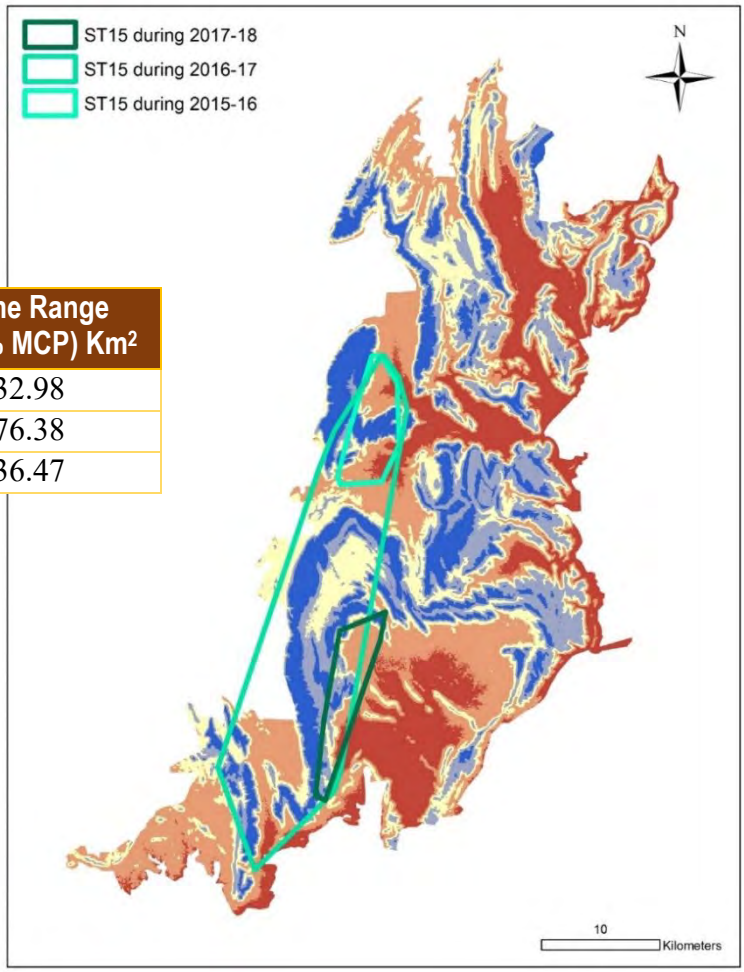
Year	Home Range (100% MCP) Km²
2017-18	35.79
2016-17	70
2015-16	15.82



ST 15
Male

ST15 is the male cub of ST9 tigress born around December 2015 at Indok beat. The animal is around two years and eight months as on June 2018. Initially, ST15 was occupying the areas of Indok, Berawas and Rekhamala, but moved out from the natal area towards the South-west part of Sariska TR, in Ajabgarh Range.

Year	Home Range (100% MCP) Km^2
2017-18	32.98
2016-17	76.38
2015-16	36.47



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Wildlife Institute of India

Rajasthan Forest Department

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Technical Report 2015

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Technical Report
2015

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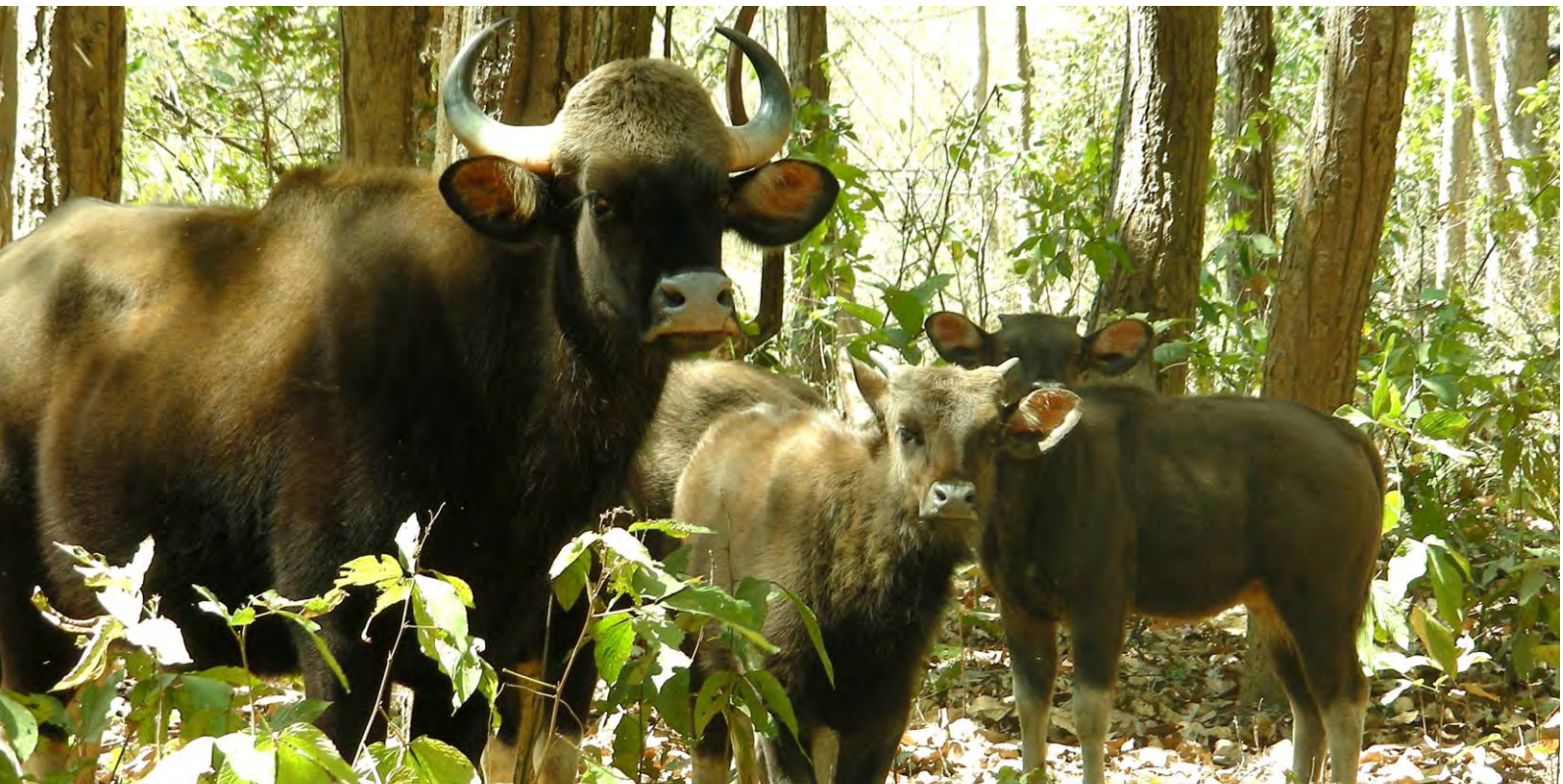

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Executive Summary

Bandhavgarh Tiger Reserve (BTR), situated in Central India, supported a small population of gaur (<40 individuals) till 1995. This gaur population became locally extinct in 1998, and the reason for the same is attributed to disruption of the migratory corridor between the forests of Bandhavgarh and Ghunghuti and Amarkantak. Even after the local extinction of gaur, Bandhavgarh continued to be an excellent habitat for gaur and hence it was decided to reintroduce gaur in Bandhavgarh as it would be a major conservation initiative for this endangered species.

The present study on reintroduced gaur was carried out from March 2011 to January 2015 covering all seasons in a year, summer (March - June), monsoon (July - October) and winter (November - February) and the objectives were to study the ranging patterns, habitat use, food habits, health condition and group size of the reintroduced gaur population.

The capture and translocation of 50 (14 male and 36 female) gaur from Kanha Tiger Reserve (KTR) to Bandhavgarh Tiger Reserve (BTR) was done in two phases i.e. phase I during January 2011 (n=19) and phase II, during March 2012 (n=31). Of these, 27 gaur individuals were fitted with radio collars. Two types of radio collars were used on gaur i.e. GPS/ SATELLITE/VHF and Very High Frequency-VHF. A hand held multichannel receiver along with uni-directional hand-held 3-element “Yagi” antenna and “H” type antenna were used to track the radio collared animals.

The study on ranging pattern of gaur was based on regular tracking of radio-collared (n=27) individuals. The radio-collared gaur was monitored periodically through ground tracking, using “triangulation” and “homing in” techniques. A total of 27,816 locations were collected from all the radio collared individuals. Twelve to fifteen locations, per radio-collared individual in a week with “biologically independent” locations i.e. 06.00 hrs interval between consecutive locations of the same animal were collected on foot and from vehicle from March 2011 to March 2015. The locations were obtained from 06.00 hrs to 18.00 hrs in all season i.e. summer, monsoon and winter. During the study period, two radio collared (GF5 and GF7) female gaur died naturally and 17 radio collars stopped functioning.

The obtained radio locations were plotted in Arc GIS 9.2. Minimum Convex Polygon (MCP) and Fixed Kernel Density estimator (FKD) methods were used to estimate the home range size. To remove the effect of exploratory movements and outlying fixes, 95% FKD were computed. Mann-Whitney-Wilcoxon test and Kruskal-Wallis test were used to test the significance of difference between the home range size, age and sex classes gaur. To estimate the home range of each gaur individual in different season, data were grouped to understand the home range size of different demography classes. To understand the overall as well as seasonal ranging

patterns, 100% MCP method was used. To estimate gaur home range in the study area, locations obtained from GPS and VHF collars (n=27,816) were used.

A total of four different herds were identified during the study period. The individual gaur herd was identified based on the radio collared animals in each gaur herd. Month wise data was used to study the home range stabilization of herds.

The minimum number needed to calculate the overall home range size of reintroduced gaur in Bandhavgarh reached an asymptode at 122 fixes (95% CI 111-133; range: 80-188). The average home range of reintroduced gaur reached an asymptote after exploring minimum of 154 km^2 (range: 71 km^2 - 279 km^2) within 143 days (range: 120 -163 days). Locations of 25 radio-collared individuals were used to analyze the stabilization of home range. It was observed that the batch I (n=12) gaur home range exploration was gradual in the new environment and batch II (n=15) gaur home range exploration was unstable for three months.

The estimated overall 100 % MCP and 95 % FKD home range of reintroduced gaur was 405.2 km^2 and 146.9 km^2 respectively. The annual home ranges of reintroduced gaur were 254.4 km^2, 405.2 km^2, 240.5 km^2 and 209.1 km^2 in 2011, 2012, 2013 and 2014 respectively. It was observed that with 100 % MCP of all the demography classes of gaur, 22 gaur had a home range of more than 100 Km^2. Among these individuals, all the three adult males, three adult female (GF14, GF31 and GF36) and two sub adult females (GF6 and GF9) had larger home range i.e. 200 km^2. The overall home range of different demography classes (AM- Adult Male; SAM- Sub Adult Male; AF- Adult Female; SAF- Sub Adult Female) was estimated using 100 % MCP. The average home range size of AM (n = 3) was 250.2 ± 10.3 (SE) km^2, SAM (n = 3) 149.1 ± 16.5 (SE) km^2, AF (n =6) 188.6 ± 33.1 (SE) km^2 and SAF (n = 13) 151.3 ± 13.6 (SE) km^2.

Of the 19 gaur individuals reintroduced in 2011, it was observed that they formed two different herds *i.e.* seven (H-1) and 13 (H-2), and both herds had mixed age-sex class individuals. The supplementation of 31 gaur in 2012, resulted in formation of four new gaur herds. A total of six different (two pre-existing and four new) gaur herds were observed during the entire summer 2012, and subsequently in early monsoon two gaur herds (H-5 with H-1and H-6 with H-2) joined with the preexisting herds. A total of four different gaur herds were observed consistently till January 2015.

The average time taken to establish the home range size of gaur varied among the age and sex classes due to intra specific competition. The observed large overall home range size of reintroduced gaur in the present study may be attributed to the availability of wide spread natural mineral licks, adequate food and water along with availability of different vegetation types in the study area.

Both habitat use and habitat availability were assessed for individual radio-collared gaur locations in the study area. The analysis of gaur habitat use data was limited to seven different vegetation classes such as agriculture, bamboo forest, grassland, open mixed forest, mixed forest, sal forest and riparian forest within the study area comprising 1614.0 km^2. To assess the habitat use pattern of reintroduced gaur in Bandhavgarh, locations of individual radio collared gaur (n=27) were obtained from March 2011 to January 2015. The collected gaur locations (n=27,816) were plotted on the classified LISS-III imagery of Bandhavgarh. Second-order resource selection function was used to determine the habitat selection of reintroduced gaur. Third-order resource selection was determined by using discrete-choice analysis at the home-

range level. Resource Selection program for Windows was used to conduct the compositional analysis, also season wise habitat use by reintroduced gaur, were computed using compositional analysis.

Gaur largely used mixed forest followed by bamboo and grassland, whereas sal forest and riparian forest were used according to their availability within their entire home range. A simplified matrix ranked the overall habitat use of reintroduced gaur in Bandhavgarh in the following order: bamboo forest > grassland > riparian> sal forest > mixed forest > open mixed forest > agriculture land. The habitat use of gaur in summer was in the following order: grassland > sal forest > bamboo forest > riparian = open-mixed forest > mixed forest > agriculture land. The habitat use of gaur in monsoon was in the following order: bamboo forest > grassland > riparian > sal forest = mixed forest > open-mixed forest > agriculture land. The habitat use of gaur in winter was in the following order: bamboo forest > mixed forest > riparian = sal forest > grassland > open-mixed forest > agriculture land.

In Bandhavgarh Tiger Reserve, the mixed forest which is the dominant vegetation type constituted 43.8 % of the total area, but the use of bamboo forest followed by grassland by gaur showed higher ranking in habitat use. The preference of bamboo forest because of the availability of green shoots throughout the year and grasslands which provide higher biomass of forbs and grasses, might have influenced the gaur to prefer these habitats. The significant avoidance of agriculture land ($p < 0.05$) and distance to village inside the Protected Area by reintroduced gaur had a strong influence and found to be an important factor in determining their habitat selection.

The data on the food plants and parts eaten by gaur was obtained from the scan sampling technique and during the scans whenever an individual was observed feeding, the plant species and plant parts eaten by the individual were recorded. Samples of the eaten food plant parts were collected for each season (summer, monsoon, winter) and these samples were later subjected to nutritional analysis (crude protein, minerals and fibre) in the laboratory at Wildlife Institute of India. Fresh dung samples of gaur were collected for each season (at least 50 samples per season) and these samples were analysed for the percentage frequency occurrence of monocot and dicot plant fragments (monocot: dicot ratio). Also the percentage frequency occurrence of the plant fragments of major food plants of gaur was calculated simultaneously with the monocot: dicot ratio for each season. Phenological study of the major tree, shrub and grass species in the study area was carried out. Changes in the phenology of the marked trees and shrubs were quantified based on ocular estimation in terms of percentage availability of vegetative phases (young leaves, matured leaves, no leaves) and reproductive phases (buds, flower, young fruit and mature fruit) every fortnight. Phenological data for the major grass communities (1 sq.m plots) was recorded in terms of percentage availability of vegetative phase (mature and young shoots), reproductive phase (flowering and seeding) and changes in the grass colour (green, green yellow, yellow, yellow brown, brown) every week.

A multispectral (LANDSAT 7 ETM+), high-resolution (30 m) satellite imagery from the Global Land Cover Facility (GLCF) was used to generate the landuse/landcover (LULC) map of the study area. For the quantification of vegetation (tree, shrub and ground layer) in Bandhavgarh Tiger Reserve (BTR) the digitized map of BTR was gridded (2 km X 2 km) in a GIS domain and systematic vegetation plots were laid in field for vegetation quantification. A ten metre radius plot was laid down to enumerate tree density, shrub density was enumerated in a five metre radius plot and the point intercept method was used to estimate the percentage ground cover (grass, herb, bare soil, leaf litter and rock) in 1 sq.m. plot. The food plants of the captive elephants in

Bandhavgarh Tiger Reserve were also recorded throughout the study period to get an understanding of the overlap between the food plants of gaur and elephant in the study area.

During the study period a total of 82 species of food plants belonging to 29 families were recorded which comprised of 34 tree species, 8 shrub species, 14 herb species, 23 grass species and 3 climber species. A total of 6,724 feeding records were collected for gaur in Bandhavgarh Tiger Reserve during the study period through the scan sampling technique. Overall, the major food items identified for gaur in Bandhavgarh Tiger Reserve based on the percent time spent feeding by gaur were bamboo leaves (*Dendrocalamus strictus* leaves), grasses, herbs, *Shorea robusta* leaves, *Butea superba* leaves (climber) and *Chloroxylon swietenia* leaves. Annually these food items combined to constitute about 93% of the total time spent feeding by gaur in the study area. Annually the time spent feeding on bamboo leaves was the highest (45.3%) followed by grasses (30.2%), herbs (8.3%), *Shorea robusta* leaves (3.9%), *Butea superba* leaves (2.6%) and *Chloroxylon swietenia* leaves (2.5%). The percent time spent feeding by gaur in summer was highest for grasses (45.9%) whereas in monsoon and winter it was highest for bamboo leaves (32.9% and 63.9% respectively).

Annually the percent time spent grazing by gaur was 84.9% whereas that spent browsing was 15.1%. The time spent grazing by gaur was observed to be highest in monsoon (89.7%) followed by winter (84.8%) and summer (81.9%) but the difference across the seasons was found to be non-significant (K.W. χ^2 = 2.439, p>0.05). In summer the crude protein content was found to be highest in herbs (9%) whereas for monsoon and winter it was found to be the most in *Butea superba* leaves (11.6% and 6.9% respectively). The NDF content was observed to be highest for herbs (71.3%), young bamboo shoots (70.2%) and *Chloroxylon swietenia* leaves (69.7%) in summer, monsoon and winter respectively. In summer the ADF content was highest for *Chloroxylon swietenia* leaves (48.2%) whereas in monsoon and winter it was found to be highest for herbs (52.4% and 52.6% respectively). The lignin content in summer was found to be highest in *Chloroxylon swietenia* leaves (14.2%) whereas in monsoon and winter the lignin content was highest in *Shorea robusta* leaves (15.3% and 15.9% respectively).

In the present study it was observed that the crude protein content of the bamboo leaves and grasses which formed the major food items of gaur was highest in monsoon as compared to summer and winter and the seasonal activity budgets of gaur showed that the percentage time spent feeding by gaur in monsoon (34%) was the lowest compared to summer and winter (42.5%, and 39.7% respectively). Thus gaur in Bandhavgarh seem to compensate for the lower crude protein contents in their main food items (bamboo leaves and grasses) in summer and winter by increasing their feeding time in summer and winter as compared to monsoon.

A total of 301 dung samples were analysed during the study period. It was observed that the percentage frequency occurrence of monocot plant fragments in the gaur dung samples was high in all the seasons (summer: 84.8%, monsoon: 90.3%, winter: 92.2%) as compared to that of the dicot plant fragments (summer: 11.3%, monsoon: 5.5%, winter: 4.8%). The percentage frequency occurrence of bamboo fragments was observed to be highest in winter (30.5%) as compared to summer (20.2%) and monsoon (17.1%). Percentage frequency occurrence of the fragments of the grass *Saccharum spontaneum* was observed to be 30% in summer, 6.8% in monsoon and 10.6% in winter. The Ivlev's selectivity index (IVI), calculated for the major food items of gaur in different seasons in Bandhavgarh showed that the utilization of bamboo leaves as a food item by gaur was higher than its availability in all the seasons. The utilization of grasses as a food resource was observed to be more than its availability in summer whereas it was lower than its availability in monsoon and winter. The utilization of herbs by gaur as a food

item was observed to be proportional to its availability in monsoon whereas it was found lower than its availability in summer and winter.

It was observed from the land use/land cover map of Bandhavgarh Tiger Reserve that the mixed forest was the most dominant vegetation type which covered an area of 40.2% whereas the area under plantation covered the lowest percent area (0.2%). In addition, the bamboo forest covered an area of 12.6%, grasslands 6.5%, whereas Sal forest covered about 13.1% area in the entire Tiger Reserve. Between 2011 and 2013 three villages (Kallwah, Kumarwah and Magdhi) were relocated from the core area of Bandhavgarh Tiger Reserve and the village relocated sites have been transformed into grasslands having mainly species like *Saccharum spontaneum* and *Vetiveria zizanoides*. These grasslands (on the relocated sites) have been observed to be used extensively by gaur during the study period and have become important feeding sites for gaur in the study area.

A total of 62 food plants eaten by the captive elephants in Bandhavgarh Tiger Reserve were identified during the study period. Of the 62 species of food plants eaten by the captive elephants in the study area, 59 species were eaten by gaur. Thus, of the 82 food plants recorded for gaur in the present study, 59 were common for gaur and the captive elephants. Hence, in terms of species of food plants eaten by captive elephants, an overall overlap of 72% with the species of food plants of gaur was observed. In summer, of the 52 food plants recorded for gaur, 24 were observed to be common between gaur and captive elephants showing an overlap of 46.2% in terms of species of food plants. Similarly, the overlap observed in terms of food plants species between gaur and captive elephants in monsoon was 69.8% and in winter was 66%.

The health condition of the reintroduced gaur population was evaluated every month from March 2012 to January 2015 using the body condition of gaur individual as an indicator of their health. To calculate the body condition index (BCI) of a gaur individual, five different parts of its body (flank area, ribs, pelvic girdle, vertebral column and lumbar shelf) were assigned score values between 0 and 2 with numerically higher values corresponding to poor body condition (0-good, 1-fair and 2-poor). A total of 2063 gaur individuals were examined for BCI with both sex and all the age classes during the study period and of these 80 % of the gaur individuals were found to be in good body condition followed by 16.1 % fair and 3.3 % in poor body condition. Season wise among the overall gaur population, about 73.4% of the population was observed in good body condition in summer. In monsoon and winter about 86.6% and 92.2% respectively of the gaur population was observed in good body condition. Thus it was concluded that overall, the health condition of the re-introduced gaur population in Bandhavgarh was good throughout the study period.

Information on group size and age-sex composition of gaur was collected based on direct observation during March 2011 to January covering all seasons viz summer, monsoon and winter in the study area. In total, 50 gaur were re-introduced in Bandhavgarh Tiger Reserve (three adult males, 11 sub-adult males, 13 adult females, 21 sub-adult females, and two yearlings).

During the study period, the observed gaur group size of gaur varied from 1 to 31 individuals. The observed overall gaur mean group size (MGS) was 13.6 ± 1.9 (SE). The observed overall gaur typical group size (TGS) was 17.1. The overall MGS in summer was 12.4 ± 1.6 (SE), in monsoon it was 14.0 ± 1.9 and in winter it was 14.8 ± 2.1. The overall gaur population by January 2015 comprised largely of adult females (n= 22) followed by sub-adult females (n= 14),

calf (n= 15), yearling (n=13) sub-adult males (n= 10) and adult males (n= 5). In total, 19 mortalities were recorded during the study period, of which 14 gaur were predated by tiger and two radio collared gaur (GF5, GF7) died naturally. Two un-collared sub adult gaur females went missing and were never reported again. A total of 47 calves were born in Bandhavgarh during the study period. The maximum gaur calves were observed in winter (n=21) followed by summer (n= 15) and monsoon (n=11). During the study period (March 2011- January 2015) the estimated overall growth of gaur population was 58 % and the mortality rate was 24%.

During the study period three villages (Kallwah, Kumuruwah and Magdhi) from the core area were successfully relocated between June 2011 and June 2013 and subsequently gaur were found using the relocated sites after monsoon. Relocated sites provide additional space for gaur and also increase the forage availability, and hence the relocation of the remaining 12 villages from the core area will play an important role in the long term conservation of this reintroduced population. There is a need to implement a wide vaccination program for the domestic livestock in and around the Tiger Reserve, to prevent the transmission of livestock diseases to gaur in the study area. Continues scientific monitoring is recommended for the reintroduced gaur population in Bandhavgarh Tiger Reserve for future periods.

Chapter I

Introduction

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1.1 Reintroduction

Reintroduction and translocation are both highly important as active conservation tools for the management of many wildlife species populations which are in decline. Reintroduction generally involves returning native species to localities where they have been lost (Campbell and Rosell 2010). Translocation moves wild-caught animals from one natural location to another, while Reintroduction moves captive-born/wild animals into their natural historical ranges (Kleiman 1989). The IUCN guidelines define re-introduction as 'an attempt to establish a species in an area which was once part of its historical range, but from which it has been extirpated or become extinct'.

An estimated 30,000 plants/ animals species are destroyed annually by tropical deforestation (Myers 1998). Populations many species are declining so rapidly that nearly 3000 vertebrate taxa face extinction, and may only be saved through conservation breeding (Ebenhard 1995). Captive breeding, reintroduction, and translocation programs are thus becoming increasingly important conservation tools (Griffith *et al.* 1989).

Two important obstacles to re-establishing a species are:

1) To understand the fundamental ecological requirements and life histories of species of concern (Sarrazin and Barbault 1996).

2) To identify appropriate areas for reintroduction or restoration, recognizing that degradation or modification can render native habitats unsuitable (Dobson *et al.* 1997 and Shugart *et al.* 2001).

Evolving reintroduction methodologies therefore demand greater scientific input. Conservation biology techniques, such as Population Habitat and Viability Assessment (PHVA) (Ellis *et al.* 1995) usually require detailed life history and habitat information. Unfortunately, such data do not exist for most species, particularly for the endangered taxa (Sarrazin *et al.* 1996), and the cost of collecting it by conventional methods can be prohibitive. Modelling is also useful for determining the most essential factors controlling an ecosystem (Levin 1992), and together, remote sensing and modelling allow ecological issues to be examined over large areas and over long times, and thus may be crucial to the long-term success of reintroduction programs (Estes 2005). In any reintroduction programme the monitoring and undertaking of ecological studies of the reintroduced species is of vital importance (IUCN 1998). Undertaking ecological studies of a reintroduced species provides an understanding as to how the species is interacting with its new environment.

Only a very few studies are available on wild animal reintroduction and restoration in the world. Reintroduction was done on wild animals, and also on captive-bred animals to the wild (Rob Laidlaw 2001) such as tiger (*Panthera tigress*) in India (Sankar *et al.* 2010, Ramesh *et al.* 2011), Grey wolf (*Canis lupus*), Arabian oryx (*Oryx leucoryx*) and Black bear (*Ursus americanus*) in USA (Campbell and Rosell 2010), White Rhinoceros (*Ceratotherium simum*) in Botswana (Pitlagano 2007), Elk (*Cervus canadensis*) in America (Schneider *et al.* 2006), Rein deer (*Rangifer tarandus)* in Finland (Kojola *et al.* 1998), American bison (*Bison bison*) in

Canada (Kay *et al.* 2001), Asiatic wild ass (*Equus hemionus*) in Israel (Saltz and Rubenstein 1995) and One Horned Rhinoceros (*Rhinoceros unicornis*) in Nepal (Jnawali 1991).

Few studies are available in the Indian Subcontinent on reintroduction of wild animal such as tiger (*Panthera tigress*) in Sariska Tiger Reserve, Western India (Sankar *et al.* 2010) and Panna Tiger Reserve, Central India (Ramesh *et al.* 2011), wild water buffalo (*Bubalus arnee*) in Dibru - Saikhowa National Park, Assam (Ashraf and Sarkar 2011), one horned rhinoceros (*Rhinoceros unicornis*) in Dudhwa Tiger Reserve, Uttar Pradesh (Sinha *et al*. 2001, Pitlagano 2006) and Manas National Park, Assam (Menon 2014).

1.2 Study Species

The gaur (*Bos gaurus*) is the largest living Bovid confined to the Oriental bio-geographic region and has been classified as follows:

Classification

Kingdom	Animalia
Phylum	Chordata
Class	Mammalia
Order	Cetartiodactyla
Family	Bovidae
Scientific name	*Bos gaurus*
Species authority	C.H. Smith, 1827

Traditionally three subspecies of gaur (*Bos gaurus*) have been recognized *viz*. *Bos gaurus readei* (Myanmar and Cambodia), *Bos gaurus hubbacki* (Thailand south of the isthmus kra and west Malaysia) and *Bos gaurus gaurus* (India and Nepal). However, NRC (1983) recognizes only two subspecies, *Bos gaurus gaurus* of India and Nepal and *Bos gaurus laosiensis* of Myanmar, Thailand, Laos, Vietnam, Cambodia and Malaysia. In North-eastern India a domestic form of gaur (Mithun, Mithan or Gayal) occurs which has arisen through breeding between wild gaur and domestic cattle. The scientific name of this subspecies is *Bos frontalis*.

Evolution and Systematics

Ungulates are a diverse group of mammals, most of which are hoofed animals. The even toed ungulates belonging to the order Cetartiodactyla are the most successful group of large herbivores on earth today (Thenius 1990). The Bovidae is a family among the order Cetartiodactyla which encompasses a diverse group of the extant ungulates that are distributed mainly in the Old World with a few species being present in North America (Vairavel 1998). The family Bovidae includes cattles, buffaloes, antelopes, sheeps and goats. The present classification scheme for bovids recognizes eight subfamilies subdivided into two clades, the Boodontia which comprises of a single subfamily, Bovinae and Aegodontia comprising of all other bovid subfamilies (Thomas 1984). Eurasia and Africa have been the centres of radiation for almost all the bovids (Gentry 1992). It has been suggested by Kingdon (1997) that a continental divide between Africa and Eurasia may have been responsible for the early divergence of the Boodontia (Eurasian in origin) and the Aegodontia (which continued evolving in Africa). The rejoining of the two continental land masses (after these two clades had become distinct) at the Arabian peninsula removed this geographic barrier which allowed both the groups to expand into the other's homeland.

The subfamily Bovinae represents an early offshoot of the family Bovidae. It diverged from the Aegodontids approximately 25 million years ago. Based on the fossil evidence, the Bovinae appear to have arisen in Asia with the first fossils appearing around 18.5 million years ago (Hernandez-Fernandez and Vrba 2005). The modern Bovinae have attained large body sizes compared to any other bovid subfamilies which might have happened because of the cooler

climates prevalent in Eurasia (Hernandez-Fernandez and Vrba 2005). Presently three tribes are recognised within the subfamily Bovinae *viz.* Bovini (cattle, buffalo, bison and saola), Boselaphini (nilgai and four-horned antelope), Tragelaphini (spiral-horned antelope). The Bovini tribe includes five genera containing ten species and 21 subspecies. The five genera include Asiatic buffalo (*Bubalus*), African buffalo (*Syncerus*), Bison (*Bison*), true cattle (*Bos*) and Saola (*Pseudoryx*). The Gaur (*Bos gaurus*) is a wild cattle belonging to the genus *Bos*.

General characteristics and ecology

Gaur is a large herbivore with the bulls (plate 1.1) weighing around 600-1000 kg and the cows (plate 1.2) about 300-700 kg. The shoulder height for gaur bulls is around 1.6 to 1.9 m whereas for cows it is about 10 cm shorter than the males (Sankar *et al*. 2001). Horns are present in both sexes but they are larger with more swath in the males (Sanderson 1968). There is a high bulging forehead ridge between the horns referred to as *Bos*. Adult males have two prominent dewlaps, a small one at the chin and a large one hanging below the throat. There is a shoulder hump which is more pronounced in the males. Newly born calves (plate 1.3) are light golden yellow in colour. The colour darkens with age, and adult females are dark brown whereas adult males are black. Both hind legs and forelegs are white to tan below the knees. Gaur reach sexual maturity at three years of age and usually produce one and rarely two calves after a gestation period of 275 days. The maximum recorded life span for captive female gaur has been 24 years (Crandall 1964) and that for captive male gaur has been 23.6 years (Ahrestani *et al*. 2011).

Gaur is a group living animal. The group structure is very fluid and dynamic. The group size in gaur may range from two individuals to more than 20 individuals. A typical group usually consists of adult cows, some calves, one or two adult bulls and a few sub adult animals. Sometimes gaur bulls also form bachelor herds (all male herds). Gaur bulls (mainly adult bulls) also roam solitary and may join different herds for short periods of time. Gaur is known to be a mixed feeder (Schaller 1967). It mainly grazes in the monsoon but is known to browse in dry seasons. Their diet mainly consists of shoots and leaves of bamboo, grasses, herbs, trees and shrubs. Fruits of *Aegale marmalos*, *Bauhinea* spp., *Cassia fistula*, *Cordia myxa*, *Diospyros melanoxylon*, *Phyllanthus emblica*, *Gmelina arborea*, *Terminalia bellerica* and *Randia dumetorum* are also eaten (Brander 1923, Schaller 1967, Krishnan 1972, Sankar *et al*. 2001) Gaur also feed on bark of trees like *Adina cordifolia*, *Tectona grandis*, *Wendlandia natoniana* and *Phyllanthus emblica* (Pasha *et al*. 2004).

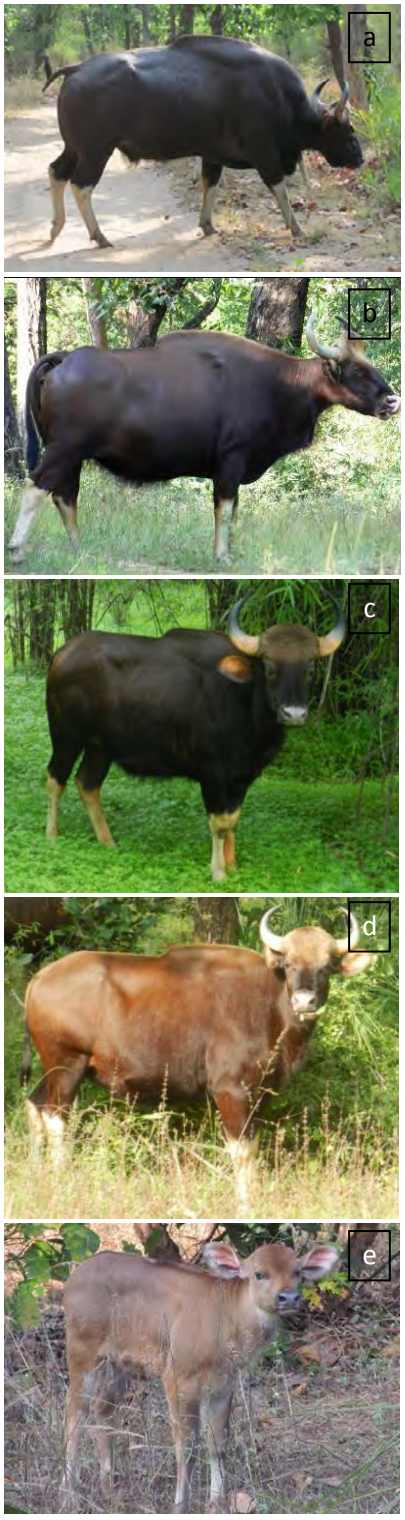


Plate 1: Different age classes of gaur (a) Adult bull (b) Adult cow (c) Sub-adult bull (d) Sub-adult cow (e) Calf

Feeding mainly occurs during early morning hours and late afternoon and evening hours.

During the hottest periods of the day gaur are seen resting in thick tree cover. The mating season of gaur varies through the entire distributional range (Prater 1971); while in some areas definitive peaks have been observed. Brander (1923) reported December-January as the peak mating season for gaur in central India. In south India, this may range from November to March (Morris 1937). An unsynchronized pattern in parturition of gaur indicates that calves are born throughout the year and some mating occurs in all months of the year (Schaller 1967, Vairavel 1998, NRC 1983). The main predator of gaur is the tiger (*Panthera tigris*) and leopard (*Panthera pardus*) is also known to predate upon calves and yearlings of gaur (Sankar *et al*. 2001).

Global distribution of gaur

Historically, the distribution of the gaur covered the entire mainland of South and South-east Asia and Sri Lanka (Duckworth *et al*. 2008). The current distribution is restricted to scattered pockets in India, Nepal, Bhutan, Cambodia, China, the Lao PDR, peninsular Malaysia, Myanmar, Thailand and Vietnam (Figure 1.1).

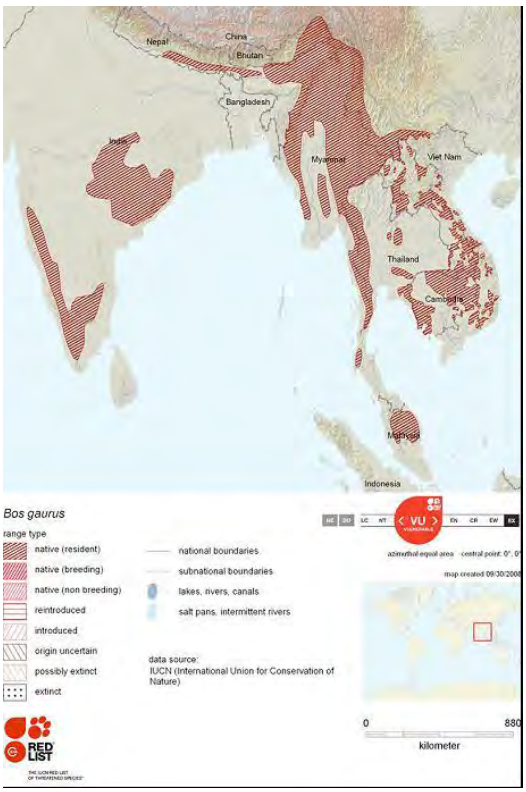


Figure 1.1: The distributional range of gaur in South and South-East Asia (Pabla *et al*. 2011)

Gaur in Nepal is found in the Royal Chitwan National Park and Parsa Wildlife Reserve. In Bhutan, the presence of gaur has been reported all over the southern foot-hill zone, notably in Royal Manas National Park, Phipsoo Wildlife Sanctuary and Khaling Wildlife Sanctuary (Choudhury 2002). In Bangladesh a few gaur were thought to occur in the Chittagong Hill tracts, Sylhet and Mymensingh areas in the early 1980s (Sarker and Sarker 1984), but are probably now extinct. Status and distribution of the sub species *Bos gaurus readei* and *Bos gaurus hubbacki* in Thailand has been well investigated (Lekagul 1952, Suchart *et al.* 1976, Sayer 1981, Kutintara and Pongumphai 1982, Dobias 1982 and 1985, Supmee 1986, Sukavanich 1988, Nakhasathien 1989, Paliphod 1989, Climo 1990, Midas 1993). After a detailed study on the status of different gaur subspecies in different ranges and its occurrence it was reviewed that no gaur sighting was reported outside Thailand's Protected Areas (Srikosamatara and Suteethorn 1995). Srikosamatara and Suteethorn (1995) had estimated a population of about 915 gaur in Thailand. A 60% decline in the gaur population in Thailand has been reported in the last 20 years (Srikosamatara and Suteethorn 1995). Blower (1982) and Yin (1993) have reported the distribution and declining status of the species in Myanmar. Rabinowitz *et al*. (1995) made a rough estimation of about 100-200 gaur in the Tamanthi Wildlife Sanctuary in Myanmar. The current status of gaur in Myanmar is threatened due to the high level of trade in wild cattle trophies along the Thailand-Myanmar border (Rabinowitz *et al*. 1995, Slater 1983).

In Vietnam, the species is distributed in Yok Don Nature Reserve, Huai Kha Khaeng Wildlife Sanctuary (Laurie *et al.* 1989, MacKinnon *et al.* 1989), Nam Cat Tien National Park (Hoe and Quy 1991) and Nui Bi Doup (Canh 1995). However, there is no published information on the estimated population of gaur in any of these areas. In Cambodia the most substantial gaur population of the country was found in eastern Cambodia centered on Mondulkiri province, where in the late 1990s potentially several hundred to a thousand gaur individuals may have

survived in a forested landscape of over 15,000 km² (Timmins and Ou 2001, Tordoff *et al*. 2005). Political unrest, hunting and habitat destruction have been the main causes of decline in the gaur population in Cambodia and Vietnam (Dang 1986, Oliver and Woodford 1994).

The presence of gaur has been documented in the southern and central parts of Lao PDR (Salter *et al.* 1990, Salter 1993, Duckworth *et al.* 1994). In Malaysia the destruction of lowland rainforest has led to the decline of gaur population (Dolan 1967). Gaur has been exterminated from most of the areas in China (Xiang and Santiapillai 1993). A remnant population has been reported to be crossing back and forth along the Chinese-Myanmar border (Ma *et al*. 1994). The global population of gaur is estimated at 13,000-30,000 animals (Duckworth *et al*. 2008).

Gaur distribution in India

In India the gaur population is distributed mostly in isolated pockets largely corresponding to the major mountain systems of the Western Ghats, the Central Indian Highlands and the North-eastern Himalayas, including the hills south of Brahmaputra. Gaur is also found in the forests of Bihar, West Bengal and parts of the south-eastern peninsula (Figure 1.2.).

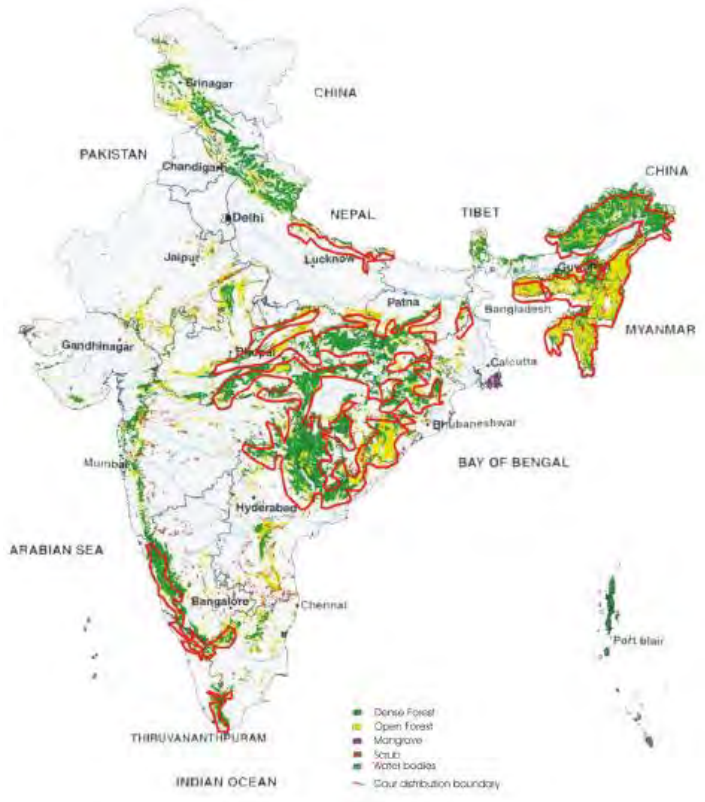


Figure 1.2: Forest cover and distributional range of gaur in India (Corbet and Hill (1992)).

Based on the present distribution of gaur, Schaller (1967) stated that in the past the distribution of gaur should have extended to the plains since to reach central India gaur had to traverse the Gangetic plains and in order to reach southern India they had to cross the upland plateau. Gaur occurs in diverse habitats ranging from tropical wet, semi-wet evergreen and bamboo forests in the North-east to Tropical Moist Deciduous forests in the Western Ghats to Tropical Dry Deciduous forests in Central India to Shola forests and Tropical Thorn forests on the eastern slopes in the Western Ghats.

Sankar *et al*. (2001) reported that the Wayand – Nagarhole - Mudumalai-Bandipur complex in the Western-Ghats landscape is one of the most extensive extant strongholds of gaur. In the Central Indian landscape the most important units for gaur population are the Satpura-Melghat landscape and Achanakmar – Kanha - Pench landscape (Jhala *et al*. 2011). In the Terai-Arc landscape gaur has been reported only from the Valmiki Tiger Reserve in Bihar which shares connectivity with the Chitwan National Park in Nepal (Jhala *et al*. 2011). The gaur habitat in North-east India is contiguous with the state of West Bengal in the west, Myanmar in the east, Bangladesh in the south and with Bhutan in the north (Sankar *et al*. 2001). Tropical moist deciduous and tropical dry deciduous forests are the dominant vegetation types within the present distribution limits of gaur (Sankar *et al*. 2001). The Western Ghats and Central Indian Landscape hold about 75% of the present gaur population in India. The gaur range represents approximately 7.12% of the geographical area and 30% of the forested area of India (Sankar *et al*. 2001).The estimated

population of gaur in India is between 12,000 and 22,000 (Ranjitsinh 1997). Sankar *et al*. (2001) estimated the gaur population in India to be approximately 23,500.

Threats

Gaur populations are under many different kinds of threats in their entire distributional range. The principal threats to gaur are habitat degradation, poaching and disease. Gaur is hunted for its meat, crop protection, medicinal uses and as trophies (Pasha *et al*. 2004). Habitat loss and fragmentation are the most serious threats. In North-east India the species is threatened with habitat degradation brought about by shifting cultivation (Choudhury 2000, Imam 1985). In the rest of the gaur distributional range, conversion of forest areas to agricultural use or commercial plantations is another serious threat. Poaching and sport hunting in the past, and habitat degradation are mainly responsible for the decline in the gaur population and it has also lead to the extinction of small local gaur populations (Sankar *et al*. 2001).

The Central Indian landscape which harbours about one fourth of the gaur population in India (Sankar *et al*. 2001) has witnessed quite a few local extinctions of gaur population in the past couple of decades. The gaur population has gone extinct from Bandhavgarh Tiger Reserve in Madhya Pradesh and from Kanger Valley National Park in Chhattisgarh (Sankar *et al*. 2001). The species is also possibly extinct in Sanjay National Park, in eastern Madhya Pradesh, which earlier had a gaur population connected with the populations in Chhattisgarh and Jharkhand. Brander (1923) had reported the extensive presence of gaur in the Betul and Khandwa districts of Madhya Pradesh at the beginning of the 20th century; the species is either extinct or unrecorded there at present. Apart from Central India the disappearance of gaur population has also been reported from Thattekad Wildlife Sanctuary in Kerala (Sankar *et al*. 2001).

The species is closely related to domestic livestock and is vulnerable to all the diseases that infect cattle. Past records indicate that populations of gaur have succumbed to epidemics of foot and mouth disease (FMD), rinderpest and anthrax in many areas of distribution. Several subpopulations of gaur in Bandipur-Mudumalai area were nearly destroyed as a result of rinderpest in 1968 (Choudhury 2002). Among the diseases reported for gaur, FMD has been found to be the most prevalent disease in the gaur populations in India (Sankar *et al*. 2001). Insurgency in some of the states of Northeast India and Central India has also affected the gaur habitat in these regions (Choudhury 2002). The increased habitat fragmentation and anthropogenic pressures in gaur habitat could effectively reduce the genetic diversity of gaur populations as a result of inbreeding and expose those isolated populations to environmental and biological stocasticities.

Conservation Status

The global population of the gaur is estimated at 13,000-30,000 animals of which, only 5200-18,000 are reproductively active individuals (Duckworth *et al*. 2008). The population has declined overall by at least 30% during the last three generations. As a consequence, the gaur is categorized as Vulnerable (criteria A2cd+3cd+4cd ver. 3.1) in the IUCN Red List of Threatened Species (Hilton-Taylor 2000). It is listed in Schedule I of the Indian Wildlife (Protection) Act of 1972 and is included in Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).

1.3 Literature review

Though gaur is the largest bovid in the world, long term ecological studies on this species have been few. The studies done by Brander (1923), Hubback (1937), Wharton (1968), Krishnan (1972) presents a sketchy account on the general ecology of gaur. In India, detailed ecological studies on gaur have been carried out by Schaller (1967) and Chandiramani (1984) in Kanha Tiger Reserve; Vairavel (1998) in Parambikulam Tiger Reserve; Sankar *et al*. (2001) in Pench Tiger Reserve, Ashokkumar *et al*. (2004) in Mudumalai Tiger Reserve and by Gad (2011) in Bhagvan Mahaveer Wildlife sanctuary and Mollem National Park in Goa. Bhattacharya *et al*.

(1997) conducted the status survey of gaur in North Bengal region. The activity pattern and feeding behaviour of gaur was studied by Moorthy (1989) in Kodaikanal hills and by Prabhakar (1992) in the Indira Gandhi National Park. Ahrestani *et al*. (2012) studied the diet and habitat-niche relationships of gaur with other large herbivores in Bandipur and Mudumalai Tiger Reserves. Lad and Gopal (1992) conducted a short study on the gaur population in Bandhavgarh Tiger Reserve. Choudhury (1999) studied gaur in Dibang valley, district of Arunachal Pradesh. Choudhury (2002) has also given information about the distribution and conservation of gaur in the Indian subcontinent. Ahrestani *et al*. (2011) studied the life history traits of gaur in wild and captivity and the age and sex determination of gaur has also been studied by Ahrestani and Prins (2011) in captivity.

A lot of observations on gaur have been published as short notes (Cameron 1929, Brander 1935, Blackburn 1935, Morris 1937, 1938a, 1938b, 1948a, 1948b, 1952, 1954a and 1954b, Biddulph 1936, Mustill 1938, Russel 1938 and 1940, Rynjah 1950, Hutton 1951). A few of the published notes have dealt with the observations on the morphology of gaur (Cameron 1929, Morris 1930 and 1947, Biddulph 1936, Robinson 1942, Hundley 1951, Pillai 1951). Morris (1948b) and Kurt (1974) have briefly mentioned about the disease aspects of gaur. Some information about the gaur in North-eastern India can be found in short notes published by Choudhury (1987, 1992, 1993, 1994a, 1994b, 1995, 1996a, 1996b, 1996c, 1997a, 1997b, 1998a, 1998b, 1999 and 2000), Wegge (1976) and Gupta and Mukherjee (1994). Some studies on gaur in Central India and Southern India are discussed in Basappanavar (1985), Imam (1985), Balakrishnan and Easa (1986), Davidar (1986), Karanth (1986), Dwivedi (1987), Samant (1990), Rao (1991), Karanth and Sunquist (1992 and 1995). Conry (1989) studied the habitat use and movement patterns of gaur in Malaysia. Information on gaur in Malaysia has been also given by Duckworth and Hedges (1998). Srikosamatara and Suteethorn (1995) have studied gaur in Thailand. Johnsingh (1998) has given information about gaur in Chitwan National Park, Nepal.

1.4 Gaur in Bandhavgarh Tiger Reserve

The Bandhavgarh Tiger Reserve, situated in Central India, supported a small population of gaur (35-38 individuals). This gaur population became extinct by 1998 and the reason for the same is attributed to the disruption of the migratory corridor between the forests of Bandhavgarh and Ghunghuti and Amarkantak. Even after the local extinction of gaur from Bandhavgarh it continued to be an excellent habitat for gaur and hence it was decided to reintroduce gaur in Bandhavgarh Tiger Reserve as it would be a major conservation initiative for this vulnerable species. The gaur population of Kanha Tiger Reserve, situated in Central India and only 200 kms from Bandhavgarh Tiger Reserve, was selected as the source population for this reintroduction program. This entire reintroduction program has been discussed in detail in the next chapter.

Chapter II

Background

Background

2.1 History of gaur presence in Bandhavgarh

The gaur was historically found in Bandhavgarh in small numbers. The small population of gaur is representative of the few herds surviving in the state of Madhya Pradesh north of river Narmada (Lad and Gopal 1992). According to the management plan prepared by Sh. M. Dixit in 1975, gaur was localized in the hilly tract around the Bandhavgarh fort. Gaur population of Bandhavgarh National Park was considered to be threatened (Sonakiya 1993). Estimated gaur population in Bandhavgarh from 1968 to 1998 is given in figure 2.1.

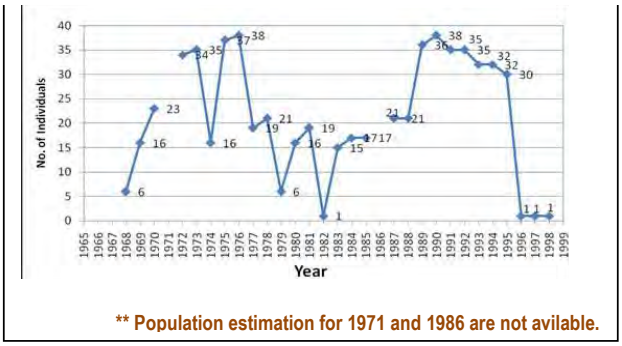


Figure 2.1: Population estimation of gaur in BTR

Gaur was usually seen in the Rajbahra, Bathan, Bhadrashila and Chakradhara areas of Tala Range, only in the open season. There is no definite information regarding where the species spent the rainy season. It was generally believed that they migrated to the Ghunghuti and Amarkantak areas (Southwest of Bandhavgarh) during the monsoon, but they were occasionally recorded within the extended park area (Kallwah and Magdhi ranges) during the rainy season as well. The 1988 monitoring program conducted by the forest department confirmed their presence in the Kallwah/Magdhi area in the monsoon

2.2 Cause of local extinction

i. It is well accepted that the disappearance of the species from BTR was sudden, not gradual. If the decline had been gradual, predation by tigers, degradation of habitat, disruption of the migratory route, etc. would have been the probable causes. Till recently, it was believed that something happened to the population during its so-called migration season, when it was believed to migrate out of the park, in 1995. The construction of a thermal power plant near Pali, along with other associated developments, and the consequent disruption of the traditional migratory route (presumed), was believed to be one of the major reasons for the extinction of the species in Bandhavgarh. However, the sudden disappearance of the entire population, which in fact had been growing for the previous 15 years or so, cannot be explained by this factor.

ii. The only other possible factors can be a disease or an accident. There is no record of any epidemic of anthrax, rinderpest or any other livestock disease in the region during the relevant period, and no gaur deaths were reported then.

iii. The information regarding mortality (natural and predation) on gaur in Bandhavgarh is incomplete (Lad and Gopal 1992). With data available for only a certain period of time (1974-1982 and 1988-1989) mortality of seven (six due to predation by tiger and one calf due to injury) gaur was reported during the period. Selective calf predation by tiger and wild dog was considered to be the main reason for the stagnation of the gaur population in the park (Lad and Gopal 1992).

Until a meeting of all the directors and assistant directors of the park of the period 1990 and 2000, serving or retired, was called in the office of the Chief Wildlife Warden in 2006, when this project was being planned, the most popularly accepted theory was that the species suffered some major setback in its monsoon range in 1995 as it did not return to the popular areas of the park after the monsoon. However, now it is confirmed that the animals did return after the 1995 monsoon as a herd of 13 was seen near the Tala gate on 1 November 1995 by the then Assistant Director of BTR. A few animals were also seen by the new Field Director in the subsequent December-January period. No animal was seen in the park after March 1996. The tragedy confirms the fact that small, isolated populations are vulnerable to local extinctions.

2.3 Gaur reintroducetion plan

As a part of active management and population building exercise, a proposal was prepared to re-introduce 20 gaur in Bandhavgarh Tiger Reserve from Kanha Tiger Reserve by the Madhya Pradesh Forest Department in 2007. Subsequently Wildlife Institute of India performed Population Viability Analysis (PVA) and based on the analysis it was planned to re-introduced 50 gaur (Male : Female ratio was 1:3) so as to achieve overall population growth rate of 5% and the probability of survival as 99% (Pabla *et al.* 2011). It was proposed to reintroduce 20 gaur (15 adult females and 5 adult males) and monitor them successfully in the first year then the supplementation of 30 gaur to the population within two years, would be under taken to maintain a viable population of approximately 50 animals (Pabla *et al.* 2011).

2.4 Pre-preparation in Kanha Tiger Reserve

Enclosure

A holding Boma (enclosure for large herbivores; Swahili term, Mozambique) was designed at Kisli range in Kanha Tiger Reserve (plate 2.1.A) where the immobilized animal was released before eventually being loaded in the transport truck. The Boma was constructed of steel sections 2.5 m high by 3 m long made out of 50 mm x 75 mm x 3 mm rectangular hollow tubes. The Boma had three sliding gates 1.5 m wide sliding on a 3 m rail and 2.5 m high (plate 2.1.B). The Boma had a loading ramp which was a 3 m section and made of solid pressed steel at 2.5 m height. The steel sections of the Boma beyond the sliding gate were covered using the agri-mesh all the way up to the entrance of the truck. Since gaur is forest dwelling animals, this was done to give them a sense of having a space to hide in. Branches with foliage were hung on the wires running across the Boma. The Boma was divided into two compartments using bamboo mats and sliding gate and provision was made for providing food, water and salt in the last compartment. A loading ramp was prepared which is a 3 m section, of solid pressed steel at 2.5 m height. The same specifications applied to the walkway of the other sections.

Transport truck and stretcher

i. Two mini transport trucks (TATA 407 four by four) were fabricated as recovery vehicles for carrying immobilized animals from the site of capture to the vehicle or the enclosure (plate 2.1.C).

ii. One heavy duty transport (TATA LPT 1615) truck was fabricated for the transport of animals by road from Kanha to Bandhavgarh Tiger Reserve (plate 2.1.D).

iii. A stretcher was specially designed for carrying immobilized animals from the site of capture to the mini transport truck (plate 2.1.E).

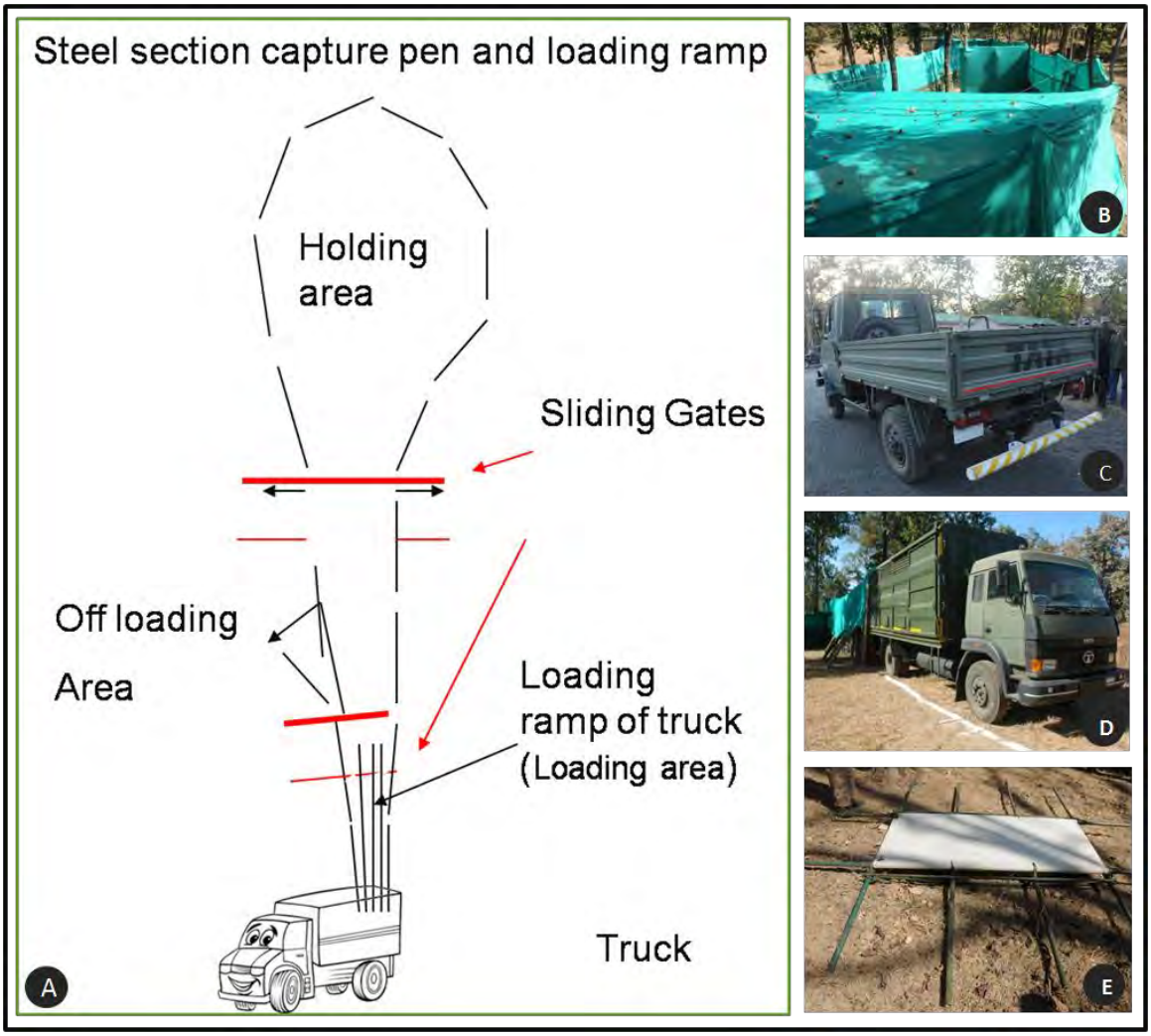


Plate 2.1: Design of boma and preparation of gaur translocation in Kanha Tiger Reserve

A- Construction design of Boma in Kanha Tiger Reserve; **B**- Holding Area;
C- Mini transportation truck (TATA 407); **D**- Heavy duty transport truck (TATA LPT 1615);
E- Stretcher

Pre-preparation in Bandhavgarh Tiger Reserve

A suitable site with good vegetation cover and water was selected for the soft release of gaur at Beheraha in Bandhavgarh Tiger Reserve at the borders of Tala and Magdhi ranges (Plate 2.2). A 50 hectare carnivore proof enclosure with solar powered electric fence was prepared for the release of animals. A small area of 2.5 hectare was fenced inside the larger enclosure to facilitate closer observation of the animals during the initial few days (Plate 2.2).

2.5 Capture and translocation of gaur

The capture and translocation of 50 (14 male and 36 female) gaur from Kanha Tiger Reserve KTR) to Bandhavgarh Tiger Reserve (BTR) was done in two phases *i.e.* phase I during January 2011 (n=19) and phase II, during March 2012 (n=31). Individuals were selected from different herds from Kisli and Kanha ranges in KTR.

In phase I, 19 individuals, were captured and translocated between 21 January and 27 January 2011. Of these, 12 animals were fitted with radio collars. Details on phase I (will be mentioned as batch I hereafter) animals are given in table 2.1.

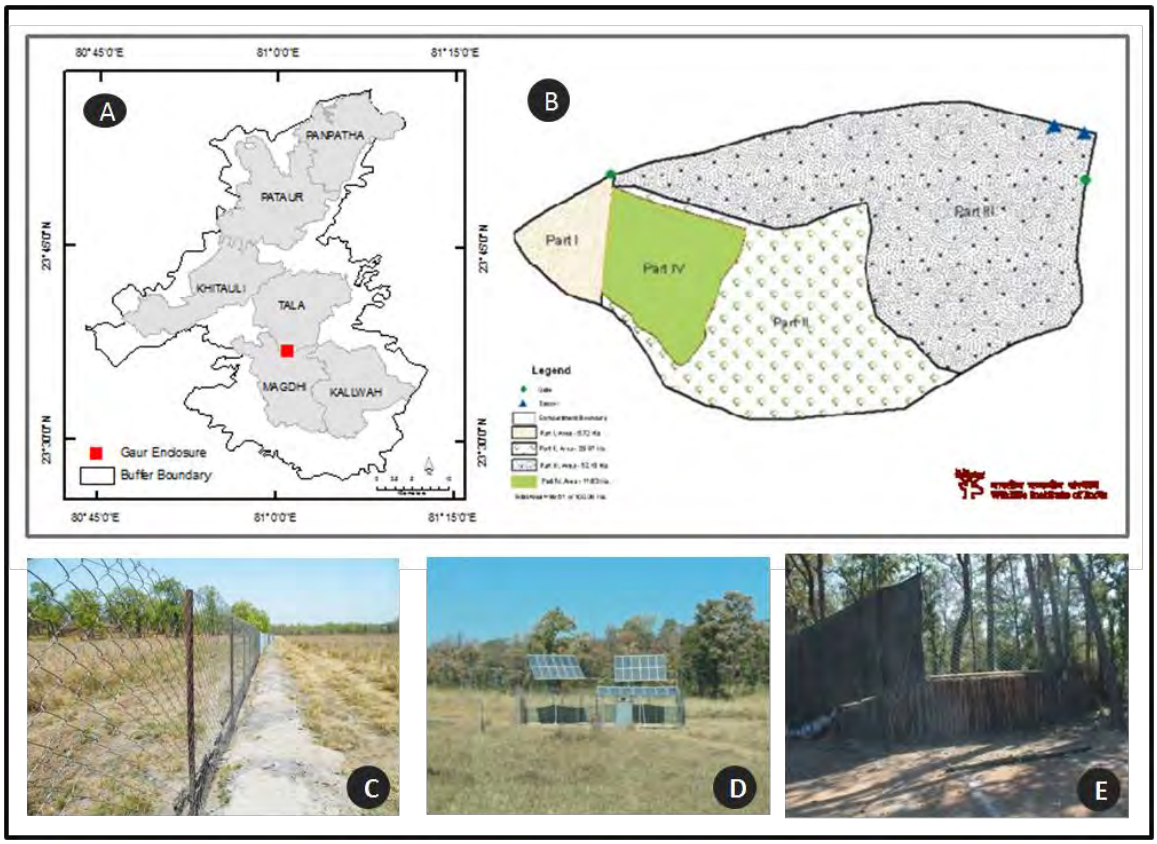


Plate 2.2: Design and preparation of enclosure in BTR

A- Gaur reintroduction enclosure site in BTR; **B-** Enclosure design at Magdhi range;
C- Solar power fencing at enclosure; **D-** Solar panel at the site;
E- Off loading ramp

Table 2.1: Details of gaur translaoced and radio collared from Kanha Tiger Reserve, Madhya Pradesh, during January 2011 and March 2012

	2011		2012	
	Male	Female	Male	Female
Number of animals translocated	5	14	9	22
Number of animal fitted with GPS collar	2	*	1	3
Number of animal fitted with VHF collar	1	9	2	9

2.6 Operation details

Nine trained captive elephants were used for the search operations. Once the herd was located, the herd size, composition, terrain conditions for darting and the distance from the road were considered prior to the actual operation. Animals were selected from the herd (plate 2.3.A) and darting of the animal was done from elephant back (plate 2.3.B). Gaur were tranquilized using Etorphine hydrochloride (Captivion, Wildlife Pharmaceuticals (Pty) Ltd., 9.8 mg/ml) mixed with 18 azaperone (Stressnil, Janssen Pharmaceutica NV, 40 mg/ml) and was remotely injected employing 3.0 ml nylon darts using a Dan Inject projector (model JM). The animal was left undisturbed till it reached a condition safe for handling. After ensuring that the animal had been sedated sufficiently so that it was safe to handle it, the animal was immediately blindfolded and maintained in sternal recumbency. Proper positioning of the tranquilized animal was maintained. After ensuring the physiological parameters were stable,

the animal was weighed, and body measurements were taken, including total body length, shoulder height, chest girth, tail length and horn length (plate 2.3.C)

Selected animals were fitted with radio-collars (plate 2.3.D). The immobilized animal was shifted onto the stretcher and loaded onto the small vehicle (plate 2.3.E) for taking it to the boma or directly loaded onto the transport truck (plate 2.3.F). All the animals captured at Kisli range were brought to the boma, whereas the animals captured at Kanha range were directly shifted into the transport truck. Once the loading of animals into the truck was done the journey *via* road, covering the distance of 250 Km almost took 8 hours to reach Bandhavgarh. The journey was commenced in the late evening so as to avoid heavy traffic to reach the release site during the early morning hours. Special care was taken to maintain a uniform speed during the journey, with the speed adjusted according to the local road conditions. The animals were monitored at every one hour interval throughout the journey.

The same capture technique and transportation procedure was followed for the second phase of gaur in March 2012. In the second phase, 31 gaur (9 males and 22 females) were captured between 3 March 2012 and 11 March 2012 and translocated to Bandhavgarh. Details on phase II (will be mentioned as batch II hereafter) animals are given in table 2.1. These animals were selected from different herds in Kisli and Kanha ranges in KTR.

2.7 Radio collar

Radio collars with mortality sensors were used for the study (TELONICS, United State of America). Two types of radio collars were used on gaur (GPS/ SATELLITE/VHF and Very High Frequency-VHF). The first batch GPS (n=2) collars were programmed to receive locations every day initially for three months and subsequently on every third day to maximize the collar life. In 2012 the GPS (n=4) collars were programmed to receive locations every day. TELONICS made TR-4 receiver along with uni-directional hand-held 3-element "Yagi" antenna and "H" type antenna were used to track the radio collared animals.

Plate 2.3: Gaur translocation operation (2011 and 2012)
A- Selection of gaur from the herd in Kanha TR; **B-** Gaur darting form elephant back in Kanha TR; **C-** Weighting of the gaur in Kanha TR; **D-** Fitting of radio collar in one of the gaur individual in Kanha TR; **E-** Gaur shifting into a small truck (recovery vehicle) in Kanha TR; **F-** Shifting the gaur into the larger truck for transportation in Kanha TR;

Chapter III

Objectives

Objectives

In any reintroduction programme for a wildlife species, it is essential to monitor the reintroduced population and study the different ecological aspects of the reintroduced population in order to understand the response of the animals to their new environment. Hence the present study was designed with the following objectives:

1. To study the ranging patterns of reintroduced gaur in Bandhavgarh Tiger Reserve
2. To study the habitat use of reintroduced gaur in Bandhavgarh Tiger Reserve
3. To study the food habits of reintroduced gaur in Bandhavgarh Tiger Reserve and
4. To study the health condition and group size of the reintroduced gaur in Bandhavgarh Tiger Reserve.

Chapter IV

Study Area

Study Area

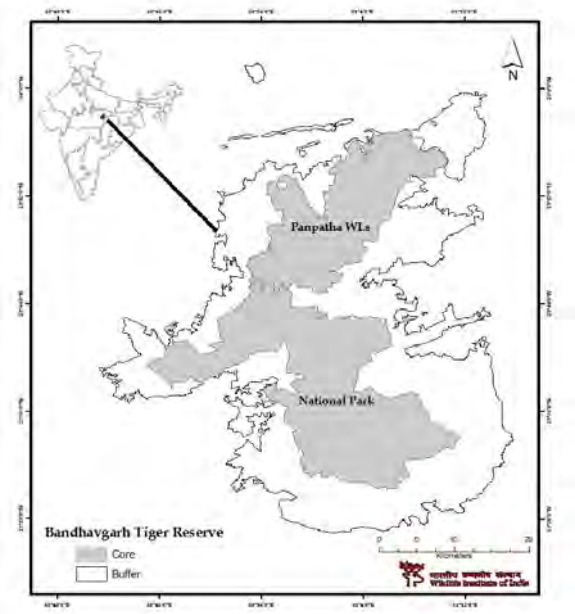


Figure 4.1: Location of BTR, Madhya Pradesh, Central India

4.1 Location and general information

The study was conducted in the Bandhavgarh Tiger Reserve (BTR) situated in the state of Madhya Pradesh in India (figure 4.1). According to the Bio-geographic classification of India, Bandhavgarh Tiger Reserve falls in the zone 6E- Deccan plateau-Central highlands (Rodgers and Panwar 1988). It is located between the Vindhyan and the eastern flanks of Satpura hill ranges and the reserve lies between 23^0 30' 08" to 23^0 57' 01" North latitude and 80^0 47' 05" to 81^0 11' 43" East longitude. Bandhavgarh Tiger Reserve comprises of the core area (716.46 km^2) and the buffer area (820.15 km^2) and the total area of the reserve is 1536.7 km^2. The core area of the Tiger Reserve is further divided into two conservation units *viz*. Bandhavgarh National Park (448.84 km^2) and Panpatha Wildlife Sanctuary (264.28 km^2). The majority of the core area of BTR lies in the Umaria Forest Division (521.30 km^2) and the remaining portion lies in the Katni Forest Division (Prakasam 2006). The reserve has a diverse assemblage of flora and fauna (Gopal 1991). The headquarters of BTR is situated in Umaria town and the nearest cities are Katni (63.3 km), Shahadol (69.8 km) and Jabalpur (139 km).

4.2 Historical and Legal Status

Bandhavgarh Tiger Reserve has a very old history and ruins of the bygone era are scattered all over the tiger reserve. In Bandhavgarh, monuments of historical significance are the Bandhavgarh fort, caves, rock paintings and carvings. The Bandhavgarh fort is considered to be approximately 2000 years old (plate 4.1) and there are references to it in the ancient texts like the *Narad Panch* and the *Shiv Samhita Puranas* (Sonakiya 1993). Legend has it that the fort was gifted by *Lord Ram* to brother *Lakshman* so as to keep a watch on Lanka and hence it acquired the name Bandhavgarh (Bandhav – brother, Garh – fort). The fort is surrounded by as many as 32 hillocks (Sonakiya 1993). There are many caves named after saints and Hindu gods, with oriental inscriptions. Large tanks cut in sand stone, wells & huge sculptures, symbolizing some of the incarnations of *Lord Vishnu* are seen on the Fort plateau. The most famous sculpture of Bandhavgarh is a sand stone carving of *Lord Vishnu* reclining on the serpent (sheshnaag) over a perennial water tank known as *Sheshshaiyya* (plate 4.2).

Plate 4.1 Bandhavgarh fort

Plate 4.2 *Lord Vishnu* reclining on the serpent (*Sheshshaiyya*)

There has been human civilisation around the fort since 300 A.D. or even earlier and various dynasties have ruled the fort over the course of time (Sharma 1997). The earliest available historical data about the fort and its rulers is from the *Bhimsen Satvat* (Sonakiya 1993) in 300 A.D. when the fort was under the *Bharhivas Vekatak Dynasty*. The *Sangure Kings* captured the fort in the 5th century A.D. and it was later taken over by the *Kalchuri Rajput Kings*. Subsequently the fort was given over in dowry to the kings of the *Baghel* clan. It remained under the *Baghel* rulers till 1494 A.D. when it was captured by the *Kuruvanshee Kings*. In 1535 the *Baghel* kings regained the control of the fort and since then the Bandhavgarh fort remained under the rule of the *Baghel* kings as a part of the princely state of Rewa until Indian independence in 1947 (Nath 2000). The area enjoyed considerable protection under the *Baghel* rule as it was maintained as a shooting reserve for the royal family and hence there were rigid laws controlling the illegal felling of trees and poaching of animals (Nath 2000). In 1617, the capital of the Baghel kings was shifted to Rewa and the fort and its surroundings were gradually deserted. The *Baghel* king, late HH Martand Singh, handed over this hunting reserve to the government of India and in 1968 the Bandhavgarh National Park, comprising an area of 105 km^2 was established. In 1982 the area of the Bandhavgarh National Park was increased to 448.84 km^2. In 1983, an adjacent forest area of 264.28 km^2 to the east of the Park, was declared as the Panpatha Wildlife Sanctuary and subsequently the entire area was declared as Bandhavgarh Tiger Reserve under Project Tiger in the year 1993 (Prakasam 2006). On the fort there is a temple dedicated to *lord Ram* known as the *Bandhavadheesh* temple. The famous poet saint *Kabir Das* also lived on the fort and there is a temple and cave where he is supposed to have lived. These sites are important pilgrimage centres for people following the teachings of *Kabir* known as *Kabir Panthis*. On the occasions of the festivals of *Ramnavami, Krishna Janmashtami* and *Kabir jayanti* about 4000 to 10000 people visit *Bandhavadheesh* temple and the *Kabir* cave on foot (Prakasam 2006).

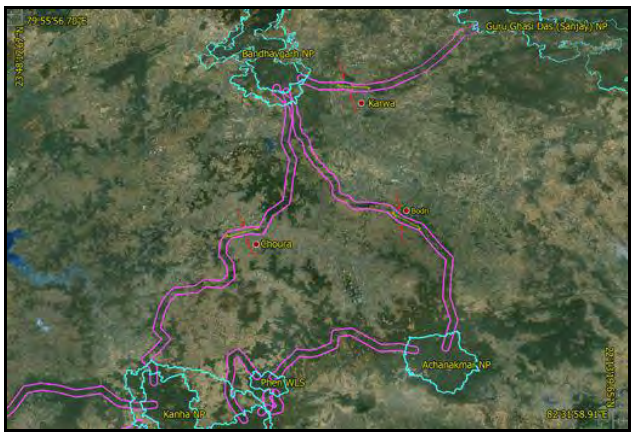


Figure 4.2: Corridors connecting Bandhavgarh Tiger Reserve with Sanjay-Dubri, Achanakmar and Kanha Tiger Reserves (Jhala *et al*. 2011)

4.3 Conservation Significance

The Central Indian Landscape comprises of some of the most important and threatened habitats of tigers in India (Jhala *et al*. 2011). Bandhavgarh is one of the major source populations of tigers in this landscape and the forest corridor connectivity of Bandhavgarh with other protected areas like Sanjay-Dubri, Achanakmar and Kanha (figure 4.2) is of vital importance for the movement and maintenance of meta-populations of tigers in this landscape (Jhala *et al*. 2011). Apart from tiger conservation, Bandhavgarh is also important with regard to the conservation of avian fauna as it not only provides suitable habitat for

resident birds but also provides wintering grounds for many waterfowl (Sonakiya 1993). Among the avian fauna, Bandhavgarh also harbours good populations of four species of vultures *viz*. long billed vulture (*Gyps indicus*), white-rumped vulture (*Gyps bengalensis*), red headed vulture (*Sarcogyps calvus*) and Egyptian vulture (*Neophron percnopterus*) (Prakasam 2006). Besides tiger and birds, the reserve harbors quite a few faunal species which figure prominently in the IUCN Red List like *Cuon alpines* (dhole), *Melursus ursinus* (sloth bear) and *Panthera pardus* (leopard) (Sonakiya 1993).

4.4 Topography and geology

Topographically, Bandhavgarh is extremely rugged with small hillocks interspersed with grassy swamps (Gopal 1991). The highest part of this landscape is the Bandhavgarh fort, which lies at an altitude of 810 m above msl (mean sea level) while the lowest point is the village of Tala at an altitude of 440 m above msl (Nath 2000). The area of Panpatha Wildlife Sanctuary is mostly plain though some parts have undulating hillocks and the highest point of the Sanctuary is 500 m above msl (Sonakiya 1993). The Bandhavgarh Tiger Reserve contains some of the oldest rocks in the world – the Gondwana rocks (Nath 2000). The rocks in the Bandhavgarh region belong to the Gondwana Super group of the South Rewa Basin (Sonakiya 1993) and the rock formations in Bandhavgarh mainly comprise of sandstone.

4.5 Physical features

Soil

The various rock formations and local topography have played an important role in the formation of soil in Bandhavgarh. The Gondwana sandstone is a poor source for good quality soils. The soil in the region is mainly sandy or sandy loam (Nath 2000). Richer clay and black cotton soils are also found in the park but their distribution is restricted to the areas of Badrehal and Pathari beats and the surrounding areas in the park (Sonakiya 1993). The pH of the soil in the park is around 20 and the composition of the chloride is 13 (Roy *et al.* 1992). The soil is usually poor in nitrogen and organic matter and fairly rich in potash.

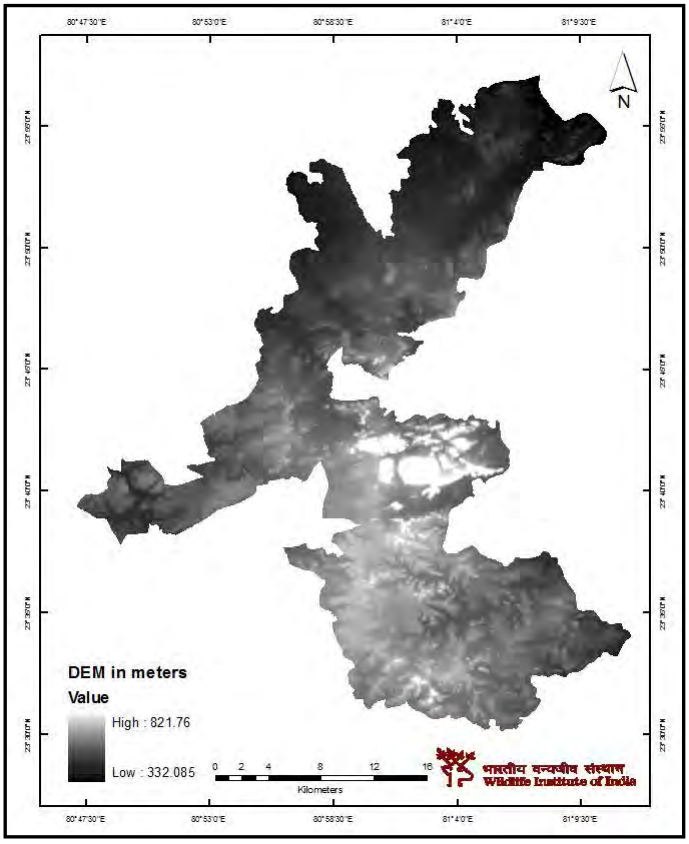


Figure 4.3: Digital Elevation Model map of BTR

Slope

The slope categories in BTR have been identified into eight classes *viz*. 330-390 degrees, 391-450 degrees, 451-520 degrees, 521- 580 degrees, 581- 640 degrees, 641-700 degrees, 701- 760 degrees and 761- 820 degrees (figure 4.3). Most of the protected area falls into flat to gentle slope class (330- 640 degrees). Part of Tala range has a rugged terrain with steep slopes (701- 820 degrees).

4.6 Drainage pattern and water availability

In Bandhavgarh Tiger Reserve the rock formations comprise mainly of sandstone which is a well-known aquifer as it is characterized by porosity and permeability (Prakasam 2006). Being permeable, sandstone is capable of high recharge and discharge making it as a storehouse of ground water which has resulted in some areas of the park having a very high water table. The Tiger Reserve has a number of seasonal and perennial streams and nullas (Lad and Gopal 1992). The major perennial rivers are Umarar, Damnar, Janad, Johila, Charanganga and seasonal nalas are Bhadar, Chachahi and Chamkuli (Prakasam 2006). The river Son flows in the north eastern direction along the boundary of Panpatha Wildlife Sanctuary. A large number of perennial springs originate on the slope of Bandhavgarh fort, the most important being Charanganga which flows as a major river outside the park area (Pabla 1998). The river Janad runs year round and flows in North-East region of the park, which originates from Magdhi range and flows into Kallwah range and joins the Son River running along the buffer boundary. In Sanctuary area the main rivers are Halphal, Jaruwahi Nala and Bagaiha Nala. The major waterholes in the park are Rajbehra dam, Devkhanni talab, Andhri jeriya, Adhawal, Bamera dam, Damdama talab, Jhurjura dam, Mahaman dam, Bodha talab, Charakava talab and Sukha dam (Prakasam 2006). Many water holes in the park dry up during summer and hence the park management supplies water in these water holes through tankers, solar pumps and hand pumps. The drainage pattern of the Tiger Reserve is shown in figure 4.4.

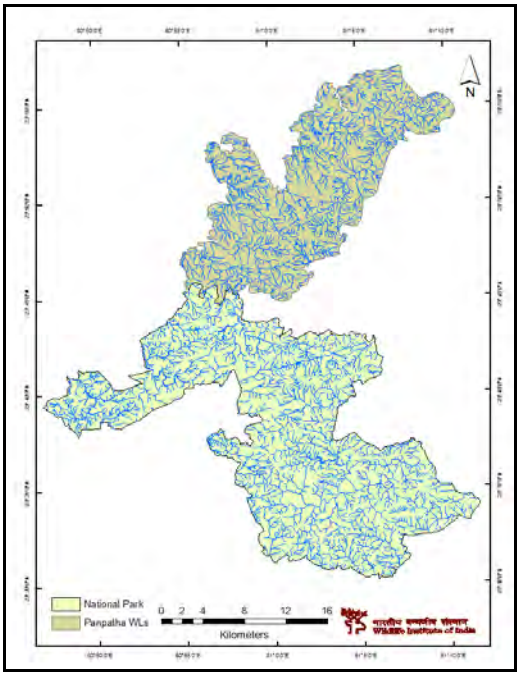


Figure 4.4: Drainage pattern of BTR

4.7 Climate

The Tiger Reserve lies within the tropical zone, having three distinct seasons *viz*. summer (March-June), monsoon (July-October) and winter (November-February).

Summer

The summer sets in the month of March and lasts till around mid June when the area receives the first showers of the Southwest monsoon. Generally, the months of May and June are the hottest, with the temperature rising up to 46°C (Prakasam 2006). During the study period the highest mean monthly temperature was recorded in the month of May at 43.8 ^{0}C (figure 4.5). Summer is usually dry, but instances of rains, hailstorms and thunder do occur in the month of March and April. The relative humidity in the early afternoon is as low as 15-20%. During this period many water holes dry up and the park area is prone to fires.

Monsoon

The area receives pre-monsoon showers by the mid of June and the regular southwest monsoon starts in the first week of July. More than 80% of the total precipitation in the year is received during July to September (Sonakiya 1993). Occasional winter rains occur during December to February from northeast monsoon constituting 5% of annual rainfall in this area (Prakasam 2006). During the study period the highest mean monthly rainfall was recorded in July as 28.7 centimetres (figure 4.5).

Winter

The winter begins in November and lasts till February, December and January being the coldest months. In severe winters, the night temperature comes down very low, mercury dropping even to sub-zero temperatures and severe ground frost occurs in the meadows and valleys (Prakasam 2006). During the study period the lowest mean monthly temperature was recorded in December at 10.2 ^{0}C (figure 4.5). Occurrence of fog in the early morning hours is common in winter. The relative humidity reaches 100% during the night, and the incidence of dew is heavy.

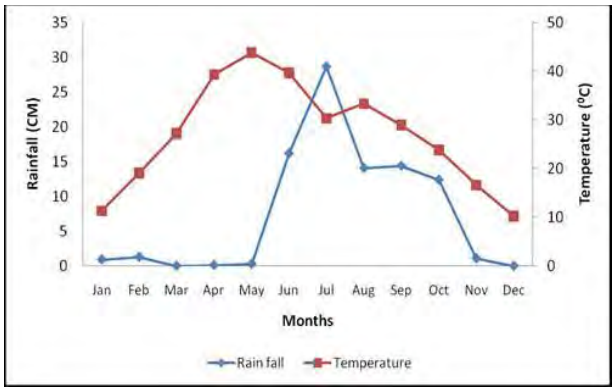


Figure 4.5: Mean rainfall and temperature in BTR (January 2011 –January 2015)

4.8 Flora

Vegetation of Bandhavgarh Tiger Reserve falls under five categories (Champion and Seth 1968) such as Moist peninsular low level Sal forest (3C/C2e), Northern dry mixed deciduous forest (5B/C2), Dry deciduous scrub (DS1), Dry grassland (5/DS4) and West Gangetic moist mixed deciduous forest (3C/C3a). The land use and land cover map of Bandhavgarh Tiger Reserve is given in figure 4.6.

A) Moist peninsular low level Sal forest (3C/C2e)

Sal typically forms a high forest in which it constitutes about 60 - 80% of the top canopy, which is 25–40 m high. The undergrowth is abundant with the presence of climbers. The main associates are *Terminalia tomentosa, Pterocarpus marsupium, Anogeissus latifolia, Madhuca indica, Phyllanthus emblica, Buchanania lanzan, Diospyros melanoxylan, Terminalia Chebula, Kydia calycina, Ougeinia oojeinensis, Bridelia retusa, Bauhinia retusa* and *Phoenix acaulis.* Sixty percent of the Tiger Reserve area comprises of Sal forests and its associates (Dwivedi 1987).

B) Northern dry mixed deciduous forest (5B/C2)

The upper canopy in this forest type is usually light, open and irregular, the trees having relatively short bole and poor form and a height rarely over 10 m. The canopy is made entirely of deciduous trees. The main species found are *Anogeissus latifolia, Acacia catechu, Butea monosperma, Buchanania lanzan, Acacia leucophloea, Syzygium cumini, Mangifera indica, Aegle marmelos, Soymida febrifuga, Cassia fistula, Flacourtia indica, Capparis decidua and Dendrocalamus strictus.* The undergrowth is comprised of *Ziziphus mauritiana, Ziziphus oenoplia, Ziziphus nummularia, Carissa opaca, Holarrhena antidysenterica, Bauhinia vahlii, Aristida depressa, Cynodon dactylon, Cymbopogon martinii, Heteropogon contortus*, *Themeda quadrivalvis* and *Cassia tora.*

C) Dry deciduous scrub (DS1)

This forest type represents a degradation stage of the dry deciduous forest and has been brought into existence by adverse biotic factors like cattle grazing, lopping and forest fires. In spite of sufficient rains, moisture retention is poor and the type has now become a stable edaphic climax. The main species found are *Butea monosperma, Diospyros melanoxylon, Cassia fistula, Anogeissus latifolia* and the undergrowth mainly comprises of *Woodfordia floribunda* and *Flacourtia indica.*

D) Dry grassland (5/DS4)

Grasslands, locally called as *bah*, are a common feature of the valleys in the park. Most of the large grasslands in the park have been created at the areas from where villages have been relocated outside of the park. The grassland communities are complex. Tall, coarse grasses are found in the marshy areas. Species which commonly occur in these grasslands include *Themeda quadrivalvis*, *Aristida setacea, Heteropogon contortus, Saccharum spontaneum, Vetiveria zizanoides* and *Phragmites karka.*

E) West Gangetic moist mixed deciduous forest (3C/C3a)

In this type of forest the canopy is comparatively open allowing good percentage of grass and herb to grow. The main species found in this type are *Lagerstroemia parviflora, Anogeissus latifolia, Adina cordifolia, Terminalia chebula, T. Bellerica, T. arjuna, Diospyros melanoxylon, Bauhinia retusa, Lannea coromandelica, Mitragyna parvifolia, Cassia fistula, Kydia calycina, Bauhinia racemosa, B. variegata, Phyllanthus emblica, Aegle marmelos, Grewia tiliaefolia, Bridelia retusa, Casearia esculenta, Gardenia turgida, G. latifolia, Holarrhena antidysenterica, Garuga pinnata, Buchanania lanzan, Butea monosperma, Helicteres isora* and *Dendrocalamus strictus* (Lall 1988). Bamboo occurs as undergrowth which are heavily browsed and become bushy. New culms of bamboo grow during November–December. These forests are highly prone to fire.

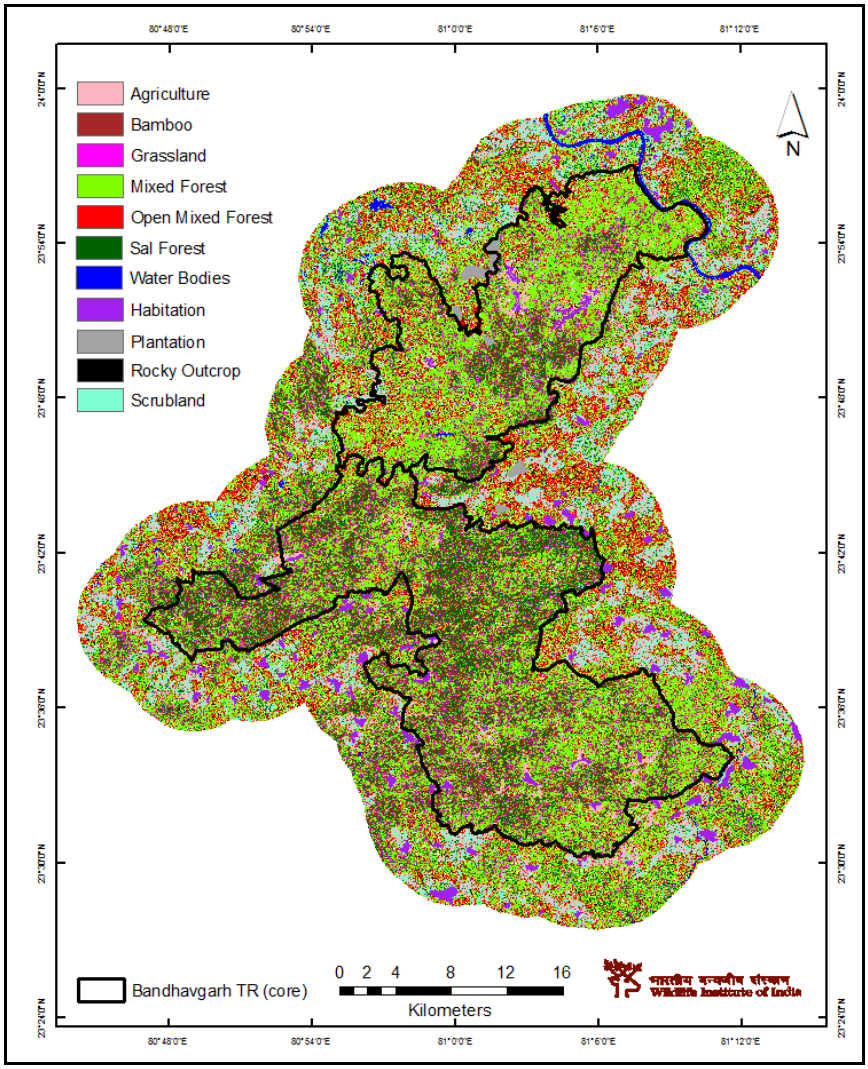


Figure 4.6: Vegetation and land cover map of BTR

4.9 Fauna

The Tiger Reserve supports a diverse assemblage of herbivores such as chital (*Axis axis),* sambar (*Rusa unicolor*) nilgai (*Boselaphus tragocamelus*), wild pig (*Sus scrofa*), barking deer (*Muntiacus muntjac*), four-horned antelope (*Tetracerus quadricornis*) and chinkara (*Gazella bennettii*). Primates such as Rhesus macaque (*Macaca mulatta)* and common langur (*Semnopithecus entellus)* are found in the park. The area supports a wide variety of large, medium and small sized carnivores such as tiger (*Panthera tigris*), leopard (*Panthera pardus*), dhole (*Cuon alpinus*), sloth bear (*Melursus ursinus*), jackal (*Canis aureus*), jungle cat (*Felis chaus*), rusty spotted cat (*Prionailurus rubiginosus*), common palm civet (*Paradoxurus hermaphroditus*), small Indian civet (*Viverricula indica*), grey mongoose (*Herpestes edwardsii*), ruddy mongoose (*Herpestes smithii*) and stripe necked mongoose (*Herpestes vitticollis*). The presence of wolf (*Canis lupus*), striped hyena (*Hyaena hyaena*), and Indian fox (*Vulpes bengalensis*) has also been recorded from the fringes of the park. The Indian porcupine (*Hystrix indica)*, blacknaped hare (*Lepus nigricollis*), three stripped squirrel (*Funambulus palmarum*) and Indian pangolin (*Manis crassicaudata*) also occur in Bandhavgarh Tiger Reserve. Domestic livestock (cattle, buffalo and goat) occur in the village areas present inside the National Park and Sanctuary (Prakasam 2006).

Around 250 species of birds have been identified in the Reserve (Prakasam 2006). The prominent birds of Bandhavgarh are the Indian peafowl (*Pavo cristatus*), red jungle fowl (*Gallus gallus*), Indian grey hornbill (*Ocyceros birostris*), Malabar pied hornbill (*Anthracoceros coronatus*), common teal (*Anas crecca*), lesser whistling teal (*Dendrocygna javanica*), crested serpent eagle (*Spilornis cheela*), lesser adjutant stork (*Leptoptilos javanicus*), long billed vulture (*Gyps indicus*), red headed vulture (*Sarcogyps calvus*), white-rumped vulture (*Gyps bengalensis*) and Egyptian vulture (*Neophron percnopterus*) (Sonakiya 1993).

4.10 Tourism

The park provides very good sighting opportunities of tiger and other wild animals (Tyabji 1991). The park remains open from mid of October to June end and tourists are allowed entry for four hours in the morning and three hours in the evening. Because of the easy sighting of tigers, around 1,00,000 tourists visit the park every year of which around 35% are foreigners (Choudhary 2013). The wildlife tourism activities are restricted only to an area of 146 km^2 which comprises of around 20% of the total core area of BTR. The tourism area in BTR is further divided into three zones among the ranges of Tala, Magdhi and Khitauli (Choudhary 2013).

4.11 Human settlements

At the start of 2011 there were 15 villages located inside the Tiger Reserve, of which seven were located in the notified Bandhavgarh National Park and eight in the Panpatha Wildlife Sanctuary (Choudhary 2013). The villages inside the core area are due for relocation in a phase-wise manner. Between 2011 and 2013 three villages *viz* Kallwah, Kumarwah and Magdhi were relocated from the core area of Bandhavgarh (figure 4.7). Soon after relocation many herbivore species like chital, nilgai, chinkara, wild pig and gaur have been observed to use these relocated sites intensively (Sankar *et al*. 2013, Choudhary 2013). Also there are 96 villages within a five kilometer radius of the outer boundary of the core area of Bandhavgarh Tiger Reserve. The total human population of these villages is estimated to be around 45,000 heads (Choudhary 2013). Agriculture is the main occupation in these villages and the major crops are wheat, ragi, cauliflower, cabbage and beans. Some villagers also work with the forest department as fire watchers, choukidars, elephant caretakers and mahout, grass cutters and as a part of antipoaching team. The livestock mainly includes a large number of buffaloes and a few cows along with some goats (Prakasam 2006).

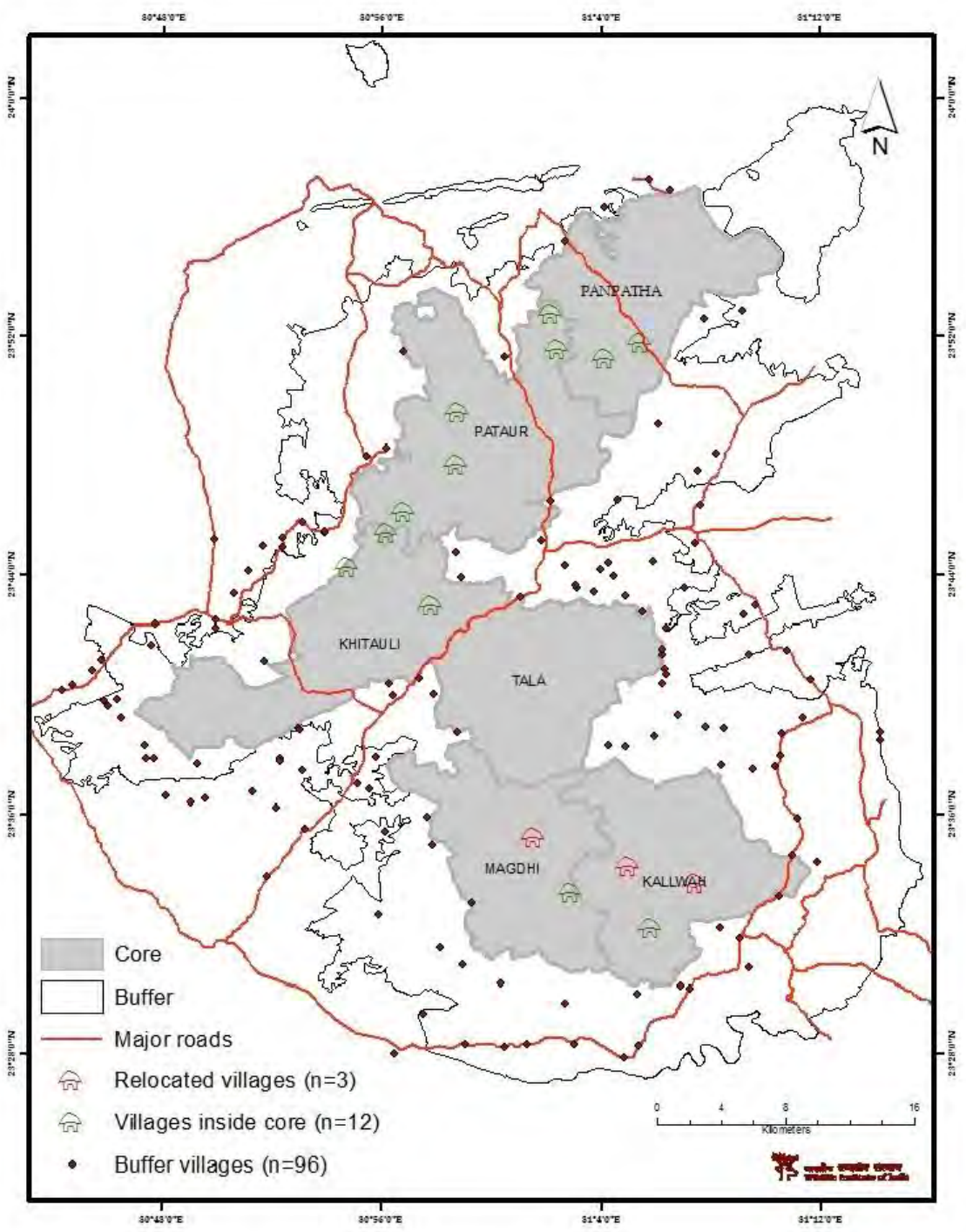


Figure 4.7: Location of villages in the core and buffer area of BTR

Chapter V

Ranging Pattern of Reintroduced Gaur

Ranging Pattern of Reintroduced Gaur

5.1 Introduction

Ranging pattern

Information on ranging pattern of animals helps in understanding their natural environments, mammals especially the gregarious ones often respond to climatic changes by altering the herd size and switching over habitats (McNaughton 1985). Radio tracking is the method of locating animals with the help of a transmitting device attached to the body of the animals (Sivakumar and Habib 2010). The studies on the home ranges in various wildlife species suggest that the size of the home ranges are directly related to body size and weight (Lindstedt *et al.* 1986, Swihart *et al.* 1988, Schoener 1968, Turner *et al.* 1969). The social structures and behavioral patterns of the animal species also have some effects on the home range size (Gittleman and Harvey 1982, Lindstedt *et al.* 1986).

Home range

"One may wonder whether it is worthwhile to attempt to measure anything as indefinite and variable as home range" (Stickel 1954). "Home range" referred to an individual or a group of animals will have an area that it habitually uses but does not necessarily defend (White and Garrott 1990). Home range has been measured in a myriad of ways *i.e.63* bounded areas or polygons (Mohr and Stumpf 1966). Burt (1943) described home range as the area traversed by an individual in its normal activities, including protection, feeding, mating, and caring for young and other life history requisites. The concept of home range has been challenged because of difficulties in quantification and calculation (White and Garrott 1990, Millspaugh and Marzluff 2001). The size of an animal's home range gives an indication of the availability of essential resources, restrictions imposed by the respective conservation areas or/and other artificial barriers and the degree of disturbance to which the animal is exposed (Hitchins 1969, Whyte 1996). The distribution and home range size of an animal is influenced by a combination of factors which include topography, elevation, soil type, amount of rainfall, human interference, and availability of food, forage quality and metabolic requirements (Laurie 1978-1982, Pomeroy and Service 1992, Bailey and Provenza 2008).

Gaur

In the mid-1900's most of the source population of gaur were secure because of the remote and isolated nature of their habitat (Hubback 1937, Foenander 1952).Very few studies reported the trend in population of gaur based on long-term and systematic monitoring. Weigum (1972) reported gaur home range as 13 km^2 in Taman Nagara National Park, Malaysia. Conry (1989) estimated home range of gaur yearling males, yearling females and adult males in Malaysia to be as 29.9 km^2 and 52.1 km^2 and 137.3 km^2 respectively. The estimated composite (one adult male, one adult female and one sub adult male) home range of gaur in Pench Tiger Reserve was 175 km^2 (Sankar *et al.* 2001). Physiographical features, temperature and rainfall fluctuations played important roles in determining the home range sizes of gaur in Pench Tiger Reserve, Madhya Pradesh (Sankar *et al.* 2001). Prayurasiddhi (1997) attempted a comparative study on gaur and banteng (*Bos javanicus*) in Thailand in which the population, feeding ecology of these species were investigated. Among the wild bovids, gaur is one of the most wide-ranging species showing seasonal and local movements between foraging sites (Schaller

1967). Thus very limited information exists on the ranging patterns of gaur especially of individuals belonging to distinct demography classes.

5.2 Methods

Radio tracking of gaur

In Bandhavgarh Tiger Reserve the study on ranging patterns of gaur was based on regular tracking of radio-collared (n=27) individuals. The radio-collared gaur were monitored periodically through ground tracking, using "triangulation" and "homing in" techniques (White and Garrot 1990). Triangulation is the process of estimating the location of an animal which involves taking bearings (Mech 1963) from three separate points based on the direction and strength of the radio signals (Kenward 1987). Homing in is done by ground tracking which involves the VHF (very high frequency) transmitters that emit radio signals of the collar over a long distance depending on the habitat and terrain and these signals are used to locate the animals visually (Kenward 1987). Details of locations collected for radio-collared gaur *i.e* annually during the study period, using "triangulation" and "homing in" techniques are given in table 5.1

Table 5.1: Details of locations collected for radio-collared gaur in different years in BTR.

	Years					Locations		
	2011	2012	2013	2014	Total	Triangulation	Homing in	GPS/ Satellite
Males	3883	1175	1011	1165	7234	1003	4872	1359
Females	5337	8537	3247	3461	20582	2926	13075	4581
Overall	9220	9712	4258	4626	27816	3929	17947	5940

Data collection

Twelve to fifteen locations, per radio-collared individual in a week with "biologically independent" locations *i.e* 6 hour interval between consecutive locations of the same animal as defined by Dolev *et al.* (2002) were collected on foot and from vehicle from March 2011 to January 2015. The locations were obtained during 0600 hrs to 1800 hrs in all seasons, summer, monsoon and winter.

Data analysis

Each radio collared gaur location was obtained with the help of Global Positioning System (GPS) and latter plotted in ArcGIS 9.2 (ESRI 2006). Minimum convex polygon (MCP) (Mohr 1947) and fixed kernel method (FKD) (Worton 1989) were used to estimate home range size. The 100% MCP is most widely used method (Harris *et al.* 1990) for the estimation of home ranges. Home ranges calculated with the MCP used either 100% of locations (to allow comparisons with other studies) or 95% of locations, in which the most peripheral points (outliers) were excluded. As pointed out by White and Garrot (1990) using outliers can greatly overestimate home range size, including parts never visited by the individuals. To remove the effect of exploratory movements and outlying fixes, 95% and 50% fixed kernel home ranges were also computed as described by Kernohan *et al.* (2001). The fixed kernel density estimator is rated as one of the most robust and least biased estimator of home range considering its performance with small sample sizes, auto-correlated data, and shape of underlying utilization distribution, outlier data and comparability between different studies (Jaremovic and Croft 1987, Kernohan *et al.* 2001, Worton 1995). Percent overlap between adjacent male home range and female home range was computed as the average proportion of overlap between male and female home ranges (Kernohan *et al.* 2001, Mizutani and Jewell 1998).

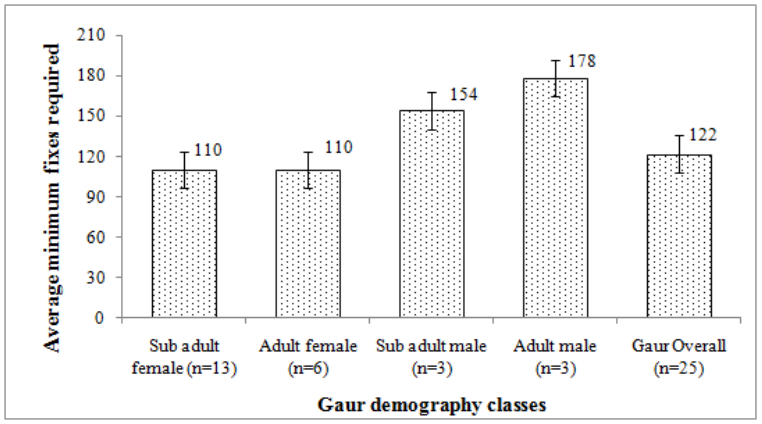
Herd formation

Total of four different herds were identified during the study period. Since gaur are herd living animal (Schaller 1967), the home range size of different herds was estimated using 100% MCP method to understand their annual ranging pattern. For the identified herds, minimum of one location per day was collected throughout the study period across different seasons (summer, monsoon and winter). Adult males were not considered in herd home range stabilization, because of their fluctuation in movment, solitariness and because of their tendency of moving from one herd to another (Schaller 1967).

5.3 Result

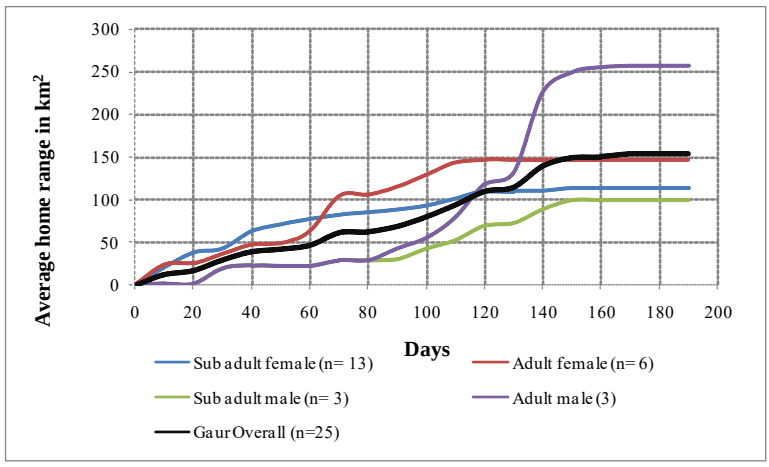
Sample size adequacy for home range estimation

The minimum number of fixes (locations) needed to calculate overall home range size of reintroduced gaur in Bandhavgarh reached an asymptode at 122 fixes (95% CI 111-133; range: 80-188) (figure 5.1). Males required more fixes for calculation of home range size than females. Especially adult males (n=3) required more number of fixes for calculation of home range size and it reached an asymptote at 178 fixes (range: 168-188). The sub adult male (n=3) home range reached an asymptote at 154 fixes (range: 145-160). In contrast, the female home range size reached an asymptote at 110 fixes (adults (n=4) range: 83-126 and sub adult (n=13) range: 80-130). For the calculation of overall home range size of gaur 100% MCP method was used and the average number of fixes ploted for different age and sex classes of gaur is given in figure 5.1.



n = sample size; Error bars as standard errors

Figure 5.1: Average minimum number of fixes required to estimate home range of gaur Home range stabilization curve



n= number of individuals

Figure 5.2: Cumulative curves of average home range areas for overall and different demographic classes of gaur plotted against number of days.

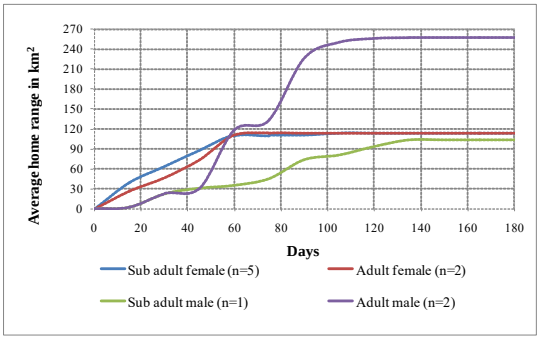
The average home range of reintroduced gaur reached an asymptote after exploring minimum of 154 km^2 (range: 71 Km^2 - 279 Km^2) within 143 days (range: 120 -163 days). Adult males were observed to explore larger areas and the average home range reached an asymptote on 257 Km^2 within 141 days. Average sub adult males home range reached an asymptote in 100 Km^2 within 163 days. In case of females, adult female average home range reached an asymptote in 149 Km^2, whereas average sub adult female home range reached an

asymptote in 111 Km^2. Both the age classes of females took an average of 120 days to establish their home range size. The cumulative curves plotted with 100% MCP home range size versus number of days are given in figure 5.2.

Batch wise home range stabilization

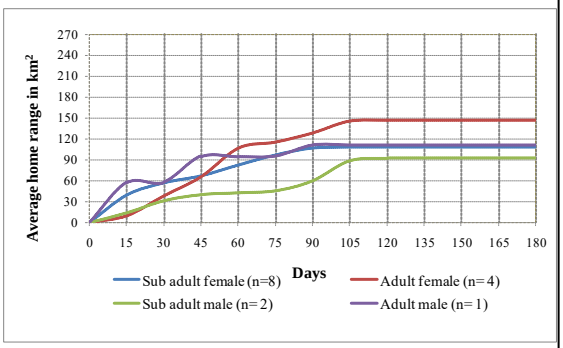
Locations of 25 radio-collared individuals were used to analyze the stabilization of home range. It was observed that the batch I (n=12) gaur home range exploration was gradual. Sub-adult females (n=5) and adult females (n=2) settled in new habitat over a period of 60 days, and the home range curve reached an asymptode in 110 Km^2. Adult male (n=2) and sub adult male (n=1) settled in the new environment within 105 and 135 days respectively. Home range curve reached an asymptode after exploring larger area of 257 Km^2 for adult male and 100 Km^2 for sub adult male (figure 5.3).

It was observed that the batch II (n=15) gaur home range exploration was unstable in the new habitat for 90 days. All the age and sex class individuals got settled in the new habitat between 90 and 105 days (figure 5.4).



n= number of individuals

Figure 5.3: Stabilization of home range for male and female gaur in BTR (Batch I - 2011)



n= number of individuals

Figure 5.4: Stabilization of home range for male and female gaur in BTR (Batch II - 2012).

Overall home range of reintroduced gaur

The overall 100 % MCP, home range of reintroduced gaur was 405.2 Km^2 (figure 5.5). The estimated 95 % FKD home ranges was 146.9 Km^2.

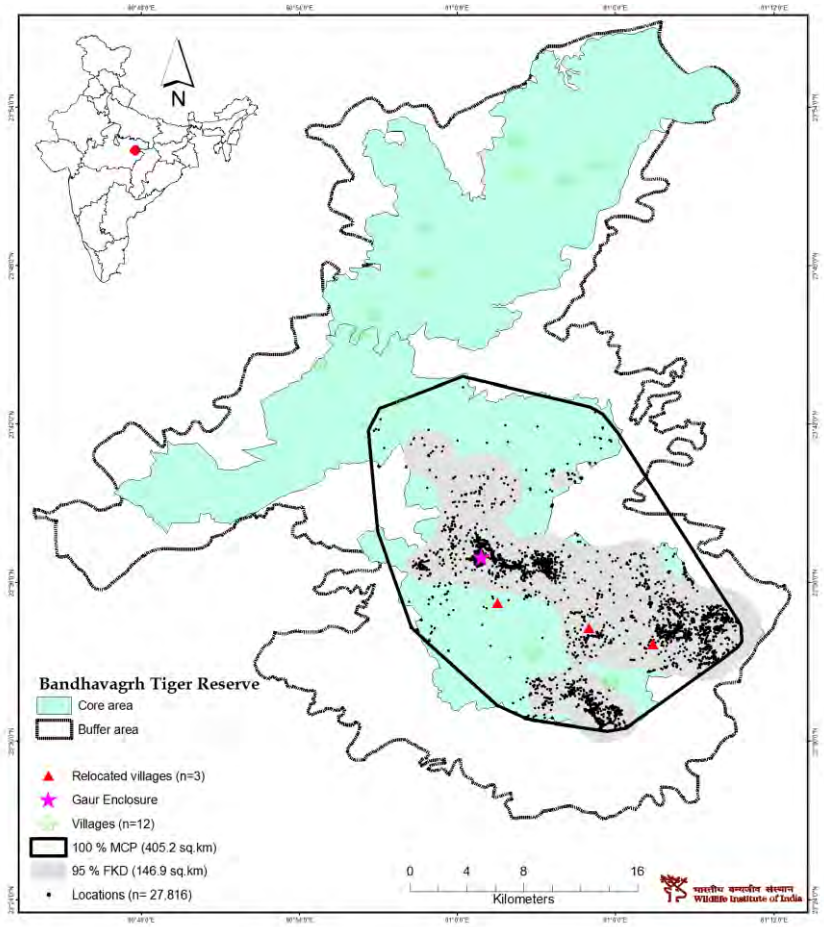


Figure 5.5: Overall home range of reintroduced gaur in BTR

Annual home range size of reintroduced gaur in Bandhavgarh Tiger Reserve

Nineteen gaur that were re-introduced in 2011 January, explored a large area (254.4 km^2) initially (figure 5.6). Subsequent addition of 31 gaur during March 2012 resulted in exploration of overall home range to 405.2 km^2 in 2012 (figure 5.6) followed by 240.5 km^2 and 209.1 km^2 in 2013 and 2014 respectively (figure 5.6). The 95 % FKD in 2011 was 140.6 km^2 followed by 197.7 km^2, 142.1 km^2 and 140.2 km^2 in the following years 2012, 2013 and 2014 respectively.

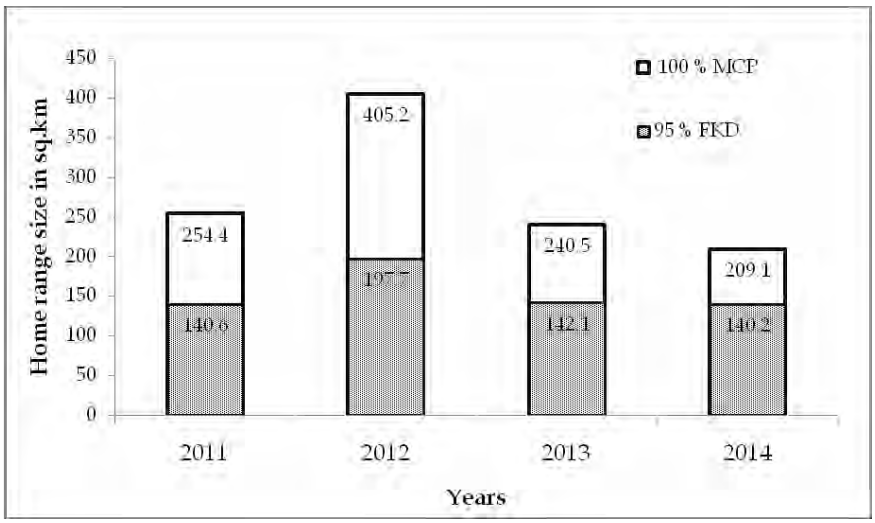


Figure 5.6: Annual home range size of reintroduced gaur across different years.

Home range size of individual radio collared gaur in different years

Using all locations of the different radio collared gaur individuals (MCP 100%) the estimated average overall home range of reintroduced gaur was 163.1 ± 13.0 (SE) km^2 (range: 71 km^2 to 279 km^2; 95 % CI – 188.5 km^2 to 137.6 km^2) (figure 5.11 and table 5.2). It was observed that with 100 % MCP of all the demography classes the average home range size of reintroduced gaur varied across years. In 2011 it was 131.8 ± 11.7 (SE) followed by 2012 when it was 128.2 ± 11.8 (SE) km^2, in 2013 it was 73.4 ± 4.7 (SE) km^2 and in 2014 it was 52.0 ± 4.9 (SE) km^2 (figure 5.7 and table 5.2).

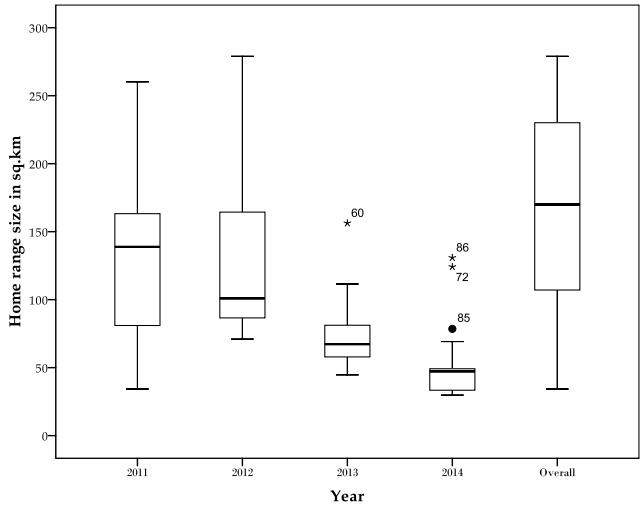


Figure 5.7: Variation in home range size in different years of reintroduced gaur

Table 5.2: Estimated year wise and overall home range size (km^2) of radio collared gaur in BTR (March 2011 – January 2015)

	100 % MCP (km^2)				
	2011	2012	2013	2014	overall
Average	131.75	128.24	73.44	51.98	163.09
SD	60.92	61.17	24.42	25.43	67.50
SE	11.69	11.77	4.88	4.89	12.99
Upper Confidence Level	166.22	152.21	83.02	61.95	188.55
Lower Confidence Level	97.28	104.26	63.87	42.01	137.63

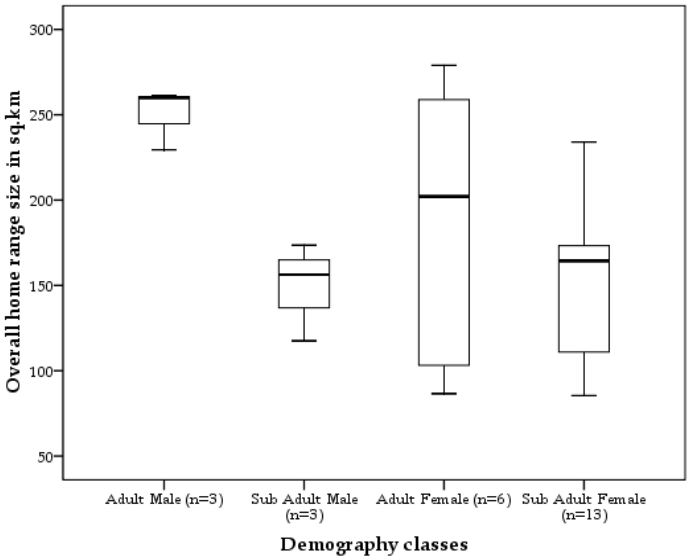


Figure 5.8: Overall demography classes home range size of reintroduced gaur

Overall home range size of demography classes

The overall home range of different demographic classes (AM- Adult Male; SAM- Sub Adult Male; AF- Adult Female; SAF- Sub Adult Female) was calculated using 100 % MCP. The average home range size of AM (n = 3) was 250.2 ± 10.3 (SE) km^2, SAM (n = 3) 149.1 ± 16.5 (SE) km^2, AF (n =6) 188.6 ± 33.1 (SE) km^2 and SAF (n = 13) 151.3 ± 13.6 (SE) km^2 (figure 5.8). Two female gaur (GF5 and GF7) died during the study period were excluded in the home range analysis.

Season wise home range of gaur

The estimated mean seasonal (summer, monsoon and winter) home range for adult male with 100 % MCP was 97.2 ± 16.6 (SE) km^2, 81.1 ± 7.1 (SE) km^2 and 62.6 ± 6.0 (SE) km^2 respectively, for sub adult male it was 45.2 ± 2.3 (SE) km^2, 58.3 ± 3.6 (SE) km^2 and 37.0 ± 6.6 (SE) km^2 respectively, for adult female it was 80.5 ± 14.9 (SE) km^2, 60.4 ± 4.0 (SE) km^2 and 30.0 ± 5.0(SE) km^2 respectively and for sub adult female it was 61.8 ± 5.4 (SE) km^2, 55.1 ± 2.4 (SE) km^2 and 34.4 ± 3.7 (SE) km^2 respectively (figure 5.9).

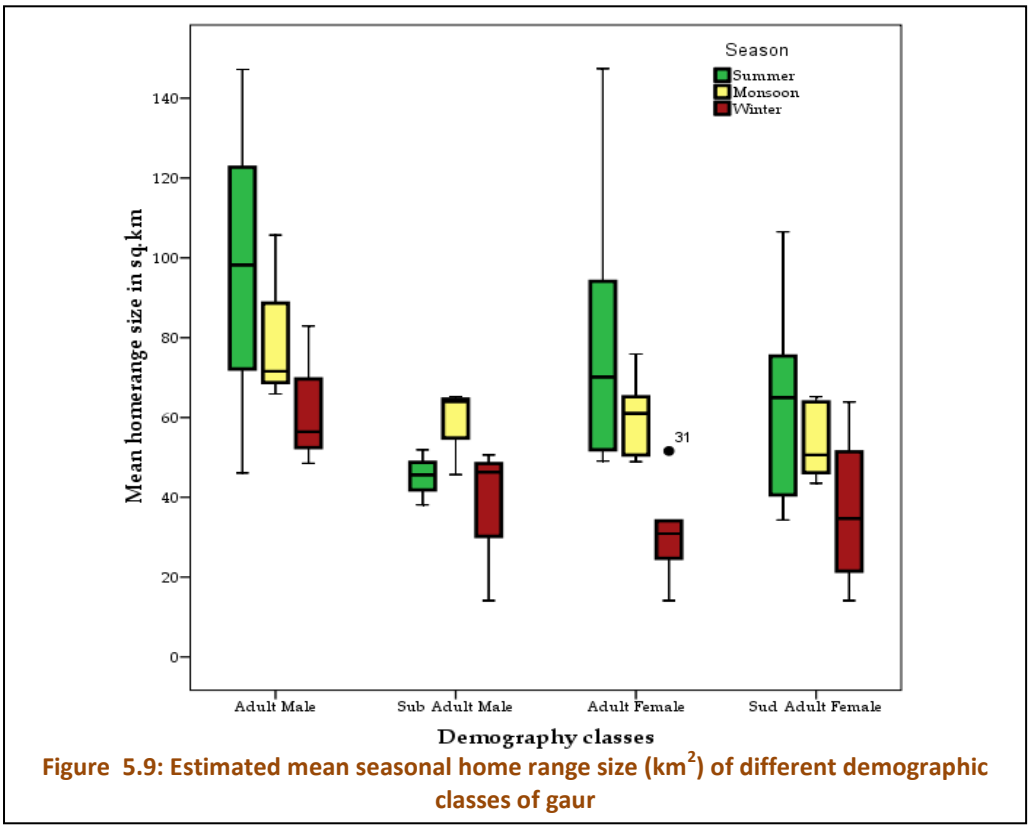


Figure 5.9: Estimated mean seasonal home range size (km^2) of different demographic classes of gaur

Home ranges of different gaur herds in Bandhavgarh

Of the 19 gaur individuals reintroduced in 2011, it was observed that they formed two different gaur herds *i.e* H-1(n=7) and H-2 (n=13), and both had mixed age and sex class individuals (table 5.3). However, none of the males were associated with H-I in the first year.

The suplimentation of 31 gaur in 2012, resulted in formation of four new gaur herds. A total of six different (two pre-existing and four new) gaur herds were observed during the entire summer season in 2012, and subsequently in early monsoon two gaur herds (H-5 with H-1and H-6 with H-2) joined with the prexisting herds. A total of four different gaur herds were observed consistantly during the remainining period of the study (table 5.3 anf figure 5.10).

Table 5.3: Annual home range of gaur herds across different years in BTR

Herd	2011		2012		2013		2014	
	Number of individuals	100 % MCP *	Number of individuals	100 % MCP *	Number of individuals	100 % MCP *	Number of individuals	100 % MCP *
1	7	169.4	10	98.5	14	26.3	16	81
2	12	173.4	24	58.6	27	21.9	30	35.4
3			19	42.3	20	37.3	23	13.8
4			7	279.2	9	37.9	10	23.4

* Home range in sq.km; MCP- Minimum Convex Polygon.

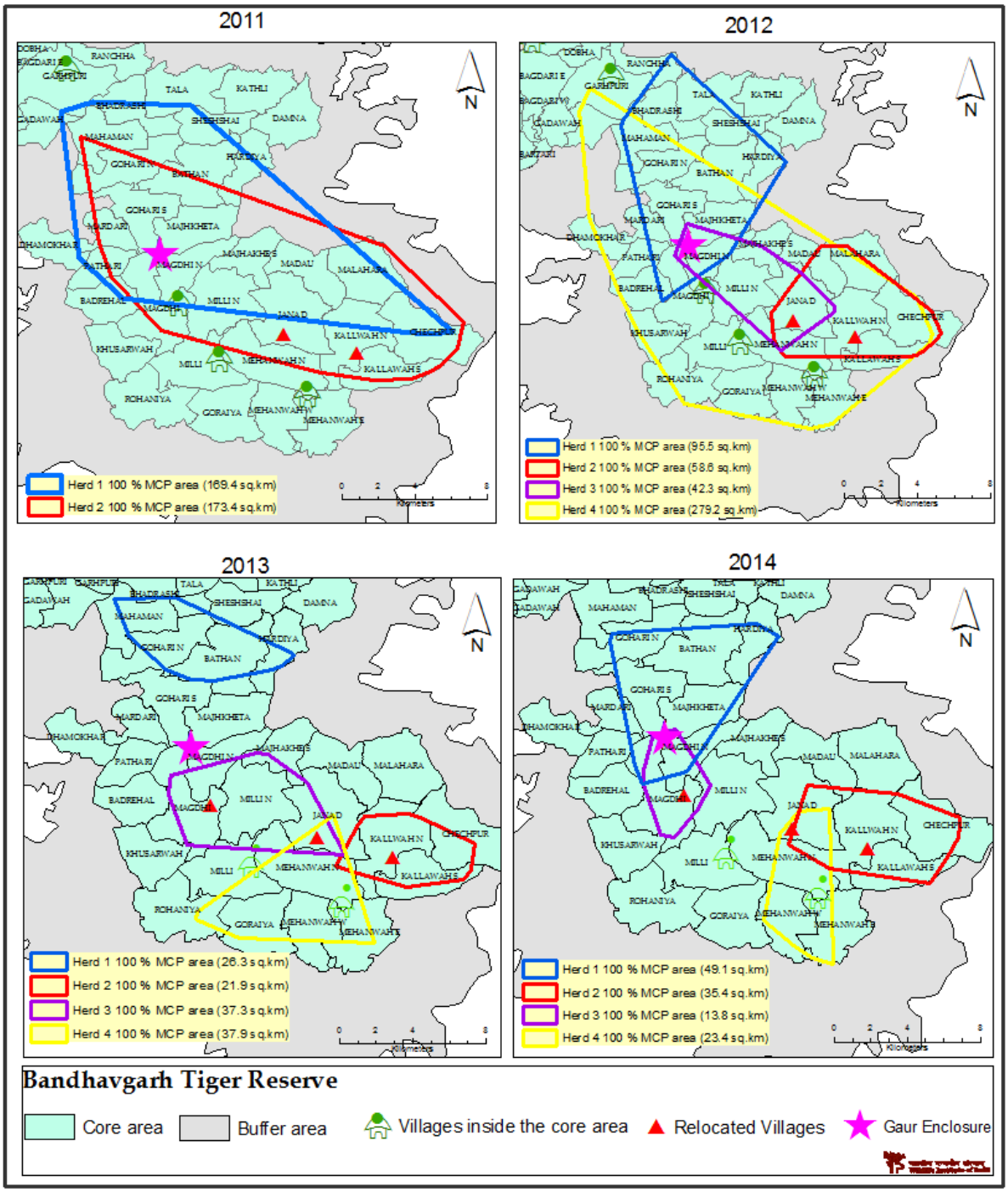


Figure 5.14: Annual home range of gaur herds across different years

5.4 Discussion

Overall home range of gaur

Gaur is one of the largest wild cattle occurring in mainland South Asia through South East Asia. Little information is available on the ranging patterns of the species. This is the first study on reintroduction and subsequent monitoring of the species. It is essential to get minimum number of fixes to calculate animal true home range size (Harris *et al.* 1990). In the present study, the minimum number of fixes (n=122) needed to calculate the reintroduced gaur home range size significantly varied between demography classes (χ^2 = 24.81, degrees of freedom = 3, p-value < 0.05).

In the present study, the reintroduced gaur home range size reached an asymptote at 154 Km^2 and significantly varied between age and sex classes (χ^2 = 99.82, degrees of freedom = 3, p-value < 0.05). In general, home range size of mammals is directly proportional to its body size (Harestad and Bunnell, 1979). The average time taken to establish the home range size (12 individuals range variation: 110 Km^2 to 260 Km^2) of batch I gaur in terms of days varied significantly among the age and sex classes (χ^2 = 45, degrees of freedom = 3, p-value < 0.05). In case of batch II, the number of days taken to establish their home ranges (15 individuals range variation: 71 Km^2 to 279 Km^2) did not show any significant difference among different age and sex classes of gaur (χ^2 = 2.30, degrees of freedom = 3, p-value > 0.05). This may be attributed to the intra specific competition between gaur individuals of batch I and batch II in Bandhavgarh for the available resources. Similar findings were reported in batch wise (in different year) reintroduction studies on white rhinoceros in Moremi Game Reserve, Botswana (Pitlagano 2007) and elk in Kentuck, United States (Schneider *et al.* 2006).

In the present study, the home range size of gaur was estimated with different estimators, such as MCP (100%) and FKD (95%). The MCP area and shape is influenced by outlying fixes, and hence it may include large unused areas causing an overestimation of home range size (Harris *et al.* 1990). Despite its limitations the MCP was the method of choice in the past and was recommended by IUCN in 1994 (Burgman and Fox 2003), hence this method was chosen to draw comparisons of present study with previous studies on the species.

In the present study, the overall home range size of reintroduced gaur was much larger (405.2 km^2) than it was reported in Pench Tiger Reserve, Central India (175 Km^2) by Sankar *et al.* (2001), which is not a reintroduced study (table 5.4). This high overall home range of gaur in Bandhavgarh is attributed to the initial explorations to new habitats after reintroduction. The initial exploration of gaur with larger areas (405.2 km^2) and latter adapting to the smaller habitats (209.1 km^2) as observed in Bandhavgarh is in accordance with other reintroduction studies on herbivores in elk, one horned rhinocerus, rein deer and wild ass (Schneider *et al.* 2006, Pitlagano 2007, Kojola *et al.* 1995, Saltz and Rubenstein 1995).

The average home range size of individual gaur recorded in Bandhavgarh using 100% MCP was 163.1 ± 13.0 (SE) km^2 which significantly varied between (n=27) different age and sex classes (χ^2 = 779.25, degrees of freedom = 26, p-value < 0.05). The observed variation in the home range size of individual gaur in Bandhavgarh might be due to availability of different habitat types.

In the present study, the observed average overall home range size of adult gaur male was large (250.2 ± 10.3 (SE) km^2) as compared to sub adult gaur male (149.1 ± 16.5 (SE) km^2) (Mann-Whitney test, V = 6, p = 0.125). The adult gaur males utilized larger areas and stayed solitary on many occasions (n= 359), and also had the tendency to move from one herd to another herd in search of females within the area. This finding was also supported by Corny (1989) and Sankar *et al.* (2001) using radio-telemetry studies on gaur (table 5.4) and without radio telemetry studies on gaur by Schaller (1967), Vairavel (1998), Easa (1998) Jayson (1999), Choudhary (2002) and Ashokkumar *et al.* (2004). Adult gaur male have the tendency of ranging larger areas in search of female, being solitary in nature (Schaller 1967). The observed

small home range size in sub adult male gaur may be attributed to their subordinate nature and their conflicts with dominant males in the study area.

The observed average overall home range size of adult gaur female was larger (188.6 ± 33.1 (SE) km^2) as compared to sub adult gaur female (151.3 ± 113.6 (SE) km^2) (Mann-Whitney test, V = 20, p = 0.04). The gaur female home range size as recorded in the present study was not comparable with other studies on gaur elsewhere (table 5.4). The observed large home range of adult gaur females may be attributed to their inherent behavior in leading the herd while exploring areas. Usually in large mammals, the home range size does not vary between sub adult females which were associated with adult females (Harestad and Bunnell 1979).

Table 5.4: Gaur home ranges as reported by different studies, using 100% MCP

Study area	Number of radio collars	Habitat	Overall home range (km^2)	Adult male (km^2 ± SE)	Sub adult male (km^2 ± SE)	Adult female (km^2 ± SE)	Sub adult female (km^2 ± SE)	Authors
Bandhavgarh TR, Central India	27	Dry Deciduous forest	405 .2	250 ± 10.3	149.1 ± 16.5	188.6 ± 33.1	151.3 ± 13.6	Present study
Pench TR, Central India	3	Dry Deciduous forest	175	150	--	75	--	Sankar *et al.* 2001
Lepar Valley, Pahang, Malaysia	5	Tropical Evergreen forest	--	137.3	29. 9	--	52.1	Corny, 1989

km- Kilometer; SE- Standard Error

Range overlap between gaur males and females *i.e.* 87.6 % in the present study indicates the competition for different resources in the habitat. Similar results were discussed by Schaller (1967), Corny (1989) and Sankar *et al.* (2001). In mammals, especially the mega herbivores, it is expected that males often have large ranges that overlap with the ranges of females to maximize their reproductive success by mating with as many females as possible (Leuthold 1977, Nelson 1995, Bond and Wolff 1999).

Initially the reintroduced gaur moved out of the Tiger Reserve on few occasions (n=21), and this might be due to exploration of new habitats, presence of large predators and anthropogenic disturbance in the study area. Similar findings were reported on other reintroduction studies on mega herbivores (Jnawali and Wegga 1991, Kojola *et al.* 1995, Schneider *et al.* 2006, Pitlagano 2007).

Season wise home range of different age and sex classes of gaur

In the present study, the estimated mean home range size of adult gaur male showed variations across seasons. The reported adult gaur male home range size (100% MCP) in Pench Tiger Reserve was 12.6 Km^2 and 7 .6 Km^2 in summer and monsoon respectively (Sankar *et al.* 2001). The estimated mean home range size of sub adult gaur male did not differ across the seasons. The estimated mean home range size of adult gaur female showed variations across seasons. The reported adult gaur female home range size (100% MCP) in Pench Tiger Reserve was 7.2 Km^2 and 13.8 Km^2 in summer and monsoon respectively (Sankar *et al.* 2001). The mean home range size of sub adult female in Bandhavgarh showed differences across the seasons.

The observed larger home range size for different age and sex classes of gaur during summer (figure 5.13) as observed in the present study may be attributed to the spatial distribution of resources such as major food plants, water, natural mineral licks, etc. The observed smaller home range of gaur males and females in summer and monsoon in Pench Tiger Reserve was

attributed to the availability of food resources and water throughout the year (Sankar *et al.* 2001).

Herd formation of gaur and their home range

Of the 19 gaur individuals translocated in 2011, the gaur individuals separated into two different herds *viz* H-1 and H-2 and considerable variation was observed between the overall home ranges of both the herds. The estimated home range size (169.4 Km^2 and 173.4 km^2) between the herds with high overlap in their home range (70 %) in 2011 may be attributed to initial response of reintroduction and less intra specific competition between reintroduced gaur in Bandhavgarh. Two villages *viz*. Kallwah and Kummuruvah from the gaur occupied home range in the Tiger Reserve were relocated in late summer 2011 (figure 5.14). It was observed that the reintroduced gaur started using the relocated sites by winter 2011.

Formation of two more herds along with the pre existing herds (n=2) was observed after the supplementation of more individuals (n=31) in summer 2012. It was observed that there was high overlap (93.6%) between all the four gaur herds for establishing their territory during 2012 and bonding of individuals was observed between the existing gaur herds and the newly introduced stock in 2012. The high range overlap observed was attributed to the intra specific competition between individuals in the new habitat, dominance-subordination interactions between gaur individuals and the presence of predators (tiger) in the study area. The overall overlap between different gaur herds in 2013 and 2014 was 4 % and 6 % respectively. One more village *viz*. Magdhi from the gaur occupied area was relocated in 2013. The wide spread area without anthropogenic pressure and disturbance may be attributed to the less home range overlap observed between the gaur herds in 2013 and 2014.

The considerable increase in home range overlap between herds in the initial stage may be attributed to the distribution of different resources like mates, food and water resources, mineral licks, etc. Similar observations were reported on mega-herbivores such as elephants in Kenya (Poole 2011) and giraffe in Zambia (Bercovitch and Berry 2012). Gradual decrease in range overlap observed between individual gaur herds in 2013 (4 %) and 2014 (6 %) may be attributed to the settlement of the different gaur herds in the new habitat by establishing their home ranges. Prior to this study, the only other investigation of the home range of different gaur herds was carried out in Malaysia by Weigum (Conry 1989), where Kula Tahan herd ranged over 13 km^2. The gaur herd home range size as recorded in the present study was not comparable to the above mentioned study because of different techniques used by Weigum in which animals were tracked based on visual observations and spoor marks (Conry 1989).

In Bandhavgarh, the gaur herd size varied from six to 31 individuals and all the gaur herds had mixed age class individuals. The overall ranging size varied among gaur herds in Bandhavgarh. In mammals, formation of herds decreases the risk of predation on individual animals (Kenward 1978, Pulliam and Caraco 1984, Lima 1995 a,b, Krause and Ruxton 2002, Uetz *et al.* 2002). Very less is known about group size formation and predation risk on mega-herbivores (Messier and Barrette 1985, Fitzgibbon 1990, Creel and Creel 2002, Goldspink *et al.* 2002, Hebblewhite and Pletscher 2002).

Chapter VI

Habitat use of Reintroduced Gaur

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Habitat use of Reintroduced gaur

6.1 Introduction

Habitat ecology is fundamentally concerned with understanding the relationships between organisms and their environment (Baker 1978). The lack of information on habitat ecology and the resource selection of animals can be a serious impediment in the conservation management of the species and landscapes (Apps et al. 2001, Lyons et al. 2003). In mammals, the concept of habitat has been defined as the resources and conditions present in an area that produce occupancy which includes the survival and reproduction of a species (Fryxell and Sinclair 1988, Hall et al. 1997, White et al. 1997, Bowyer et al. 1998). Among large herbivores, the habitat selection depends upon various factors, such as availability and quality of forage sites (Klein 1970, Skogland 1980, Bowyer 1986, Albon and Langvatn 1992, Cameron et al. 1993), mineral requirements (Belovsky and Jordan 1981), climatic factors (Ion and Kershaw 1989), parasite avoidance (Duncan 1983), predation (Bleich et al. 1997), inter specific competition (Caro and stoner 2003, Vanak and Gomper 2009) and food supply (Sinclair 1975, White 1978, Duncan 1983, McNaughton 1984 and 1988, Murden and Risenhoover 1993).

The habitat selection affects individual fitness, and the resource selection is a multilevel and hierarchical process in response to various environmental factors, starting from the geographic range of a species till the selection of particular elements within the territory of the species (Johnson 1980, Hall et al. 1997, Manly et al. 2002).

Most of the habitat degradation and habitat loss to the species in the globe is mainly due to habitat fragmentation (Erickson et al. 1998). As the habitat fragmentation occurs, it affects the distribution of species and may lead to species extinction from some the areas (Griffith et al. 1989, Wolf et al. 1996, Fischer and Lindenmayer 2000). Translocation is one of the major management options for restoration and conservation of species (IUCN 1998), in areas from where the species has been extirpated (Fischer and Lindenmayer, 2000). The restoration of animals is considered to be a success if it results in a self sustaining population (Griffith *et al.* 1989). Understanding the scale in which the environmental context influences habitat selection and the resource use of the reintroduced population is essential (Matson *et al.* 2004).

There are several factors that influence translocation success, including the number of animals released (Griffith *et al.* 1989, Wolf *et al.* 1996, Fischer and Lindenmayer, 2000, Matson *et al.* 2004), the habitat quality of the release area and the location of the release area in relation to the historical range of the species (Griffith *et al.* 1989, Wolf *et al.* 1996). The information on habitat use and resource selection leads to a better understanding of the species in its environment (Anderson *et al.* 2005). This information is useful to get an idea on maximum space use of animals in an area, where the prime habitats are shrinking due to fragmentation and degradation (Vairavel 1998). Selection of seasonal habitat in mega herbivores between different habitat types to fulfill their need has been well documented in bison and European bison (Fuller 1960, Krasinska *et al.* 1987).

Knowledge of the habitat selection of reintroduced species is crucial to the successful re-establishment of viable populations and effective conservation decision making (Yan *et al.* 2013). Therefore, in-depth investigation on the habitat selection of reintroduced species becomes crucial for making decisions about conservation and management planning (Seddon *et al.* 2007). The reintroduction of species is assumed to be more successful when they are less

affected by human disturbance and have adapted to more suitable habitat (Oakleaf *et al.* 2006, Kiwan *et al.* 2008).

Schaller (1967) evaluated the vegetation maps of India with regard to distribution of gaur and concluded that the species is largely confined to evergreen, semi-evergreen, and moist deciduous forests but it also occurred in dry deciduous forests and thorn forests. Information on habitat use and resource selection of gaur was reported in a few Protected Areas in its entire distribution range. In Malaysia, Weigum (1972) observed that the abundance of grass, forbs and several browse species in agricultural lands are the most important factors influencing gaur distribution. Conry (1989) reported that gaur mostly preferred agricultural patches in Malaysia. In Western Ghats Landscape, India, Vairavel (1998) reported that gaur mostly preferred grassland. Imam and Kushwaha (2012) reported that gaur was largely found in mixed forests in Maharashtra. In Central Indian landscape (Pench Tiger Reserve), Sankar *et al.* (2001) reported that gaur largely used teak forest and miscellaneous forest, whereas Paliwal and Mathur (2012) reported that gaur in Tadoba-Andhari Tiger Reserve showed positive association with open forest. Conry (1983) and Sankar *et al.* (2001) reported the habitat use of gaur based on radio-telemetry studies. In order to study the habitat use and resource selection of reintroduced gaur in Bandhavgarh, data on 27 radio-collared individuals was collected from March 2011 to January 2015 respectively.

6.2 Methodology

Both habitat use and habitat availability were assessed for individual radio-collared gaur locations in the study area (refer-table 5.1. chapter V). Second-order (selection of home ranges within a geographic range) and third-order (selection of habitats within established home ranges) resource selection functions (Johnson 1980) were used to evaluate the habitat preference of reintroduced gaur. A multispectral (LANDSAT 7 ETM+), high-resolution (30 m) satellite imagery from the Global Land Cover Facility (GLCF) was used to generate the landuse/ landcover (LULC) map of the study area (figure 6.1). The overall habitat was classified into 11 different vegetation classes *viz* agriculture, bamboo forest, grassland, open-mixed forest, mixed forest, sal forest, riparian forest, habitation, plantation, rocky outcrop and scrubland.

1. Agriculture land: This is represented by irrigation and rain fed lands in Bandhavgarh, which breaks the connectivity between forest patches. The main crop includes wheat, corn flour, mustard and edible vegetables.

2. Bamboo Forest: The dense bamboo distribution occurs mainly in the National Park and also occurs in Panpatha Wildlife Sanctuary. Some bamboo patch areas also occur along with mixed-forests in the National Park. Due to strict protection measures and ban in forestry operations, the natural regeneration of bamboo occurs in all areas (Gopal 1989).

3. Grassland: Grassland patches occur in the valleys and along the streams (nallas) and also near the villages. The major grass species includes *Bothriochoa odorata*, *Chrysopongen fulous*, *Digitaria spp*, *Cynodon dactylon*, *Dichanthium annulatum, Saccharum spontaneum* and *Vetiveria zizanoides.*

4. Open-Mixed Forest: This occurs in patches near to the villages. The major tree species includes *Anogeissus pendula, Acacia catechu, Butea monosperma, Acacia leucophloea, Soymida febrifuga, Careya arborea, Maduca indica, Zizyphus xylopyrus,* and *Capparis decidua.* The major shrub species found are *Holarrhena antidysenterica, Mimosa hamata* and *Woodfordia floribunda* and major climbers are *Bauhinia vahlii* and *Butea superb.* The major grass species are *Aristida depressa, Cymbopogon martini, Heteropogon centortus, Aristida depressa,* and *Themeda quadrivalvis*.

5. Mixed Forest: This is distributed throughout the park and provides good canopy cover to the animals. Few patches of mixed forest also occur in riparian areas, where alluvial black clayey soils are present especially in Kallwah range. The major tree species includes *Anogeissus latifolia, Acacia spp, Dendrocalamus strictus, Holarrhena antidysenterica, Terminalia tomentosa,*

Emblica officinalis, Pterocarpus marsupium, Lagerstroemia parviflora, Terminalia chebula, Kydia calycina, Salmalia malabarica, Dispyros melanoxylon and *Zizyphus spp.*

6. Sal Forest: Sal (*Shorea robusta*) patches in Bandhavgarh constitute 60 to 90 % of the top canopy. The associated species are *Anogeissus latifolia, Buchanania lanzan, Diospyros melanoxylan, Emblica officinalis, Kydia calcina, Madhuca indica* and *Terminala spp.*

7. Riparian Forest: This type is restricted to perennial and semi perennial rivers and streams. The canopy is dominated by species like *Dendrocalamus strictus, Ficus bengalensis, Zizyphus spp, Butea monosperma, Syzygium cuminii and Terminalia spp.*

8. Habitation: This is found in buffer area of Bandhavgarh, where livestock grazing is observed.

9. Plantation: Very few patches of plantation are found in buffer areas with species like *Shorea robusta, Dendrocalamus strictus* and *Tectona grandis*.

10. Rocky Outcrop: This is found in Bandhavgarh Fort and other hilly areas in the Sanctuary.

11. Scrubland: This is found in the fringes of National Park and in Sanctuary area with dominant species like *Acacia spp* and *Lantana camara*.

The analysis of gaur habitat use data was limited to seven different vegetation classes such as agriculture, bamboo forest, grassland, open mixed forest, mixed forest, sal forest and riparian forest within the study area comprising 1614.0 km^2 (table 6.1). The vegetation classes such as habitation, plantation, rocky outcrop and scrubland were dropped from the habitat use analysis since they are found in buffer area of the Tiger Reserve and falls outside the intensive area, used by gaur during the study period.

The Minimum Convex Polygon (MCP) home range estimates were used to describe the outer limits of each radio collared gaur movements from 2011 to 2015. To evaluate habitat use pattern of reintroduced gaur in Bandhavgarh, locations of individual radio collared gaur (n=25) were obtained from March 2011 to January 2015, which are spaced throughout the study area at different time intervals. The collected gaur locations (27,816) were plotted on the classified LISS-III imagery of Bandhavgarh.

Habitat use of reintroduced gaur in Bandhavgarh was estimated as the percent number of locations recorded in each habitat type as determined by Aebischer *et al.* (1993), White and Garrot (1990). The habitat availability for gaur in each gaur MCP home range, and the proportion of radio locations from radio collared gaur within each habitat type were calculated using the program Arc GIS 9.3 (ESRI 2006).

Compositional analysis

Second-order resource selection function (Aebischer *et al.* 1993) was used to determine the habitat selection of reintroduce gaur, by plotting a minimum convex polygon around the 100% MCP home range of all the radio collared gaur. Compositional analysis (Aebischer *et al.* 1993) was followed to determine the habitat selection of reintroduced gaur, but with a modification that and assigned values based on the utilization distribution (UD) as described by Millspaugh *et al.* (2006). Habitat use of each radio collared gaur individual was defined as the number of locations obtained in each land cover types (Millspaugh *et al.* 2006). Third-order resource selection was determined by using discrete-choice analysis (Cooper and Millspaugh 1999, 2001) at the home-range level. Resource Selection program for Windows (RSW; Leban 1999) was used to conduct the compositional analysis. We also estimated the season wise habitat use by reintroduced gaur, using compositional analysis (Aebischer *et al.* 1993), to understand whether any significant difference was observed in habitat use across seasons.

Table 6.1: Available vegetation and land cover classes in BTR

Vegetation/Land cover type	Area (km²)	Percentage
Agriculture (Agr)	69.2	4.3
Bamboo Forest (Bam)	221.9	13.7
Grassland (Gra)	115.3	7.1
Mixed Forest (Mix)	706.9	43.8
Open-Mixed Forest (OMF)	196.4	12.2
Sal Forest (Sal)	231.1	14.3
Water Body (Riv)	73.2	4.5
	1614.0	100.0

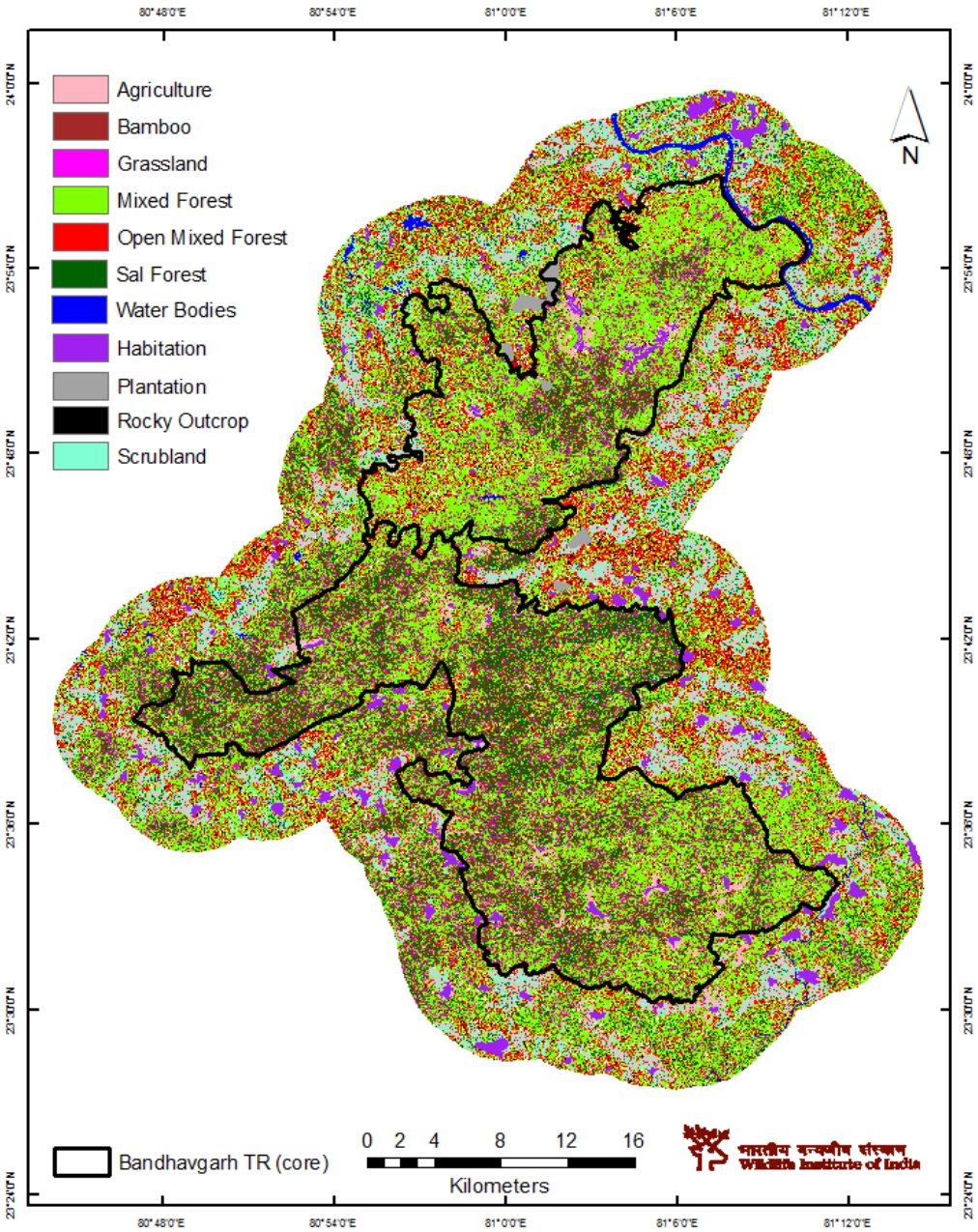


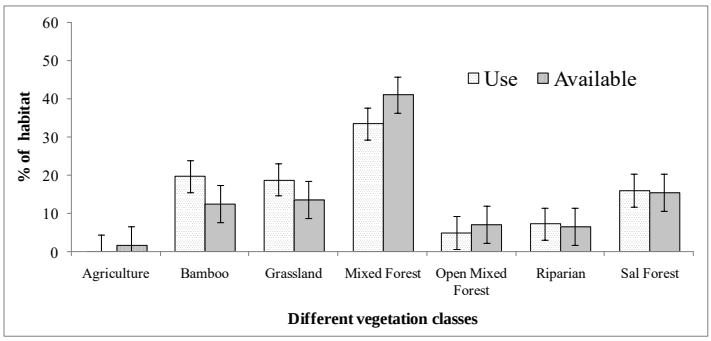
Figure 6.1: Land use and land cover (LULC) map of BTR with 5 km buffer

6.3 Results

Overall habitat use by reintroduced gaur in Bandhavgarh

Compositional analysis

Gaur largely used mixed forest followed by bamboo and grassland whereas sal forest and riparian forests were used according to its availability within their entire home range (figure 6.2).



Error bars are standard error

Figure 6.2: Overall use and availability of different vegetation types by the reintroduced gaur

A simplified matrix (table 6.2) ranked overall habitat use of reintroduced gaur in Bandhavgarh in the following order: bamboo forest > grassland > riparian> sal forest > mixed forest > open mixed forest > agriculture land (χ^2 = 75.1, df = 6, P < 0.001). There was no detectable difference in use of the two top-ranking habitats (bamboo forest, grassland), but each showed significantly greater use than the remaining habitat types. The implication is that rank 4 and 3 are inter changeable (riparian and sal), but that there is a clear split between them and the lower ranks.

Table 6.2 Simplified ranking matrix of reintroduced gaur in Bandhavgarh Tiger Reserve, based on comparing the UD of radio collared locations for each gaur in each vegetation class with proportion to total available habitat classes. Each mean element in the matrix was replaced by its sign A (-3) represents significant deviation from random at p < 0.05.

Resource	Agriculture	Bamboo forest	Grassland	Mixed forest	Open mixed forest	Riparian	Sal forest	Rank
Agriculture		-3	-3	-3	-3	-3	-3	0
Bamboo forest	3		1	3	1	1	3	6
Grassland	3	-1		3	1	1	3	5
Mixed forest	3	-3	-3		1	-1	-3	2
Open mixed forest	3	-1	-1	-1		-1	-1	1
Riparian	3	-1	-1	1	1		1	4
Sal forest	3	-3	-3	3	1	-1		3

Seasonal habitat use of reintroduced gaur in Bandhavgarh

In summer and monsoon gaur largely used grassland and riparian forest and in winter bamboo forest was largely used followed by mixed forest, whereas the sal forest was used according to its availability in all the seasons within their entire home range (figure 6.3). The habitat use of gaur in summer was in the following order: grassland > sal forest > bamboo forest > riparian = open-mixed forest > mixed forest > agriculture land (χ^2 = 148.4, df = 6, P-value < 0.001) (table 6.3.A). The habitat use of gaur in monsoon was in the following order: bamboo forest > grassland > riparian > sal forest = mixed forest > open-mixed forest > agriculture land (χ^2 = 158.2, df = 6, P < 0.001) (table 6.3.B). The habitat use of gaur in winter was in the following order: bamboo forest > mixed forest > riparian = sal forest > grassland > open-mixed forest > agriculture land (χ^2 = 136.1, df = 6, P < 0.001) (table 6.3.C).

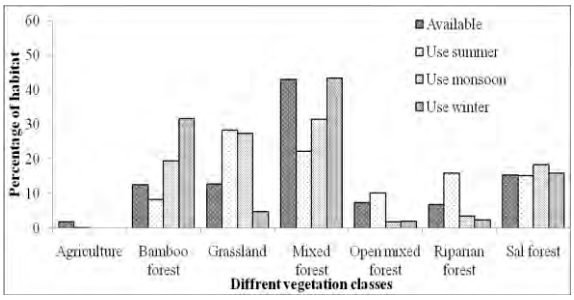


Figure 6.3: Use and availability of different vegetation types by the reintroduced gaur across seasons

Table 6.3 Simplified ranking matrix of reintroduced gaur in Bandhavgarh Tiger Reserve, based on comparing the UD of radio collared locations for each gaur in each vegetation class with proportion to total available habitat classes. Each mean element in the matrix was replaced by its sign (-3) represents significant deviation from random at $p < 0.05$.

A. Summer

Resource	Agriculture	Bamboo forest	Grass land	Mixed forest	Open mixed forest	Riparian	Sal forest	Rank
Agriculture		-3	-3	-3	-1	-1	-3	0
Bamboo forest	3		-3	3	3	3	-3	4
Grassland	3	3		3	3	3	3	6
Mixed forest	3	-3	-3		3	-1	-3	1
Open mixed forest	1	-3	-3	-3		1	-3	2
Riparian	1	-3	1	-1	1		-3	3
Sal forest	3	3	-3	3	3	3		5

B. Monsoon

Resource	Agriculture	Bamboo forest	Grass land	Mixed forest	Open mixed forest	Riparian	Sal forest	Rank
Agriculture		-3	-1	-1	-1	-1	-1	0
Bamboo forest	3		3	3	3	3	3	6
Grassland	1	-3		3	3	1	1	5
Mixed forest	1	-3	-3		1	-1	-3	2
Open mixed forest	1	-3	-3	-1		-3	-3	1
Riparian	1	-3	1	1	3		-1	4
Sal forest	1	-3	-1	3	3	1		3

C. Winter

Resource	Agriculture	Bamboo forest	Grass land	Mixed forest	Open mixed forest	Riparian	Sal forest	Rank
Agriculture		-3	-3	-3	3	-3	-3	1
Bamboo forest	3		3	3	3	3	3	6
Grassland	3	-3		-1	3	-1	-1	2
Mixed forest	3	-3	1		3	1	1	5
Open mixed forest	-3	-3	-3	-3		-3	-3	0
Riparian	3	-3	1	-1	3		1	4
Sal forest	3	-3	1	-1	3	-1		3

6.4 Discussion

Radio-telemetry allows for intensive data collection for most of the wild animal species and this data can be used for detailed studies about their habitat selection (Aebischer *et al.* 1993). In the present study the gaur habitat use was evaluated using radio telemetry. The resource selection analysis was done by a second order compositional analysis (Vanak and Gompper 2010) and also related to Johnson's (1980) rank based method. Though the habitat use of gaur was reported in a few Protected Areas in its distribution range (Weigum 1972, Conry 1989, Vairavel 1998, Sankar *et al.* 2001) the present study gave more detailed account on their habitat preference.

In Bandhavgarh Tiger Reserve, the mixed forest is the dominant vegetation type constituting 43.8 % of the total area but the use of bamboo forest was highest followed by grassland by

gaur in the study area. The reintroduced gaur preferred bamboo forest because bamboo leaves constitute a major food item of gaur and bamboo leaves are available throughout the year in the study area. Also the bamboo forest provides better shelter/resting areas as compared to other available habitat types in Bandhavgarh. Grasslands provide much higher biomass of forbs and grasses (Song and Li 1994) which might have influenced gaur to prefer grasslands in the study area. In general, herbivores select grassland where they can forage freely in large numbers (Treydte *et al.* 2013). Whereas in Chihao region, China, the reintroduced Eld's deer selected shrubs, because grasslands were available only in conditions of poor forage and were mostly distributed (Yan *et al.* 2013).

Gaur in Parambikulam National Park largely used grasslands as compared to other available habitats (Vairavel 1998). In Pench Tiger Reserve the use of teak dominant forest and miscellaneous forest by gaur was significantly higher than other habitat types (Sankar *et al.* 2001). Free-ranging large herbivores have to make many foraging decisions at different resolution levels (Senft *et al.* 1987, Stuth 1991) resulting in a foraging strategy that meets the specific nutrient and energy requirements of large herbivores that ultimately determines differential habitat selection by them.

Gaur used sal forest and riparian forest according to their availability and this is attributed to the distribution and availability of these habitats in study area. The observed less habitat use of open- mixed forest by gaur in Bandhavgarh may be attributed to lack of food resources and water availability in this habitat. In general, mega herbivores avoid the habitat that does not have good forage with nutrition level (Roever *et al.*2013). Agricultural land was least used by gaur because of anthropogenic disturbance in Bandhavgarh.

In the present study, the use of different habitat types by gaur did not vary much across seasons, although grassland in summer and bamboo forest in monsoon and winter were preferred. Gaur is a generalist feeder but prefers to browse in dry season and predominantly graze in monsoon and winter (Schaller 1967, Vairavel 1998, Sankar *et al.* 2000, Ashokkumar *et al.* 2010). Schaller (1967) observed that gaur frequently moved to meadows and the low-lying forested areas during most part of the year except monsoon when the animals moved up and dispersed into the hills. Lad and Gopal (1992) reported that gaur moved to higher elevations during monsoon so as to escape the flies which are abundant during the rainy season in the grasslands and low-lying areas of the forest. Gaur in Pench Tiger Reserve showed similar results as that of to Schaller's observation in Kanha Tiger Reserve regarding the use of forested areas by gaur across seasons (Sankar *et al.* 2001). Use of different habitat types across seasons by European Bison as per availability of food plants has been reported (Gill 1967, Krasinska *et al.* 1987, Krasinski and Krasinska 1992). Forest meadows were preferred by American bison (Shackleton 1968). The mega-herbivores show high selectivity of habitat and food species across seasons (McNaughton and Georgiadis 1986).

Chapter VII

Food Habits of Reintroduced Gaur

Food Habits of Reintroduced Gaur

7.1 Introduction

The study of food habits of any wild animal species is of considerable importance since it gives an insight into the food preferences and feeding strategies of the species. Riney (1982) has discussed the relevance of food habits studies of large mammals in making management decisions. The study of food habits of reintroduced species may lead to valuable conservation implications. The problems that herbivores face in contrast to omnivores and carnivores are the availability and the physical and chemical characteristics of their diets. The food resources of herbivores vary between different habitat types and also show marked seasonal variations within a given habitat in response to changes in rainfall patterns (Philipson 1975, Sinclair 1975). The feeding habits of ungulates are influenced by the seasonal and spatial differences between plant communities in species composition, production, food quality and quantity (Jarman and Sinclair 1979). The 'Jarman-Bell Principle', as labelled by Geist (1974) states that large bodied ungulates are able to tolerate a lower quality diet as compared to smaller bodied species. Thus large herbivores can subsist on bulk and coarser diets as compared to smaller species. Small bodied animals, as a result of the maintenance of their body weight, require an intake of diet with higher proportions of protein and soluble carbohydrates at the expense of fibre (Bell 1971).

For large herbivores, Owen-Smith (1988) has characterised the dietary intake in terms of (i) the plant species eaten, (ii) the plant parts ingested, or (iii) the nutrient contents of the ingested material. Rodgers (1988) identified four kinds of herbivore responses to utilization constraints posed by food resources:

1. Herbivores could grow in body size to levels where they become huge mobile fermentation chambers dependent on bulk input of a low quality fibrous diet. Large body size also means energetic considerations require a low input of energy and protein per unit body weight (Robbins 1983, Hudson and White 1984). Large size not only allows animals to use tall coarse grasses, but also to modify grassland structure by trampling and feeding and thus, in most situations, stimulate production of nutrient fresh shoots.
2. Herbivores could become smaller in size with very selective feeding habits and adaptations to allow greater diet selection.
3. Herbivores could migrate to areas of different levels and timing of grassland production and
4. Herbivores could become generalists or opportunists and switch diets away from grasses when nutrient production and accessibility becomes limiting. Herbivores would then change to higher quality browse items i.e. dicot leaf, stem, bark, flower and fruit.

Herbivore food choice is influenced by nutritional and non-nutritional factors. Nutritional factors include positive nutrients such as calories, non-structural carbohydrates, protein, fat and minerals such as calcium and sodium and negative nutrients such as digestibility reducers (fibers and tannins) and toxins (alkaloids and terpenes) (Freeland and Janzen 1974, Westoby 1978, Rosenthal and Janzen 1979). Studies in rain forests of Africa, Central America and Asia (Hladik 1977, Glander 1978, Milton 1979, Oates *et al*. 1980, Davies *et al*. 1988) have shown that the crude protein content is a good predictor of food selection. The ratio of protein to fibre content has also been shown to be important criteria for food selection (Jarman 1974, Leuthold

1970). Among digestibility reducers, fibre is a major deterrent of food selection for herbivores (Waterman 1983 and 1984). Among fibre, lignin is a primary factor causing decline in digestibility since it presents a physical barrier to digestive enzymes and also interferes with digestion by binding to the carbohydrate substrate and digestive enzymes in the gut (Waterman *et al*. 1980, Van Soest 1982). Tannins, a group of polyphenols (condensed tannins, total phenolics, oxytannins and prototannins), also act as digestibility reducers since they form insoluble complexes with proteins in food and with digestive enzymes, thereby preventing digestion (Swain 1979).

Food habits of the members belonging to the wild cattle group (cattle, buffalo, bison and saola) have been studied for bison (Reynolds *et al*. 1982, Bergman *et al*. 2001, Fortin *et al*. 2002, Courant and Fortin 2012), African buffalo (Sinclair 1977, Prins 1996), Asiatic wild water buffalo (Chaiyarat 2002), anoa (Pujaningsih *et al*. 2009), wild yak (Harris and Miller 1995, Cao *et al*. 2009), banteng (Halder 1976, Prayurasithi 1997, Pudyatmoko 2005, Bhumpakphan and McShea 2011) and gaur (Schaller 1967, Krishnan 1972, Moorthy 1989, Prabhakar 1992, Vairavel 1998, Sankar *et al*. 2001, Gad and Shyama 2009, Gad 2011, Ahrestani *et al*. 2012, Sankar *et al*. 2013). In the present study food habits of the reintroduced gaur population in Bandhavgarh Tiger Reserve were studied from March 2011 to December 2014.

7.2 Methodology

The data on the food plants and parts eaten by gaur was obtained from the scan sampling technique (Altman 1974) used for studying the behavioural patterns of gaur. Instantaneous scan samples were recorded at five-minute intervals and during the scans whenever an individual was observed feeding, the plant species and plant parts eaten by the individual was recorded. On such instances when the gaur being observed were far enough so as not to be able to identify the plant species being eaten, inspection of the feeding sites were made so as to identify the food plants after the gaur had left the site. Samples of the eaten food plant parts were collected for each season (summer, monsoon, winter) by hand clipping. These samples were sun dried and packed in paper bags in the field station and were later subjected to nutritional analysis in the laboratory at Wildlife Institute of India, Dehradun. Samples of a single item were pooled to obtain a single nutrient value for the item for each season. In the laboratory, the samples were kept in an oven at 60˚C for drying for a week. The oven-dried samples were finely ground in Cyclotech's grinding mill and kept in plastic bags for further analysis.

The samples of food plants of gaur collected from Bandhavgarh Tiger Reserve were analysed for the following positive and negative nutrients:

1. Positive nutrients - crude protein and minerals (Ca, Na, Mg, K, Fe, Zn).
2. Negative nutrients – fiber in terms of neutral detergent fiber (NDF), acid detergent fiber (ADF) and lignin.

Crude protein was estimated using Kjeldahl method (Maynard and Loosli 1969). The analysis of crude protein was done using the Auto Kjeldhal Nitrogen Analyzer (FOSS Analytical 2003a). The auto kjeldhal nitrogen analyzer consists of two separate units, the block digester and the distillation, titration assembly. 0.5 gm of oven dried sample was taken and mixed with a catalyst ($CuSO_4$ + K_2SO_4) and 10 ml. of concentrated sulphuric acid and was digested at 420˚C for five to six hours in the block digester. The digested samples were transferred into the distillation titration assembly where the ammonia generated during distillation was absorbed in 2% Boric acid, which was then titrated against 0.01N sulphuric acid. A blank (without sample) was run for each set of samples. The percent crude protein was estimated as follows:
n (%) = (S – B) X N X 1.407/ Sample weight (g)

Where

n (%) = Percent nitrogen
S = Volume of acid used against sample.
B = Volume of acid used against blank.
N = Normality of acid.
Therefore, Crude protein (CP) % = n X 6.25.

The analysis of minerals (Ca, Mg, Na, K, Fe and Zn) was performed using atomic absorption spectrophotometer (AAS) and flame photometer (Buurman *et al*. 1996, Singh *et al*. 1999 and Chaturvedi and Sankar 2006). 0.5 gm of sample was weighed and mixed with nitric acid and perchloric acid (9ml:4ml). The mixture was then digested at 180˚C for about 5 – 6 hrs. After digestion the sample was filtered through Whatman # 42 filter paper. Sodium (Na) and Potassium (K) were estimated using flame photometer and Calcium (Ca), Magnesium (Mg), Zinc (Zn) and Iron (Fe) were estimated using atomic absorption spectrophotometer. The flame photometer and atomic absorption spectrophotometer were calibrated with standard solutions of the elements to be analysed and the minerals in the samples were estimated as parts per million (ppm) and then converted to percentage.

The fibre content in terms of neutral detergent fibre (NDF), acid detergent fibre (ADF) and lignin (acid detergent lignin) was estimated according to Van Soest's (1963 and 1967) method. The instrument, Fibre Analyzer (FOSS Analytical 2003b and 2003c) was used for fibre analysis. For the estimation of NDF and ADF, 0.5 gm of oven dried sample was boiled and refluxed with 100 ml. of neutral detergent solution (NDS) or acid detergent solution (ADS). It was filtered through a pre weighed crucible and washed with hot water and then with acetone. All the above processes were carried out in the fibre analyzer. The crucibles were kept overnight in an oven at 80˚C and then cooled in a desiccator and weighed. The residue which remained insoluble in the hot NDS/ADS was the amount of NDF/ADF, percentage of which was calculated as follows:
NDF or ADF (%) = $(W_3 – W_1)/W_2$ X 100

Where
W_1 = Empty crucible weight
W_2 = Sample weight
W_3 = Weight of crucible after extraction process

After the estimation of ADF the crucibles were filled with 72% sulphuric acid (20 ml.) and after three hours the acid was filtered off and the contents were washed with boiling water. The crucibles were kept in an oven overnight at 80˚C and weighed. The crucibles were then burned in a muffle furnace at 550˚C for three hours so as to ash the entire sample. The crucibles were then cooled in a desiccator and weighed again. The percent lignin (acid detergent lignin) was estimated as follows:
Lignin (%) = $(W_5 – W_6)/W_2$ X 100

Where
W_5 = Weight after lignin extraction (crucible + lignin)
W_2 = Sample weight at ADF initiation
W_6 = Weight after ash (crucible + ash)

Fresh dung samples of gaur were collected for each season (at least 50 samples per season). These samples were washed through a 0.1 mm mesh sieve under running water and were air dried and stored in paper bags in the field. In the laboratory the dung samples were ground over a 1mm mesh grinding machine and stored in plastic bags. For slide preparation of the fecal material the methodology described by Middleton and Sanchez (1994) was followed. To prepare slides a small amount of the fecal material was boiled on a microscope slide in a few drops of Hoyer's solution over a spirit lamp. The material was spread evenly. After that a few drops of Hertwig's mounting medium was placed on the material and it was boiled again and

while the solution was still hot, a cover slip was placed on the material. Hoyer's solution clears the fecal material of pigments whereas Hertwig's solution acts as a mounting medium. Four slides were prepared from each dung sample. For the preparation of reference slides of the plant material of the major food plants of gaur, the plant samples were ground over a 1 mm mesh grinding machine and the same methodology described above for slide preparation was followed. The slides were then observed under a compound light microscope.

Phenological study of the major tree, shrub and grass species in the study area was carried out. For this purpose ten individuals of each selected tree, shrub and grass patch were tagged in the study area. The plant species that were selected for phenological studies were as follows: Trees- *Shorea robusta, Madhuca indica, Diospyros melanoxylon, Boswellia serrata, Chloroxylon swietenia, Anogeissus latifolia, Terminalia tomentosa, Zizyphus mauritiana, Buchanania lanzan, Phyllanthus emblica* and *Dendrocalamus strictus*; Shrubs- *Phoenix acaulis, Wrightia tinttoria and Woodfordia floribunda* and Grasses- *Aristida setacea, Saccharum spontaneum, Phragmites karka, Vetiveria zizanoides* and *Imperata cylindrica*. Changes in the phenology of the marked trees and shrubs were quantified based on ocular estimation in terms of percentage availability of vegetative phases (young leaves, matured leaves, no leaves) and reproductive phases (buds, flower, young fruit and mature fruit) every fortnight (Borges 1989). Phenological data for the major grass communities (1 sq.m plots) was recorded in terms of percentage availability of vegetative phase (mature and young shoots), reproductive phase (flowering and seeding) and changes in the grass colour (green, green yellow, yellow,yellow brown, brown) every week.

A multispectral (LANDSAT 7 ETM+), high-resolution (30 m) satellite imagery from the Global Land Cover Facility (GLCF) was used to generate the landuse/landcover (LULC) map of the study area. For the quantification of vegetation (tree, shrub and ground layer) in Bandhavgarh Tiger Reserve (BTR) the digitized map of BTR was gridded (2 km X 2 km) in a GIS domain and systematic vegetation plots were laid in field for vegetation quantification. A ten metre radius plot was laid down to enumerate tree density, shrub density was enumerated in a five metre radius plot and the point intercept method (Jonasson 1988) was used to estimate the percentage ground cover (grass, herb, bare soil, leaf litter and rock) in 1 sq.m. plot.

The food plants of the captive elephants in Bandhavgarh Tiger Reserve were also recorded throughout the study period to get an understanding of the overlap between the food plants of gaur and elephant in the study area. The food plants of captive elephants were recorded through opportunistic sightings and by interviewing the Mahouts (elephant riders).

7.3 Data analysis

Excel spreadsheet was used for data entry and summarization. The percentage time spent feeding on a particular food item was estimated from the scan sampling data as follows (Kumar 1987):

$P_i = (n_i / N) \times 100$

where

P_i = % time spent on food item 'i'

n_i = number of records of feeding on item 'i'

N = total number of feeding records.

As rainfall and temperature has an effect on activity (Joshua 1992), the entire year was divided into three seasons *viz*. summer (March-June), monsoon (July-October) and winter (November-February). The percentage time spent feeding on different plant species and plant parts by gaur was estimated for each season. For the estimation of percentage time spent feeding on major food plants annually by gaur the feeding records obtained during the entire study period (six seasons) were pooled together. The statistical package SPSS was used for data analysis (Norusis 1993). The Kolmogorov-Smirnov test was used to test the data for normality (Siegel

1956) and since the data was found to be non-normal, non parametric tests such as Kruskal-Wallis and Mann-Whiteny were used to analyse the data (Siegel 1956). The percentage time spent feeding on major food plants by gaur was tested for significant difference across the seasons.

The slides prepared from the dung samples of gaur were used to calculate the percentage frequency occurrence of monocot and dicot plant fragments (monocot : dicot ratio) in the gaur dung samples for each season. The sample slides were observed from left to right starting at the upper left hand corner under the 10X objective of the microscope. A field with at least 8 to 10 fragments was observed and the fragments were grouped into three categories *viz*. monocot, dicot and unknown. In this manner ten fields were observed on each slide. The reference slides prepared from the plant material of the major food plants of gaur were used to identify plant fragments with distinguishing characters (trichomes, cellular patterns) for each plant species and photographs were taken of such fragments. These photographs were used as a reference key for the identification of the plant fragments on the dung sample slides and the percentage frequency occurrence of the plant fragments of major food plants of gaur was calculated simultaneously with the monocot : dicot ratio for each season.

The percentage availability of different vegetative and reproductive phases of the plant species selected for phenological study was estimated for each season and the results were compared with the time spent feeding by gaur on these plant species in each season. The density of different tree and shrub species in the study area was estimated from the vegetation plot data. These density estimates were used to calculate the proportion of the major food plants (tree and shrub) of gaur in the study area. Also the proportion of ground cover constituting the food items of gaur (grasses and herbs) in the study area was estimated from the vegetation plot data. The proportion of the major food plants of gaur in the study area and the proportion time spent feeding by gaur on the major food plants was used to calculate the Ivlev's (1961) index of selectivity for different food items of gaur as follows:
IVI (Ivlev's index of selectivity) = U – A/U + A

Where,
U = Proportion of resource utilized.
A = Proportion of resource available.

A positive index indicated that a particular food item was used more than its availability whereas a negative index indicated that a particular food item was used less than its availability.

7.4 Results

7.4.1 Food plants of gaur

During the study period a total of 82 species of food plants belonging to 29 families were recorded. The food plants eaten by gaur were classified into five categories such as trees, shrubs, herbs, grasses and climbers. The 82 species of food plants recorded comprised of 34 tree species, 8 shrub species, 14 herb species, 23 grass species and 3 climber species (table 7.1). Season-wise a total of 52, 53 and 50 food plants were recorded for summer, monsoon and winter respectively.

The different plant parts eaten by gaur were classified as leaf (for trees, shrubs and climbers), shoot (for grasses and herbs), floral bud, flower and fruit. Leaves and shoots comprised the major portion of gaur diet in the study area. Gaur were also observed to feed on the fruits of *Madhuca Indica*, *Phyllanthus emblica*, *Syzizium cuminii*, *Terminalia bellerica*, *Zizyphus mauritiana* and *Zizyphus xylopyra*. During the study period gaur were observed to feed on the floral buds of *Shorea robusta* and the flowers of *Shorea robusta*, *Madhuca Indica* and *Chloroxylon swietenia*.

Table 7.1 Food plants of gaur in BTR (March 2011-December 2014)

S.No.	Plant species (Trees)	Family	Parts eaten	Season
1	*Aegle marmelos*	Rutaceae	Le	S
2	*Albizzia procera*	Fabaceae	Le	M, W
3	*Anogeissus latifolia*	Combretaceae	Le	S, W
4	*Bauhinia Racemosa*	Fabaceae	Le	S
5	*Bauhinia veriegata*	Fabaceae	Le	S, W
6	*Boswellia serrata*	Burseraceae	Le	M, W
7	*Bridelia retusa*	Euphorbiaceae	Le	S, W
8	*Buchanania lanzan*	Anacardiaceae	Le	S, M, W
9	*Cassia fistula*	Fabaceae	Le	M, W
10	*Chloroxylon swietenia*	Meliaceae	Le, Fl	S, M, W
11	*Dalbergia paniculata*	Fabaceae	Le	S, W
12	*Dendrocalamus strictus*	Poaceae	Le, Sh	S, M, W
13	*Diospyros melanoxylon*	Ebenaceae	Le	S, M
14	*Ficus bengalensis*	Moraceae	Le	W
15	*Ficus hispida*	Moraceae	Le	S
16	*Ficus religiosa*	Moraceae	Le	W
17	*Flacourtia ramontchi*	Bixaceae	Le	S, M
18	*Grewia tiliifolia*	Tiliaceae	Le	S
19	*Lagerstroemia parviflora*	Lythraceae	Le	S
20	*lannea grandis*	Anacardiaceae	Le	S
21	*Madhuca indica*	Sapotaceae	Le, Fr, Fl	S, M, W
22	*Miliusa tomentosa*	Annonaceae	Le	S, W
23	*Mitragyna parviflora*	Rubiaceae	Le	S
24	*Phyllanthus emblica*	Euphorbiaceae	Le, Fr	S, M, W
25	*Randia uliginosa*	Rubiaceae	Le	W
26	*Semecarpus anacardium*	Anacardiaceae	Le	S, W
27	*Shorea robusta*	Dipterocarpaceae	Le, Flb, Fl	S, M, W
28	*Syzygium cuminii*	Myrtaceae	Le, Fr	S, W
29	*Terminalia arjuna*	Combretaceae	Le	S
30	*Terminalia bellerica*	Combretaceae	Le, Fr	S, W
31	*Terminalia chebula*	Combretaceae	Le	W
32	*Terminalia tomentosa*	Combretaceae	Le	S, M
33	*Ziziphus mauritiana*	Rhamnaceae	Le, Fr	S, M, W
34	*Ziziphus xylopyra*	Rhamnaceae	Le, Fr	S, W
	Plant species (Shrubs)			
35	*Gloriosa sps*	Colchicaceae	Le	M, W
36	*Holarrhena antidysenterica*	Apocynaceae	Le	W
37	*Lantana camara*	Verbinaceae	Le	S, M
38	*Mimosa hamata*	Fabaceae	Le	M
39	*Phoenix acaulis*	Arecaceae	Le	S, M, W
40	*Randia dumetorum*	Rubiaceae	Le	S
41	*Woodfordia floribunda*	Lythraceae	Le	S, M, W
42	*Wrightia tinttoria*	Apocynaceae	Le	M, W
	Plant species (Herbs)			
43	*Eranthemum purpurascens*	Acanthaceae	Sh	S, W
44	*Anthraxon spp.*	Poaceae	Sh	M
45	*Asparagas racemosus*	Asparagaceae	Sh	S,M
46	*Bulbostylis barbata*	Cyperaceae	Sh	M, W
47	*Cassia tora*	Fabaceae	Sh	S, M
48	*Desmodium heterocarpus*	Fabaceae	Sh	M

S.No.	Plant species (Trees)	Family	Parts eaten	Season
49	*Desmodium pulchellum*	Fabaceae	Sh	M, W
50	*Euphorbia hirta*	Euphorbiaceae	Sh	M
51	*Leucas aspera*	Lamiaceae	Sh	M
52	*Leucas biflora*	Lamiaceae	Sh	M
53	*Ocimum tenuiflorum*	Lamiaceae	Sh	M
54	*Oplismenus spp.*	Poaceae	Sh	M, W
55	*Achyranthes aspera*	Amaranthaceae	Sh	M, W
56	*Sida spp.*	Malvaceae	Sh	S, M, W
	Plant species (Grasses)			
57	*Aristida setacea*	Poaceae	Sh	S, M, W
58	*Andropogon spp.*	Poaceae	Sh	M
59	*Apluda mutica*	Poaceae	Sh	S
60	*Bothriochloa spp*	Poaceae	Sh	S, M, W
61	*Chloris dolichostachya*	Poaceae	Sh	S, M, W
62	*Cynodon dactylon*	Poaceae	Sh	S, M, W
63	*Cyperus spp.*	Cyperaceae	Sh	S, M
64	*Dicanthium sps.*	Poaceae	Sh	S
65	*Digitaria spp.*	Poaceae	Sh	M
66	*Eragrostis spp.*	Poaceae	Sh	S, M, W
67	*Heteropogon contortus*	Poaceae	Sh	S, M, W
68	*Imperata cylindrica*	Poaceae	Sh	S, M
69	*Lipocarpha chinensis*	Cyperaceae	Sh	M
70	*Paspalidium flavidum*	Poaceae	Sh	M
71	*Phragmites karka*	Poaceae	Sh	S, M, W
72	*Saccharum spontaneum*	Poaceae	Sh	S, M, W
73	*Setaria glauca*	Poaceae	Sh	M
74	*Seteria pumila*	Poaceae	Sh	M
75	*Sorghum halepense*	Poaceae	Sh	S
76	*Sporobolous pulchelus*	Poaceae	Sh	W
77	*Themeda triandra*	Poaceae	Sh	S, M, W
78	*Thysanolaena maxima*	Poaceae	Sh	M
79	*Vetiveria zizanoides*	Poaceae	Sh	S, M, W
	Plant species (Climbers)			
80	*Butea superba*	Fabaceae	Le	S, M, W
81	*Bauhinia Vahilii*	Fabaceae	Le	S, M, W
82	*Ziziphus oenoplia*	Rhamnaceae	Le	W

Le- leaves, Flb- Floral bud, Fl- flower, Fr-fruit, Sh- shoot.
S-summer, M-monsoon, W-winter.

7.4.2 Percentage time spent feeding by gaur on major food plants

A total of 6,724 feeding records were collected for gaur in Bandhavgarh Tiger Reserve during the study period through the scan sampling (Altman 1974) technique. Of the total feeding records, 2,946 were collected in summer, 1,957 in monsoon and 1,821 in winter. Overall, the major food items identified for gaur in Bandhavgarh Tiger Reserve based on the percent time spent feeding by gaur were bamboo leaves (*Dendrocalamus strictus*), grasses, herbs, *Shorea robusta* leaves, *Butea superba* leaves (climber) and *Chloroxylon swietenia* leaves. Annually these food items combined to constitute about 93% of the total time spent feeding by gaur in the study area. It was observed that annually gaur spent the major portion of their time feeding on bamboo leaves and grasses (figure 7.1). Annually the time spent feeding on bamboo leaves was the highest (45.3%) followed by grasses (30.2%), herbs (8.3%), *Shorea robusta* leaves (3.9%), *Butea superba* leaves (2.6%) and *Chloroxylon swietenia* leaves (2.5%).

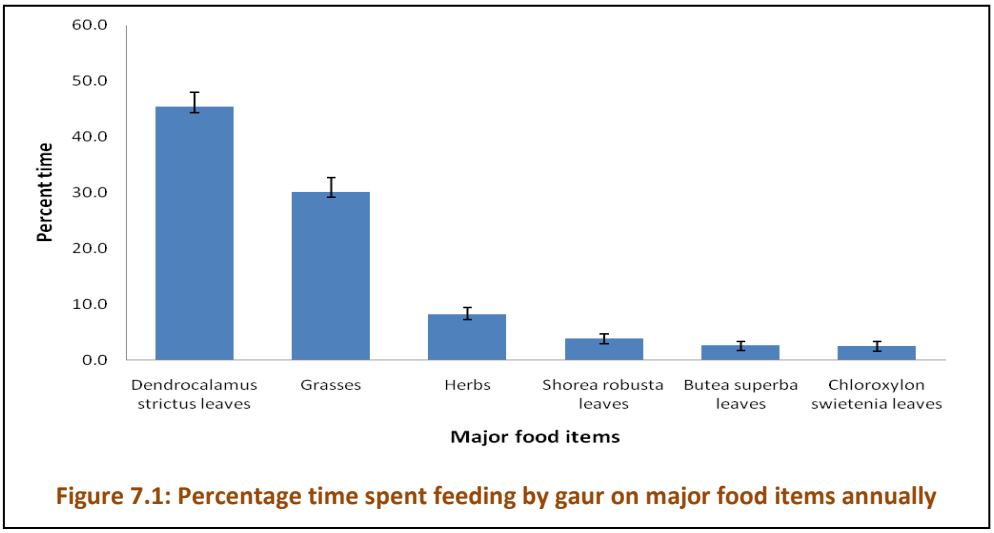


Figure 7.1: Percentage time spent feeding by gaur on major food items annually

The different species of grasses and herbs that were mainly consumed by gaur across seasons is provided in table 7.2.

Table 7.2: Major grasses and herbs eaten by gaur in different season

Summer	Monsoon	Winter
Grasses *Saccharum spontaneum, Vetiveria zizanoides, Phragmites karka* **Herbs** *Sida spp.*	***Grasses*** *Saccharum spontaneum, Vetiveria zizanoides, Phragmites karka, Aristida setacea, Andropogon spp., Digitaria spp., Heteropogon contortus* **Herbs** *Oplismenus spp., Anthraxon spp., Sida spp.*	***Grasses*** *Saccharum spontaneum, Vetiveria zizanoides, Phragmites karka, Heteropogon contortus, Bothriochloa spp.* **Herbs** *Oplismenus spp. Sida spp.*

The percent time spent on feeding different food items during summer was found highest for grasses (45.9%) followed by bamboo leaves (33.1%), young *Shorea robusta* leaves (7.8%) and herbs (5.0%). During monsoon, the major food items were highest for bamboo leaves (32.9%) followed by grasses (28.1%), herbs (19.7%), young bamboo shoots (9.1%), *Butea superba* leaves (3.4%) and *Chloroxylon swietenia* leaves (2.9%). The time spent for major food items during winters were highest for bamboo leaves (63.9%) followed by grasses (17.3%), herbs (4.4%), *Chloroxylon swietenia* leaves (3.7%) and *Butea superba* leaves (3.3%).

It was observed that bamboo leaves, grasses and herbs formed the major food items of gaur in all the seasons whereas *Shorea robusta* leaves were eaten by gaur mainly in summer and young bamboo shoots were consumed only in monsoon. *Butea superba* and *Chloroxylon swietenia* leaves were consumed by gaur mainly in monsoon and winter. The percentage time spent feeding by gaur on bamboo leaves differed significantly across the three seasons (Kruskal Wallis: χ^2 = 30.771, $p<0.05$). Also, the percentage time spent feeding on bamboo leaves was seen to differ significantly between summer and winter (Mann Whitney: Z = -4.802, $p<0.05$) and monsoon and winter (M.W: Z = -4.544, $p<0.05$) but there was no significant difference between summer and monsoon. For grasses, the percentage time spent feeding by

gaur differed significantly across the three seasons (K.W: χ^2 = 20.053, p<0.05). Between two seasons, the percentage time spent feeding by gaur on grasses was found to differ significantly between summer and winter (M.W: Z = -4.007, p<0.05) and monsoon and winter (M.W: Z = -3.336, p<0.05). The percent time spent feeding by gaur on herbs was also found to differ significantly across the three seasons (K.W: χ^2 = 42.473, p<0.05). Between two seasons, the percent time spent feeding on herbs was found to be significantly different between summer and monsoon (M.W: Z = -5.409, p<0.05) and monsoon and winter (M.W: Z = -5.737, p<0.05) but there was no significant difference in the time spent feeding on herbs between summer and winter. The difference in the time spent feeding by gaur on both, *Butea superba* leaves and *Chloroxylon swietenia* leaves between monsoon and winter was found to be non-significant.

The percentage time spent grazing and browsing by gaur in different seasons and annually is given in figure 7.2. The time spent grazing included the time spent feeding by gaur on monocotyledonous plant items like bamboo leaves, young bamboo shoots, grasses and monocot herbs (mainly *Oplismenus* and *Anthraxon* spp) whereas time spent browsing included the time spent feeding by gaur on dicotyledonous plant items like leaves of trees, shrubs, climbers and dicot herbs (mainly *Sida* spp). Annually the percent time spent grazing by gaur was 84.9% whereas that spent browsing was 15.1%. The time spent grazing by gaur was observed to be highest in monsoon (89.7%) followed by winter (84.8%) and summer (81.9%) but the difference across the seasons was found to be non-significant (K.W. χ^2 = 2.439, p>0.05). In summer gaur spent about 18.1% time browsing followed by winter (15.2%) and monsoon (10.3%) but the difference was found to be non-significant (K.W. χ^2 = 2.310, p>0.05) across the seasons.

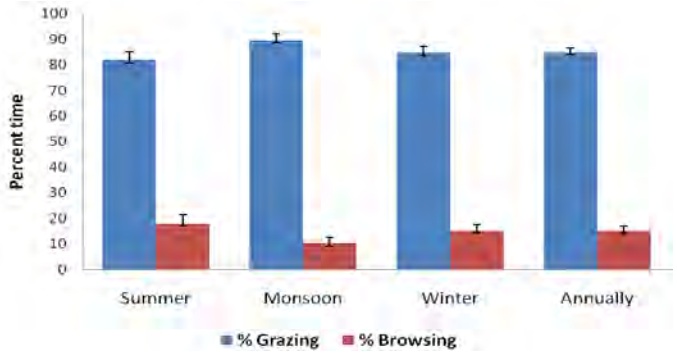


Figure 7.2: Percent time spent grazing and browsing across seasons and annually

7.4.3 Nutritional contents of the food plants of gaur

During the study period a total of 68 food plant samples were analysed for nutritional contents. The results obtained for the nutritional analysis of the major food items of gaur in the different seasons are given below.

Crude protein

The crude protein content of major food items of gaur in different seasons is shown in figure 7.3. In summer the crude protein content was found to be highest in herbs (9%) whereas for monsoon and winter it was found to be the most in *Butea superba* leaves (11.6% and 6.9% respectively). For grasses the crude protein was observed to be highest in monsoon (3.2%) followed by summer (3%) and winter (2.3%). Bamboo leaves had higher crude protein

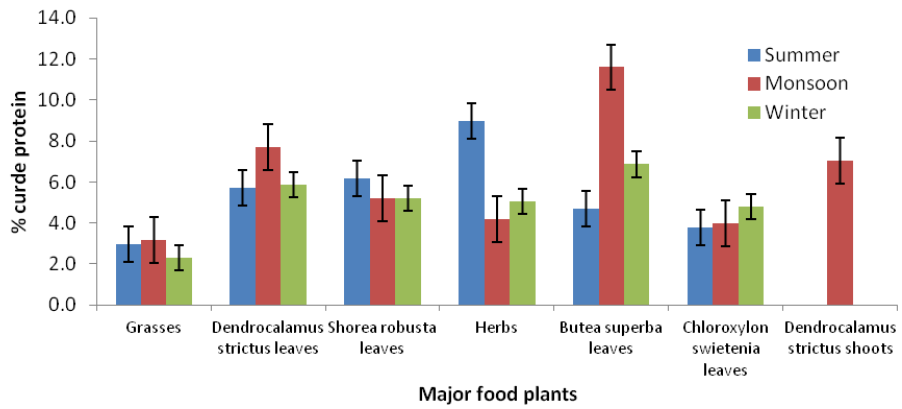


Figure 7.3: Crude protein content of major food items of gaur in different season

content in monsoon (7.7%) as compared to winter (5.9%) and summer (5.7%). The crude protein in herbs was observed to be highest in summer (9%) and lowest in monsoon (4.2%). The young leaves of *Shorea robusta* in summer had higher crude protein content (6.2%) compared to the mature leaves of *Shorea robusta*, which had similar crude protein content in monsoon and winter (5.2%). The crude protein content for *Butea superba* leaves was observed to be highest in monsoon (11.6%) whereas for *Chloroxylon swietenia* leaves it was found to be highest in winter (4.8%).

Neutral detergent fibre (NDF) and Acid detergent fibre (ADF)

The NDF and ADF contents of the major food items of gaur for the three seasons are given in table 7.3. The NDF content was observed to be highest for herbs (71.3%), young bamboo shoots (70.2%) and *Chloroxylon swietenia* leaves (69.7%) in summer, monsoon and winter respectively. In summer the ADF content was highest for *Chloroxylon swietenia* leaves (48.2%) whereas in monsoon and winter it was found to be highest for herbs (52.4% and 52.6% respectively). For grasses the NDF content was found to be highest in winter (62.5%) and the ADF content was highest in monsoon (46%). The NDF content in bamboo leaves was observed to be similar in all the seasons (range: 58-59) whereas the ADF content was observed to be highest in monsoon (48.2%) compared to the other two seasons. For *Butea superba* leaves the NDF content was found to be highest in monsoon (62.4%) and the ADF content was highest in summer (45.7%).

Table 7.3: NDF and ADF content of major food items of gaur in different season

	Summer		Monsoon		Winter	
	NDF	ADF	NDF	ADF	NDF	ADF
Grasses	55.4	43.9	55.9	46.0	62.5	36.8
Dendrocalamus strictus leaves	58.0	43.8	58.2	48.2	59.0	41.4
Shorea robusta leaves	52.1	36.7	48.39	47.82	53.4	36.8
Herbs	71.3	25.6	54.1	52.4	50.6	36.8
Butea superba leaves	60.1	45.7	62.4	44.7	54.2	40.5
Chloroxylon swietenia leaves	63.3	48.2	54.3	33.5	69.7	28.4
Dendrocalamus strictus shoot			70.2	47.3		

Lignin

The lignin content in the major food items of gaur in different seasons is given in figure 7.4. In summer the lignin content was found to be highest in *Chloroxylon swietenia* leaves (14.2%) whereas it was lowest in grasses (11.7%). In monsoon and winter the lignin content was highest in *Shorea robusta* leaves (15.3% and 15.9% respectively) and was lowest in *Chloroxylon swietenia* leaves (5.3% and 9.4% respectively). Grasses showed higher lignin content in winter (13.2%) as compared to summer (11.7%) and monsoon (9.5%) whereas the lignin content in bamboo leaves was highest in summer (12.4%) and lowest in monsoon (8.9%). The lignin content in herbs was highest in monsoon (13.9%) as compared to summer and winter (12.6% and 11.9% respectively).

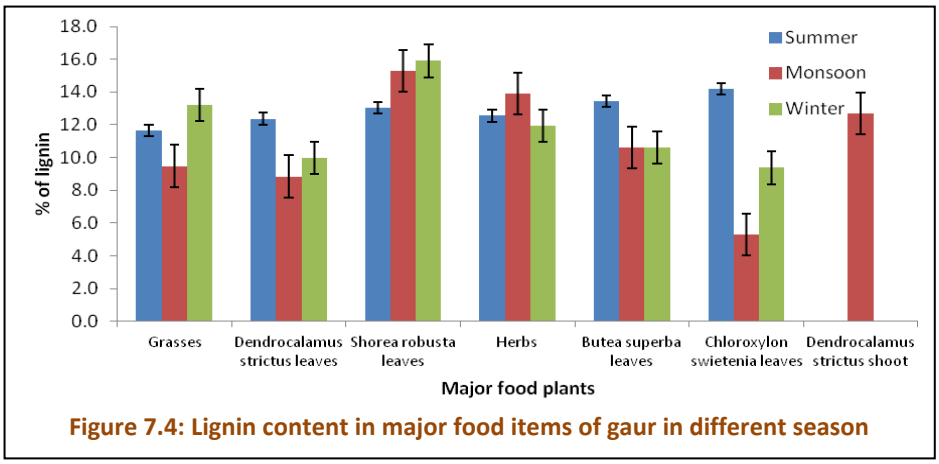


Figure 7.4: Lignin content in major food items of gaur in different season

Minerals

The mineral contents in the major food items of gaur for different seasons are given in tables 7.4 to 7.6. In summer herbs had the highest Potassium, Magnesium and Zinc content (1.71%, 0.53% and 0.0047% respectively). For summer the Sodium and Calcium content was found to be highest in *Chloroxylon swietenia* leaves (0.09% and 2.53% respectively) whereas the Iron content was found highest in *Butea superba* leaves (0.14%). In monsoon, Sodium and Magnesium content were observed to be highest in bamboo leaves (0.075% and 0.29% respectively) whereas Potassium and Zinc were found to be most in bamboo shoots (2.91% and 0.006% respectively). Also, in monsoon the Calcium content was found highest in *Chloroxylon swietenia* leaves (1.0%) whereas the Iron content was found to be highest in herbs (0.2%). In winter, *Butea superba* leaves had the highest content of Sodium, Calcium and Iron (0.08%, 1.55% and 0.13% respectively) whereas the Potassium and Zinc content was found to be highest in herbs (1.85% and 0.006%). The Magnesium content in winter was found to be highest in bamboo leaves (0.36%).

Table 7.4 Mineral contents in major food items of gaur in summer

Food items	Minerals					
	% K	% Na	% Ca	% Mg	% Zn	% Fe
Grasses	0.53	0.08	1.21	0.23	0.0044	0.08
Dendrocalamus strictus leaves	1.08	0.08	0.99	0.27	0.0037	0.11
Shorea robusta leaves	0.82	0.04	0.66	0.27	0.0028	0.02
Herbs	1.71	0.07	1.45	0.53	0.0047	0.08
Butea superba leaves	0.39	0.07	2.319	0.43	0.0030	0.13
Chloroxylon swietenia leaves	0.35	0.09	2.53	0.49	0.0032	0.12

Table 7.5 Mineral contents in major food items of gaur in monsoon

Food items	Minerals					
	% K	% Na	% Ca	% Mg	% Zn	% Fe
Grasses	1.11	0.058	0.6	0.18	0.005	0.09
Dendrocalamus strictus leaves	0.85	0.075	0.7	0.29	0.004	0.18
Dendrocalamus strictus shoot	2.91	0.060	0.3	0.14	0.006	0.05
Herbs	1.40	0.065	0.6	0.28	0.005	0.20
Chloroxylon swietenia leaves	0.62	0.059	1.0	0.21	0.003	0.03
Butea superba leaves	0.61	0.064	0.9	0.21	0.002	0.07
Shorea robusta leaves	0.45	0.036	0.5	0.17	0.002	0.05

Table 7.6 Mineral contents in major food items of gaur in winter

Food items	Minerals					
	% K	% Na	% Ca	% Mg	% Zn	% Fe
Chloroxylon swietenia leaves	0.57	0.06	1.30	0.18	0.0029	0.03
Butea superba leaves	0.61	0.08	1.55	0.21	0.0029	0.13
Dendrocalamus strictus leaves	0.66	0.06	1.15	0.36	0.0027	0.05
Grasses	0.60	0.05	0.48	0.14	0.0049	0.05
Herbs	1.85	0.07	0.65	0.34	0.0060	0.07
Shorea robusta leaves	0.48	0.03	0.5	0.18	0.002	0.05

7.4.4 Phenology of major food plants of gaur in Bandhavgarh Tiger Reserve

The percentage availability of different vegetative phenophases (young leaves, mature leaves and no leaves) of major food plants of gaur in the study area in different seasons is given in figures 7.6 to 7.12. Young leaves of *Shorea robusta* were available only in summer whereas mature leaves formed the major portion of the foliage in all the seasons (figure 7.15). The reproductive phases (floral buds and flowers) of *Shorea robusta* were mainly recorded during the early part of summer (March and April). For *Dendrocalamus strictus* it was observed that the percentage of young leaves available was highest during summer (23.5%) whereas the availability of mature leaves was observed to be highest in winter (94.9%). *Dendrocalamus strictus* were observed to shed leaves during summer and a considerable proportion of the plant was recorded to be leafless during this season (34.5%). The *Chloroxylon swietenia* trees were observed to be mainly leafless during summer (86.4%) which was also the time of the year when they were recorded in reproductive phases (floral buds, flowers and fruits). The percentage of young leaves of *Chloroxylon swietenia* was observed to be highest in monsoon (18%) whereas the percentage of mature leaves was the most during winter (86.2%). The foliage of the climber *Butea superba* consisted mainly of mature leaves in all the seasons (figure 7.18) whereas young leaves were available in summer (21.4%) and monsoon (8.3%). *Butea superba* was observed to flower in late monsoon (September-October) and the climbers were observed with mature fruits for the most part of the year except from August to October.

The phenology of the major grass species like *Saccharum*, *Vetiveria* and *Phragmites* was found to be very similar in the study area. For all the three species of grasses it was observed that the percentage of young shoots was the highest in monsoon followed by summer and winter whereas the percentage of mature shoots was the highest in winter for all the three species (figures 7.19 to 7.21). In terms of reproductive phenology, all the three species mainly flowered in monsoon (August-September) and it was observed that some flowering also occurred in early winter (November-December).

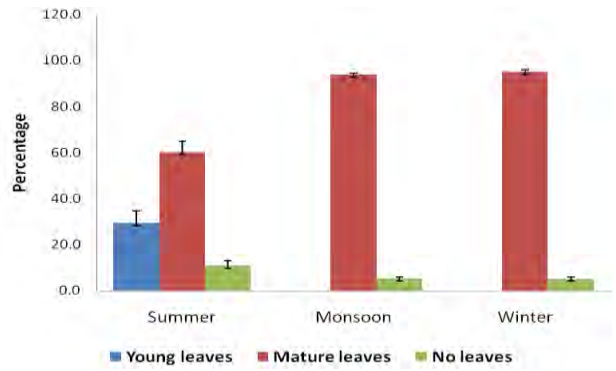


Figure 7.5: Phenology of *Shorea robusta* in different seasons

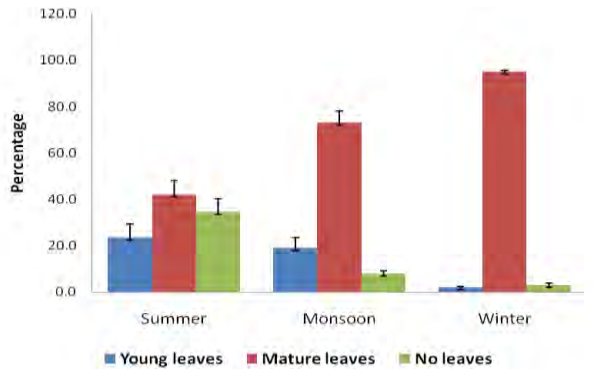


Figure 7.6: Phenology of *Dendrocalamus strictus* in different seasons

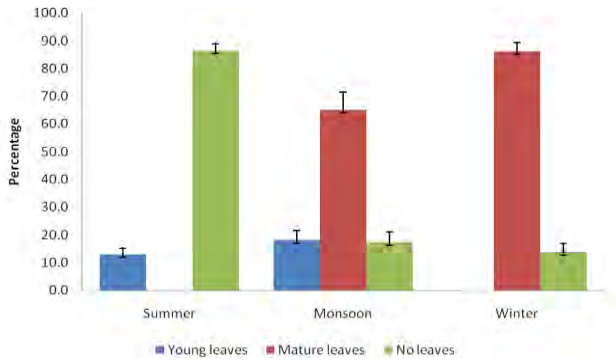


Figure 7.7 Phenology of *Chloroxylon swietenia* in different seasons

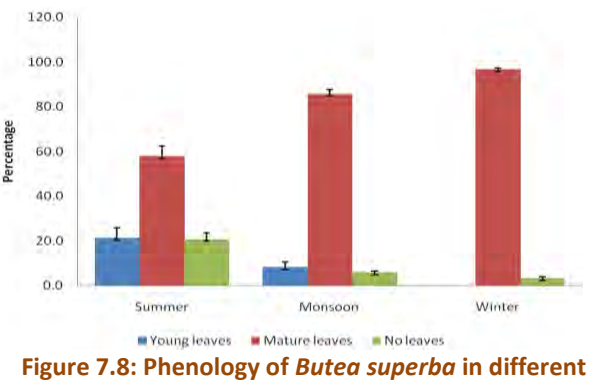


Figure 7.8: Phenology of *Butea superba* in different seasons

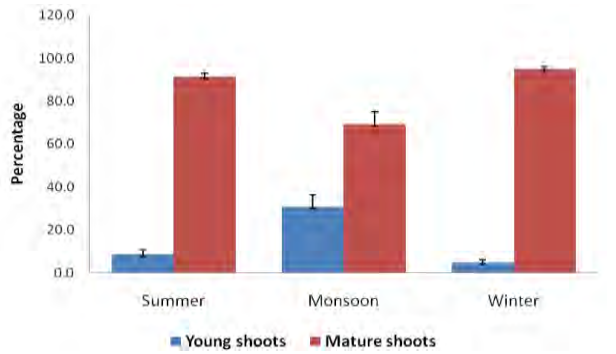


Figure 7.9: Phenology of *Saccharum spontaneum* in different seasons

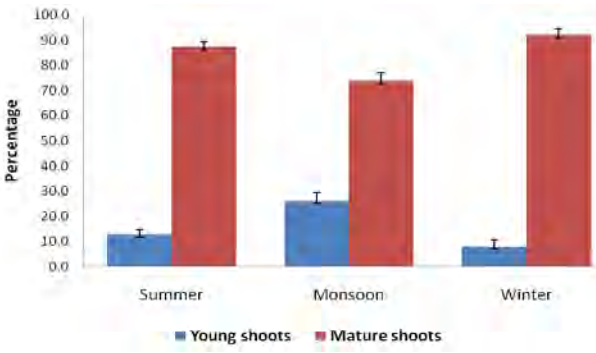


Figure 7.10: Phenology of *Vetiveria zizanoides* in different seasons

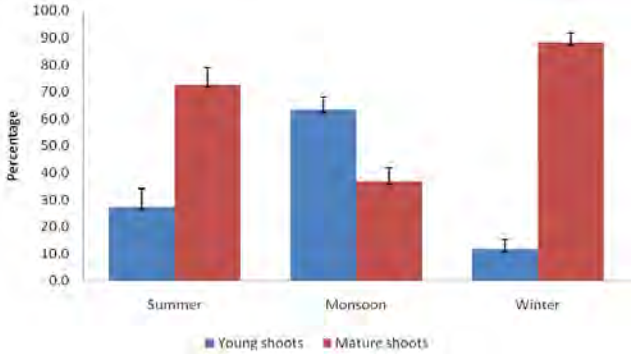


Figure 7.11: Phenology of *Phragmites karka* in different seasons

7.4.5 Diet composition of gaur through dung analysis

A total of 301 dung samples were analysed during the study period (summer-101, monsoon-100, winter-100). The percentage frequency occurrence of monocot and dicot plant fragments in the dung samples of gaur in different seasons and annually is given in figure 7.12. It was observed that the percentage frequency occurrence of monocot plant fragments in the gaur dung samples was high in all the seasons as compared to that of the dicot plant fragments (figure 7.12). The percentage frequency occurrence of dicot plant fragments was observed to be the most in summer (11.3%) as compared to monsoon and winter (5.5% and 4.8% respectively). Annually, it was observed that the percentage frequency occurrence of monocot plant fragments in the gaur dung samples was 89.1% whereas that of dicot fragments was 7.2%.

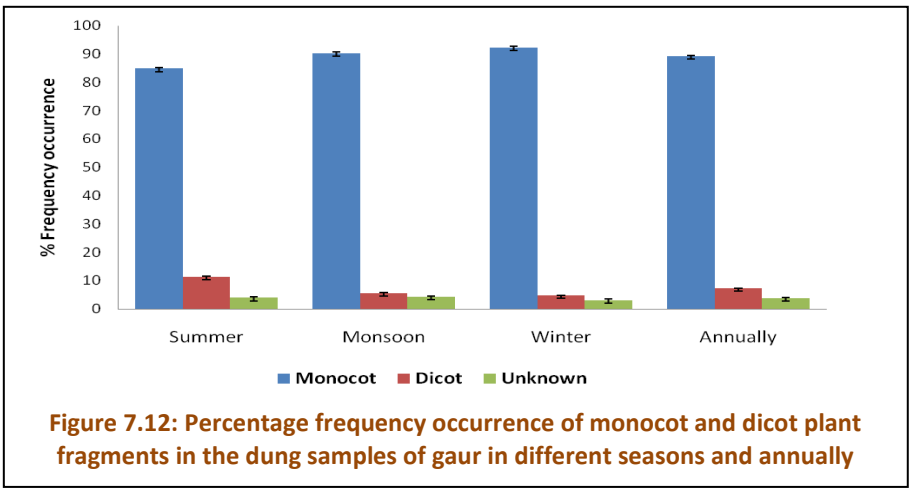


Figure 7.12: Percentage frequency occurrence of monocot and dicot plant fragments in the dung samples of gaur in different seasons and annually

The percentage frequency occurrence of plant fragments of major food plant species of gaur in the gaur dung samples in different seasons is given in table 7.7.

Table 7.7 Percentage frequency occurrence of plant fragments of major food plant species of gaur in different season in BTR

Food plant species	Percentage frequency occurrence of plant fragments in different seasons.		
	Summer	Monsoon	Winter
Saccharum spontaneum	30 (3.6)	6.8 (1.1)	10.6 (1.7)
Phragmites karka	9.8 (1.4)	4.3 (1.2)	2.4 (0.6)
Vetiveria zizanoides	5.1 (1.2)	1.3 (0.4)	2.5 (0.7)
Dendrocalamus strictus	20.2 (3.4)	17.1 (2.7)	30.5 (2.2)
Oplismenus spp.	0.0	14.7 (2.4)	3.1 (0.9)
Shorea robusta	5.4 (1.5)	0.8 (0.4)	0.5 (0.2)
Chloroxylon swietenia	0.0	0.5 (0.3)	0.5 (0.2)
Butea superba	0.8 (0.3)	0.1 (0.1)	0.2 (0.1)

Standard errors are given in parenthesis.

The percentage frequency occurrence of bamboo fragments was observed to be highest in winter (30.5%) as compared to summer (20.2%) and monsoon (17.1%). The percentage frequency occurrence of the fragments of the herb *Oplismenus* was observed to be the most in monsoon (14.7%) as compared to winter (3.1%). Percentage frequency occurrence of *Saccharum spontaneum* fragments was observed to be 30% in summer, 6.8% in monsoon and 10.6% in winter. Among dicotyledonous species the percentage frequency occurrence of *Shorea robusta* was observed to be highest in summer (5.4%) followed by monsoon (0.8%) and winter (0.5%).

7.4.6 Availability of the major food plants of gaur in Bandhavgarh Tiger Reserve

A total of 281 vegetation plots were laid in the study area during the study period. The density of major food plants of gaur (Trees and climbers) is given in table 7.8. The percentage grass and herb cover and the percentage of green and dry grass available in different seasons in the study area are given in tables 7.9 and 7.10.

Table 7.8 Density of major food plants of gaur

Food plant species	Density (per meter square)
Shorea robusta	0.041 (±0.003)
Dendrocalamus strictus	0.039 (±0.003)
Chloroxylon swietenia	0.011 (±0.002)
Butea superba	0.002 (±0.001)

Table 7.9 Percentage grass and herb cover in different seasons

Seasons	% Grass cover	% herb cover
Summer	19.2 (±1.4)	9.1 (±0.9)
Monsoon	41.3 (±2.4)	19.7 (±1.4)
Winter	20.3 (±2.0)	8.4 (±0.6)

Table 7.10 Percentage availability of green and dry grass in different seasons

Seasons	% Green grass	% Dry grass
Summer	55.6 (±4.2)	44.4 (±2.3)
Monsoon	96.4 (±2.3)	3.6 (±3.1)
Winter	32.9 (±5.1)	67.1 (±1.3)

It was found that among the major food plants of gaur in Bandhavgarh, *Shorea robusta* had the highest density (0.041/m^2) followed by *Dendrocalamus strictus* (0.039/m^2), *Chloroxylon swietenia* (0.011/m^2) and *Butea superba* (0.002/m^2). The percent grass cover was found to be significantly higher in monsoon (41.3%) as compared to summer (19.2%) and winter (20.3%) (K.W: $\chi^2 = 63.341$, $p<0.05$). Similarly, the percent herb cover was also found to be significantly higher in monsoon (19.7%) as compared to summer (9.1%) and winter (8.4%) (K.W: $\chi^2 = 66.806$, $p<0.05$). The percentage availability of green grass was observed to be higher in monsoon and summer as compared to the percentage availability of dry grass whereas the availability of dry grass was higher than that of green grass in winter (table 7.10).

7.4.7 Selection of major food items by gaur in different seasons

The Ivlev's selectivity index (IVI), calculated for the major food items of gaur in different seasons in Bandhavgarh is given figure 7.13. It was observed that the utilisation of bamboo leaves as a food item by gaur was higher than its availability in all the seasons (figure 7.13). The utilisation of grasses as a food resource was observed to be more than its availability in summer whereas it was lower than its availability in monsoon and winter. The utilisation of herbs by gaur as a food item was observed to be proportional to its availability in monsoon whereas it was found lower than its availability in summer and winter. Gaur utilised *Butea superba* leaves more than its availability in monsoon and winter whereas the use of *Chloroxylon swietenia* leaves by gaur was found to be lower than its availability in monsoon and winter. *Shorea robusta* leaves were used less by gaur than their availability in summer whereas the utilisation of young bamboo shoots in monsoon was observed to be lower than their availability.

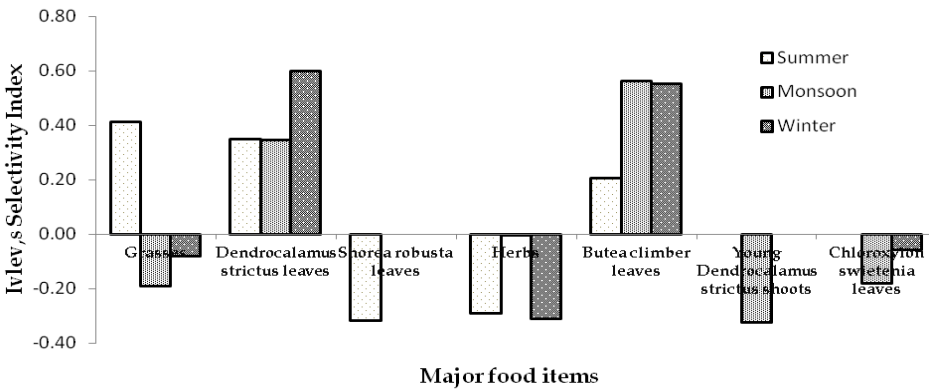


Figure 7.13: Ivlev's selectivity index of major food items of gaur in diffrent seasons

7.4.8 Land use and Land cover map of Bandhavgarh Tiger Reserve

The overall habitat was classed into 11 different vegetation/land cover classes *viz* agriculture, bamboo forest, grassland, open-mixed forest, mixed forest, sal forest, riparian forest, habitation, plantation, rocky outcrop and scrubland. The area and percentage of different vegetation and land cover classes in BTR is given in table (refere Chapter VI) 6.1 and figure 6.1. It was observed that in BTR, the mixed forest was found to be the most dominant vegetation type that covers the highest percentage of area (40.2%) whereas the area under plantation covers the lowest percent area (0.2%). In addition, the bamboo forest covers an area of 12.6%, grasslands 6.5%, whereas Sal forest covers about 13.1% area in the entire Tiger Reserve.

7.4.9 Food plants of captive elephants in Bandhavgarh Tiger Reserve

A total of 62 food plants eaten by the captive elephants in Bandhavgarh Tiger Reserve were identified during the study period (table 7.11). In total there were 13 captive elephants (8 adults and 5 calves) distributed in different groups in the study area. Of the 62 species of food plants eaten by the captive elephants in the study area, 59 species were eaten by gaur (table 7.11). Thus, of the 82 food plants recorded for gaur (table 7.1) in the present study, 59 were common for gaur and the captive elephants. Hence, in terms of species of food plants eaten by captive elephants, an overall overlap of 72% with the species of food plants of gaur was observed. In summer, of the 52 food plants recorded for gaur (table 7.1), 24 were observed to be common between gaur and captive elephants showing an overlap of 46.2% in terms of species of food plants. Similarly, the overlap observed in terms of food plants species between gaur and captive elephants in monsoon was 69.8% and in winter was 66%.

Table 7.11 Food plants of captive elephants in BTR

S. No.	Plant species (Trees)	Family	Parts eaten	Season
1	*Aegle marmelos**	Rutaceae	Le	S
2	*Albizzia procera**	Fabaceae	Le	M, W
3	*Anogeissus latifolia**	Combretaceae	Le	W
4	*Bauhinia veriegata**	Fabaceae	Le	S, W
5	*Boswellia serrata**	Burseraceae	Le	M, W
6	*Bridelia retusa**	Euphorbiaceae	Le	S
7	*Buchanania lanzan**	Anacardiaceae	Le	S, M, W
8	*Cassia fistula**	Fabaceae	Le	S, M, W
9	*Chlorozylon swetiena**	Meliaceae	Le	M, W
10	*Dendrocalamus strictus**	Poaceae	Le, Sh	S, M, W
11	*Diospyros melanoxylon**	Ebenaceae	Le, Roots	S, M, W
12	*Ficus bengalensis**	Moraceae	Le	S, M, W

S. No.	Plant species (Trees)	Family	Parts eaten	Season
13	*Grewia tiliifolia**	Tiliaceae	Le	S
14	*Lagerstroemia parviflora**	Lythraceae	Le	S, W
15	*lannea grandis**	Anacardiaceae	Le	M, W
16	*Madhuca indica**	Sapotaceae	Le, Fr, Fl	S, M, W
17	*Miliusa tomentosa**	Annonaceae	Le	W
18	*Mitragyna parviflora**	Rubiaceae	Le	S, M
19	*Mangifera indica*	Anacardiaceae	Le, Fr	S, M, W
20	*Phyllanthus emblica**	Euphorbiaceae	Le, Fr	S, M, W
21	*Randia uliginosa**	Rubiaceae	Le	M
22	*Semecarpus anacardium**	Anacardiaceae	Le	M, W
23	*Shorea robusta**	Dipterocarpaceae	Le, Flb, Fl	S, M, W
24	*Syzygium cuminii**	Myrtaceae	Le, Fr	S, M, W
25	*Tectona grandis*	Lamiaceae	Le	W
26	*Terminalia arjuna**	Combretaceae	Le	S, M, W
27	*Terminalia bellerica**	Combretaceae	Le, Fr	S, M
28	*Terminalia chebula**	Combretaceae	Le	M
29	*Terminalia tomentosa**	Combretaceae	Le	M, W
30	*Zizyphus mauritiana**	Rhamnaceae	Le, Fr	W
31	*Zizyphus xylopyra**	Rhamnaceae	Le, Fr	M, W
32	*Kydia calycina*	Malvaceae	Le	M, W
	Plant species (Shrubs)			
33	*Gloriosa spp**	Colchicaceae	Le	M, W
34	*Holarrhena antidysenterica**	Apocynaceae	Le	M, W
35	*Mimosa hamata**	Fabaceae	Le	M
36	*Phoenix acaulis**	Arecaceae	Le	S, M, W
37	*Woodfordia floribunda**	Lythraceae	Le	M, W
38	*Wrightia tinttoria**	Apocynaceae	Le	S, M, W
	Plant species (Herbs)			
39	*Anthraxon spp.**	Poaceae	Sh	M, W
40	*Desmodium heterocarpus**	Fabaceae	Sh	M
41	*Desmodium pulchellum**	Fabaceae	Sh	M
42	*Euphorbia hirta**	Euphorbiaceae	Sh	M, W
43	*Leucas aspera**	Lamiaceae	Sh	M
44	*Leucas biflora**	Lamiaceae	Sh	M, W
	Plant species (Grasses)			
45	*Aristida setacea**	Poaceae	Sh	M, W
46	*Andropogon spp.**	Poaceae	Sh	M
47	*Bothriochloa spp**	Poaceae	Sh	S, M, W
48	*Chloris dolichostachya**	Poaceae	Sh	M, W
49	*Cynodon dactylon**	Poaceae	Sh	M, W
50	*Cyperus spp.**	Cyperaceae	Sh	S, M, W
51	*Dicanthium spp.**	Poaceae	Sh	M
52	*Digitaria spp.**	Poaceae	Sh	M
53	*Heteropogon contortus**	Poaceae	Sh	M, W
54	*Imperata cylindrica**	Poaceae	Sh	M, W
55	*Phragmites karka**	Poaceae	Sh	S, M, W
56	*Saccharum spontaneum**	Poaceae	Sh	S, M, W
57	*Sorghum halepense**	Poaceae	Sh	S, M
58	*Themeda triandra**	Poaceae	Sh	M, W
59	*Thysanolaena maxima**	Poaceae	Sh	M
60	*Vetiveria zizanoides**	Poaceae	Sh	S, M, W
	Plant species (Climbers)			
61	*Butea superba**	Fabaceae	Le	S, M, W
62	*Bauhinia Vahilii**	Fabaceae	Le	S, W

Le- leaves, Flb- Floral bud, Fl- flower, Fr-fruit, Sh- shoot.
S – summer, M – monsoon, W – winter.; * - food plants eaten by gaur.

7.5 Discussion

Gaur has been described as a generalist feeder (Sankar *et al*. 2001) and is known to feed on a large variety of food plants across many different forest types in India (Schaller 1967, Krishnan 1972, Vairavel 1998, Sankar *et al*. 2001, Gad 2011, Sankar *et al*. 2013). In the present study gaur were observed to feed on 82 species of food plants (table 7.1) which indicates the polyphagous feeding habit of this mega-herbivore. Schaller (1967) reported that such a varied diet of gaur has enabled it to colonize a wide range of vegetation types across its distributional range in the country.

In the present study it was observed that bamboo leaves and grasses formed the bulk of gaur diet in all the seasons. Annually, the percentage time spent grazing by gaur in Bandhavgarh Tiger Reserve was about 84.9% whereas that spent browsing was 15.1% (figures 7.5). During the study period it was observed that the time spent browsing by gaur was very low as compared to the time spent grazing by gaur in all the seasons. The analysis of gaur dung samples also showed a very high percentage frequency occurrence of monocot plant fragments (summer: 84.8%, monsoon: 90.3% and winter: 92.2%) in all the seasons as compared to dicot plant fragments (figure 7.22) which indicates that browse species do not form a major portion of the gaur diet in any season in Bandhavgarh Tiger Reserve. Schaller (1967) reported that grasses formed the major portion of gaur diet in summer in Kanha Tiger Reserve. A short study conducted on the small gaur population of Bandhavgarh before its extinction reported that gaur were seen to graze mainly in summer and winter whereas it preferred to browse in monsoon (Lad and Gopal 1992). Vairavel (1998) reported that in Parambikulam Tiger Reserve the time spent grazing by gaur was observed to be high in all seasons as compared to browsing. In Pench Tiger Reserve and Bhagwan Mahaveer Wildlife Sanctuary, gaur has been reported to browse mainly in summer whereas graze predominantly in monsoon and post-monsoon (Sankar *et al*. 2001 and Gad 2011). A study conducted in the Bandipur and Mudumalai Tiger Reserves found that gaur were grazers throughout the year (Ahrestani *et al*. 2012). Apart from gaur, studies on the feeding habits of African buffalo have reported that in some parts of Africa the African buffalo is known to be a primary grazer throughout the year whereas in others it supplements its diet to a large extent with browse in the dry seasons (Jarman 1971, Sinclair 1977, Mloszewski 1983 and Prins 1996).

Among the nutritional contents, crude protein and fibre contents are mainly considered to influence the selection of food plants among herbivores (Gupta 1991). Lignin is considered to be a major digestion inhibitor present in plant materials (Waterman 1983) which interferes with the digestive process among herbivores. The crude protein content of grasses was found to be highest in monsoon (3.2%) whereas the lignin content was observed to be highest in winter (13.2%). Bamboo leaves had the highest crude protein content in monsoon (7.7%) whereas the lignin content was observed to be highest in summer (12.4%). Browse species like *Shorea robusta* in summer and *Butea superba* in monsoon and winter had higher crude protein levels as compared to grasses and bamboo leaves (figures 7.6 to 7.8) but they also had higher levels of lignin as compared to bamboo leaves and grasses in summer and monsoon (figures 7.12 and 7.13). In winter bamboo leaves had the lowest content of lignin as compared to grasses, *Shorea robusta* leaves and *Butea superba* leaves (figure 7.14). In general the presence of toxins (alkaloids, terpenoids etc.) and digestibility reducing compounds like tannins has been found to be higher in leaves of woody and herbaceous dicots (Owen-Smith 1988). Minson (1976) has reported that herbivores can obtain nutrition from fibre contents like unlignified and partially lignified cellulose and hemicellulose but lignin is indigestible. A high fibrous diet increases the digestive efficiency by increasing the retention time of the food in the gut (Owen-Smith 1988). Gaur is a mega-herbivore and all large herbivores, owing to their large body sizes are known to subsist on poorer quality diets (Bell 1971).

The phenological studies of major food plants of gaur in Bandhavgarh Tiger Reserve showed that among the browse species only the *Chloroxylon swietenia* trees remained mainly leafless in summer whereas *Shorea robusta* trees and *Butea superba* climbers bore leaves throughout the year. Young leaves of *Shorea robusta* emerged in the early part of summer (March-April)

which formed a major food item of gaur in the study area. It was observed that the percentage of young bamboo leaves was highest in summer followed by monsoon (figure 7.16). Overall it was observed that the bamboo plants were never completely leafless especially in summer when they bore about 65% leaves. The phenology of major grass species like *Saccharum*, *Vetiveria* and *Phragmites* showed that the percentage availability of young shoots was the highest in monsoon and was lowest in winter. It was also observed that the percentage availability of green grass was higher than that of dry grass in summer and monsoon whereas the percentage of dry grass was higher in winter (table 7.11).

Long-term studies on gaur in Pench Tiger Reserve and Bhagwan Mahaveer Wildlife Sanctuary (Sankar *et al*. 2001 and Gad 2011) have reported that gaur grazes mainly in monsoon and post monsoon but switches over to browsing in summer. It has been reported by Sankar *et al*. (2001) that in Pench Tiger Reserve, during summer the herbaceous layer almost dried up which resulted in poor quality of food resources for gaur and that this was the probable reason for gaur feeding mainly on available browse species in summer. Gad (2011) has also reported that due to a decrease in the green vegetation in summer in Bhagwan Mahaveer Wildlife Sanctuary, gaur switched to browsing mainly in summer. In Bandhavgarh Tiger Reserve the continued availability of bamboo leaves and green grasses throughout the year seems to be the reason that the time spent grazing by gaur does not show any significant difference across the seasons and is high throughout the year.

The land use/land cover map of Bandhavgarh Tiger Reserve showed that of all the vegetation types, the mixed forests covered the highest area in the reserve. Bamboo (*Dendrocalamus strictus*), which formed the major food resource of gaur in the study area is widely distributed in Bandhavgarh Tiger Reserve. About 13.7% area is covered by bamboo forest in the reserve and apart from that bamboo also forms a major part of the mixed forest vegetation type in Bandhavgarh Tiger Reserve. In the present study the utilisation of bamboo as a food resource by gaur was observed to be higher than its availability in all the seasons. Grasses are the other major food resource of gaur in Bandhavgarh Tiger Reserve. The percentage area under grasslands in Bandhavgarh Tiger Reserve is quiet low (table 7.12) and hence management of grasslands, especially in summer is very important as the time spent feeding by gaur on grasses is the highest in summer and also gaur use grasses more than their availability in summer. In Bandhavgarh Tiger Reserve, most of the grasslands become dry by the end of winter and systematic burning of the grasslands is undertaken by the forest staff during this time of the year. Presently, there are 12 villages located inside the core area of Bandhavgarh Tiger Reserve. Between 2011 and 2015 three villages (Kallwah, Kumarwah and Magdhi) have been relocated from the core area of Bandhavgarh Tiger Reserve and the village relocated sites have been transformed into grasslands having mainly species like *Saccharum* and *Vetiveria*. These grasslands (on the relocated sites) have been observed to be used extensively by gaur during the study period and have become important feeding sites for gaur in the study area.

During the study period there were 13 captive elephants in Bandhavgarh Tiger Reserve. There was observed to be an overall overlap of 72% in the food plant species of captive elephants and gaur in Bandhavgarh Tiger Reserve. A certain amount of stall feeding is carried out for the captive elephants and they are also let loose in the night for feeding into the forest. Bamboo leaves and grass species like *Saccharum* and *Vetiveria* which are important gaur food plants also form a major food source of the captive elephants in Bandhavgarh. Since at present the gaur population is low in Bandhavgarh Tiger Reserve (n=80) and the availability of major food items like bamboo leaves and grasses is considerably high throughout the year it is highly unlikely that presently there is any competition for food resources between gaur and the captive elephants. However, as the gaur population increases over a time period, competition for the available food plants may arise between the two mega-herbivore species in Bandhavgarh Tiger Reserve. For a better understanding of this aspect there is a need for a long-term study of the food habits of the captive elephants and gaur in Bandhavgarh Tiger Reserve.

Chapter VIII

Health condition and Group size of Reintroduced Gaur

Chapter VIII

Health Condition and Group Size of Reintroduced Gaur

8.1 Health Condition

8.1.1 Introduction

The health condition of an animal is primarily a reflection of its fat reserves which in turn are generally assumed to determine an individual's reproductive potential (Gerhart *et al*. 1996), food availability and/or presence or absence of diseases/disorders. Body condition scoring gives a reasonable idea of the health condition of an animal (Ramesh *et al*. 2011). It provides an index of the energy stored as fat and muscle and is a quick reliable means of identifying extremes in nutritional status (Riney 1960). The average health condition among animals indicates the response of a population to the prevailing environmental conditions (Reuter and Adcock 1998). However, behaviour and sex-based differences between individuals also affect body condition. For example, nutritional demands on females increase greatly during late pregnancy and lactation, and such females are often the first to lose body condition when food limitations arise.

In animal management, many important decisions, *e.g.* the provision of supplementary feed, are based on the assessment of body condition. In the livestock industry, body condition scores have been widely applied as measures of nutrition, reproductive potential and herd health or productivity (Russell *et al*. 1969, Wildman *et al*. 1982, Otto *et al*. 1991, Ruegg 1991) and the same has been found applicable in wild ungulates (Gerhart et al. 1996, Riney 1960, Singh *et al*. 2009), wild African elephants (Pinter-Wollman *et al*. 2009) and domestic and wild Asian elephants (Wemmer *et al*. 2006, Ramesh *et al*. 2011). Evaluating body condition of wild herbivores is therefore essential to monitor the population situation in relation to the environment and to be able to detect possible imbalances in the health condition of the population before serious problems arise (Ezenwa *et al.* 2009).

8.1.2 Methodology

The health condition of the reintroduced gaur population was evaluated every month from March 2012 to March 2015. The reintroduced gaur were tracked with the help of radio telemetry and approached within the visible vicinity (<50 m) with the help of vehicle (four wheel), camp elephants or on foot. The reintroduced gaur population was classified into different age and sex classes based on the criteria following Schaller (1967) and Krishnan (1972) *viz*. adult male (>5 years), sub adult male (3-5 years), adult female (> 5 years), sub adult male (3-5 years), yearlings (> 1 years) and calf (< 1 year).

To calculate the body condition index (BCI) of a gaur individual, five different parts of its body (flank area, ribs, pelvic girdle, vertebral column and lumbar shelf) were assigned score values between 0-2 with numerically higher values corresponding to poor body condition (0-good, 1-fair and 2-poor) (Riney 1960) (plate 8.1 and table 8.1.1). Finally these score values were added up for each gaur individual to calculate the BCI of that particular individual. The total score was on a scale of 0-10. Gaur individuals having a total score (BCI) ranging from 0-2 were considered in good body condition; 3-5 were considered to be in fair body condition and those having a score of 6 and above were considered in poor body condition (plate 8.2).

Plate 8.1 The body regions and specific anatomical features to be observed when assessing a gaur body condition

A) Good

B) Medium

C) Poor

Plate 8.2: Body Condition

Table 8.1.1 Health assessment of gaur population through body condition index in BTR

Generalized description and evaluation of different parts of ungulates (Riney 1960).

BODY PART	POINT=0	POINT-1	POINT-2
FLANK AREA	Depression barely visible. Flank area outline is indistinct	Flank area slightly concave & outline visible	Depression concave and tucked in
RIBS	Thoracic surface is smooth and ribs are difficult to see	Ribs are visible but not all can be counted with ease	Ribs prominent with distince inter-costal depression
PELVIC GIRDLE	Bony projections of pelvic girdle are barely visible	Pelvic girdle outline slightly visible	Bony projections of pelvic girdle are clearly visible
VERTEBRAL COLUMN	When seen laterally, it runs smooth without any breaks. Lumbar process visible	Lateral processes of lumbar vertebrae are visible but not prominent	Lateral processes of lumbars very prominent. Dorsal processes of vertebrae seen
LUMBAR SHELF	No depression in shelf. Appears almost round from behind	Slight depression on either side	Depression deep and concave
Body Condition Index: Interpretation: 0-2= 'Good'; 3-5 = 'Fair'; 6 & above = 'Poor'			

8.1.3 Results

Of the 50 gaur reintroduced, a total of 1933 body scores were examined for BCI for both sex and all the age classes during the study period. In total 80.6 % of the gaur individuals were found to be in good body condition followed by 16.1 % fair and 3.3 % in poor body condition (figure 8.1.1). Sex wise, about 86% of the gaur males were observed in good body condition as compared to female gaur (70.3%). Among the different demographic classes it was observed that calves were always found in good body condition (100%). About 86.5% of the yearlings were observed in good body condition followed by sub adult males (85%), adult males (80%), sub adult females (75%) and adult females (52%). During the entire study period, about 10% of the adult and sub adult females were observed in poor body condition. Among sub adult males and adult males, about 2.8% and 1.0% of the individuals were observed in poor body condition respectively (figure 8.1.1).

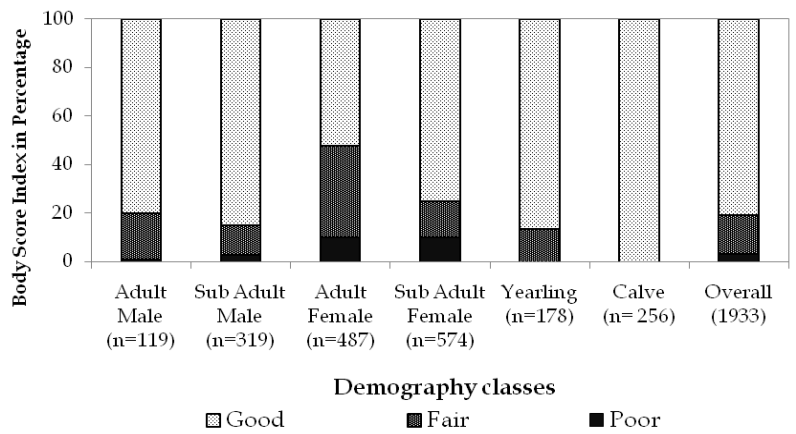


Figure 8.1.1: BCI within each demographic classes of reintroduced gaur

Season wise

Season wise among the overall gaur population, about 73.4% of the population was observed in good body condition in summer. In monsoon and winter about 86.6% and 92.2% of the gaur population was observed in good body condition. Among the different demographic classes of gaur, 16.6% adult females and 1.3% sub adult females were observed to be in poor body

condition in summer. About 11.6% of adult males and 1.7% of sub adult males were observed in poor body condition in summer. Among adult cow, 3.2% and 2.9% of the individuals were observed in poor body condition in monsoon and winter respectively. No adult and sub adult males were found in poor body condition in monsoon and winter (figure 8.1.2).

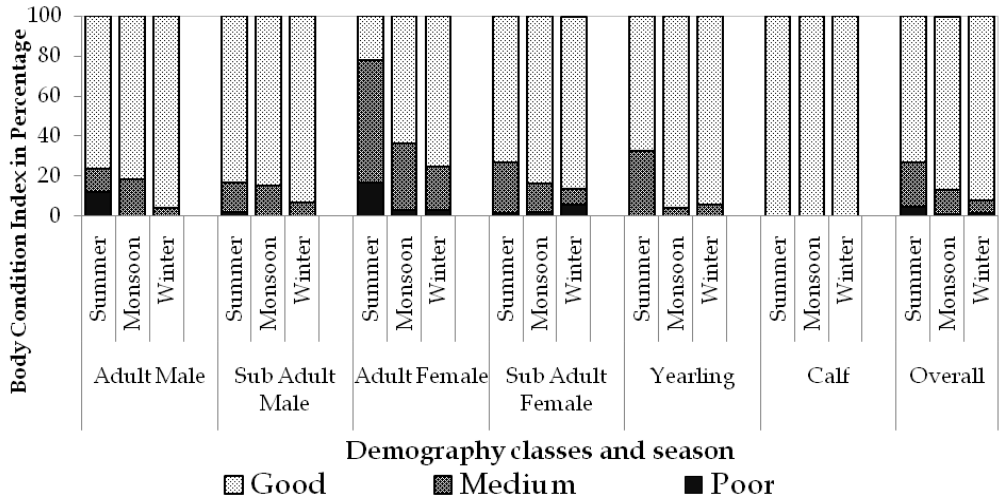


Figure 8.1.2 Mean BCI (good/fair/poor) score of different demographic classes of reintroduced gaur across different seasons

8.1.4 Discussion

In the present study the health condition of the reintroduced gaur population was assessed using simple body scoring method. This is the first study on the health condition of a free ranging (and also re-introduced) gaur population in its entire distributional range. During the entire study period a majority of the gaur population was found to be in good body condition (80%) followed by 16.1% in fair body condition and only about 3.3% in the poor body condition. Thus it can be concluded that overall, the health condition of the re-introduced gaur population in Bandhavgarh was good. It was observed that among the overall gaur population about 4.9% of the population showed poor body condition in summer followed by 1.2% in winter and 0.7% in monsoon. These variations might be related to the fluctuations in the nutritional contents of the major food items (bamboo leaves and grasses) of gaur in the study area. The nutritional contents (especially crude protein) of the major food items of gaur were lower in summer as compared to monsoon and winter (chapter 7) which might be the reason for a higher percentage of gaur individuals in poor condition in summer. Scarcity of nutritious forage makes the animals more stressful which may lead to poor body condition (Ramesh *et al.* 2011).

Among the different age and sex classes, it was observed that a higher percentage of adult cows were found in fair and poor body condition compared to other age and sex classes (especially in summer). It was observed in Bandhavgarh that late winter and early summer (February-March) was the peak calving season of gaur and hence by the time peak summer set in (April-May) a considerable proportion of the gaur population had lactating females and nutritional stress might have resulted in more adult females exhibiting poor body condition. Also a difference in patterns of fat deposition may exist between sexes and age groups of a species (Huot and Goudreault 1985) which might be the reason for a higher proportion of males in good body condition as compared to females. Thus in the present study it was observed that the body condition index was a good indicator of the health of the gaur population and this method can be very useful for the long-term health monitoring of this re-introduced population.

8.2 Group Size

8.2.1 Introduction

Understanding demographic aspects of wild animals facilitates population monitoring and effective conservation planning (Caughley 1977; Khan *et al.* 1995). Most of the mammalian species often live in groups, the size of which constitutes the simplest and most basic elements of their social organization (Eisenberg 1966; Crook *et al.* 1976). Group size varies widely within and between species (Altman 1974; Geist 1974; Jarman 1974; Clutton-Brock and Harvey 1977; Rodman 1981). Mega herbivores group sizes tend to be larger in open habitats than in habitats with relatively dense vegetation which serves as cover (Lagory 1986), reflecting varied anti-predator strategies in different habitat types (Hamilton 1971; Estes 1974; Hirth 1977). This variation needs to be explained if it is to be considered as a part of the species adaptation to its environment (Southwell 1984). Minimizing predation risk is arguably the most general and important benefit in group formation and cooperative defense (Pulliam and Caraco 1984; Krause and Ruxton 2002), especially in large herbivores such as bovids and cervids (Jarman 1974; Kaufmann 1974; Hirth 1977; Brashares and Arcese 2002). The distribution of group sizes in a population can be viewed as the outcome of decisions made by multiple individuals evaluating the benefits and costs of being in groups of different sizes (Alexander 1974; Pulliam and Caraco 1984).

Group size is generally considered as a fundamental attribute of the social organization of many ungulates (Jarman 1974; Clutton-Brock and Harvey 1978; Shankar Raman 1997). Animals in groups may have to forage over larger areas and spend more time in search of food than solitary animals (Wrangham *et al.* 1993). Jarman (1974) reported that food quality, abundance, and dispersion varies with cover density and may at least partially influence the group size of herbivores. Understanding the population trend in wild ungulates and their group compositions becomes crucial in changing habitat structure (Lott 1991; Brashares and Arcese 2002; Alexander 1974; Pulliam and Caraco 1984). Studying the group size in mega herbivores leads to an understanding of the shape and magnitude of the relationship among group sizes of the species (Wrangham *et al.* 1993).

Very few studies have reported the trend in gaur population based on long-term and systematic monitoring in its entire distribution range. Most of the available information on the group size and composition of gaur are limited to Protected Areas (PAs) (Ashokkumar 2004). Except a few long term ecological studies on gaur population in Parambikulam, Pench and Mudumalai (Vairavel 1998, Sankar *et al.* 2001, Ashokkumar *et al.* 2010b), no detailed study on gaur group size and population structure of this species has been reported in India. However, several short observations on group size and sex ratios of gaur were available from PAs such as Kanha Tiger Reserve (Schaller 1967, Belsare *et al.* 1984), Palamu Reserve Forest (Sahai 1977), Garuimara Wildlife Sanctuary (Guin and Pal 1980), Periyar Tiger Reserve (Nair *et al.* 1985), Berijam Reserve (Moorthy 1989), Indira Gandhi National Park (Prabakar 1992), Shevaroy Hills (Kannan 2001), Mudumalai Tiger Reserve (Ashokkumar *et al.* 2010b, Ramesh *et al.* 2012), Parsa Wildlife Reserve (Chetri 2006), and in Trishna Wildlife Sanctuary (Dasguptha *et al.* 2008). Lad and Gopal (1992) reported the status of gaur in Bandhavgarh Tiger Reserve before the local extermination.

8.2.2 Methodology

Information on group size and age-sex composition of gaur was collected based on direct observation between March 2011 and March 2015 covering all seasons' *viz.* summer monsoon and winter in the study area. In total, 50 gaur were re-introduced in Bandhavgarh Tiger Reserve (three adult males, 11 sub-adult males, 13 adult females, 21 sub-adult females, and two yearlings) from Kanha Tiger Reserve (table 8.2.1). The reintroduced gaur were classified based on the criteria following Schaller (1967) and Krishnan (1972) (table 8.2.2).

Table 8.2.1: Details of age and sex classes of gaur selected for translocation from Kanha Tiger Reserve, Madhya Pradesh

Gaur age and sex class	Number of individuals
Adult Male (AM)	3
Sub-adult Male (SAM)	11
Adult Female (AF)	13
Sub-adult Female (SAF)	21
Yearling (YE) or Juveniles (JU)	2
Calf (CA)	0
Total	50

No gaur calf was selected for translocation from Kanha to Bandhavgarh. Each gaur group after re-introduction was distinguished based on the radio-collar individuals. All the identified gaur groups were considered for group composition analyses, where mean group size (MGS) and typical group size (TGS) was computed across seasons in different years following Jarman (1974) and Barrette (1991). TGS is an animal centred measure of group size, reflecting the experience of an average individual in a group and the MGS are the observer-centred estimates of group size. The solitary gaur was not considered for calculating mean group size. The number of calves present in the group and their percentage contribution to the population in different months were considered for calving season. The adult female: adult male ratio and calf: adult female ratio was calculated following Schaller (1967).

Table 8.2.2 Classification and description of age class of gaur

S. No	Age class	Description
1	Adult Male (AM)	Sooty black in colour, enlarged dewlap, well diverged and fully converged tip of horn, prominent dorsal ridge and rotary movement of hump while walking (> 5 years)
2	Sub Adult Male (SAM)	Black or brownish black in colour, prominent dewlap, the diverged horn about to converge.
3	Adult Female (AF)	Dark brown and closer to black in colour, non-prominent dewlap, less diverged but not converged horn, less prominent dorsal ridge.
4	Sub Adult Female (SAF)	Brownish black in colour (blacker in thoracic portion and more brownish colour in the rump portion), dewlap absent and less diverged but not converged horn.
5	Yearling (YR)	Brownish in colour with dagger like spike horn (approximately 20 to 25 cm in length in both sexes).
6	Calf (CA)	Golden brownish in colour and can pass through between the legs of its mother (less than three months old and approximately 1 m in height) in both sexes. Lack of conspicuous white stockings.

8.2.3 Results

Group size

During the study period, the observed gaur group size of gaur varied from 1 to 31 individuals. The observed overall gaur mean group size (MGS) was 13.6 ± 1.9 (SE). The overall gaur MGS in summer was 12.4 ± 1.6 (SE), in monsoon it was 14.0 ± 1.9 and in winter it was 14.8 ± 2.1. The observed overall gaur typical group size (TGS) was 17.1, gaur TGS in summer was 15.8, in monsoon it was 17.8 and in winter it was 19.2. More solitary individuals were observed in males (16 %) than females (6%).

Overall gaur composition and sex ratio

The present gaur population (n= 79) comprises mostly of adult females (n= 22) followed by calf (n= 15), sub-adult females (n= 14), yearling (n=13), sub-adult males (n= 10) and adult males (n= 5) (table 8.2.3). The estimated overall gaur sex ratio (adult male: adult female) was 1: 2.7, and adult female: calf ratio was 1: 0.5.

Table 8.2.3 Age and sex classes of reintroduced gaur from Kanha Tiger Reserve (2011-12) and the change in composition of age and sex classes at the end of study period in Bandhavgarh Tiger Reserve (March 2015)

Age and sex class	Number of reintroduced gaur from Kanha (2011-2012)	Present gaur individuals under different age and sex classes in BTR (March 2015)
Adult Male (AM)	3	5
Sub-adult Male (SAM)	11	10
Adult Female (AF)	13	22
Sub-adult Female (SAF)	21	14
Juveniles (JU)	2	13
Calf (CA)	--	15
Total	50	79

Mortality and natality in the reintroduced gaur population

In total 19 mortalities were recorded during the study period (March 2011 – March 2015), of which 14 (three adults, nine sub adults, one yearling and six calf) gaur were predated by tiger and three (two radio collared and one un-collared) gaur died naturally. Two un-collared sub adult gaur females went missing (one in 27th March 2011 and one in 22nd April 2012) and were never reported again.

A total of 47 calves were born in Bandhavgarh during the study period. The maximum gaur calves were observed in winter (n=21) followed by summer (n= 15) and monsoon (n=11). The relationship between mean monthly temperature and number of gaur calves born showed an increase in number of gaur calves during low temperature. The number of gaur calf births month wise along with the mean rainfall (2011-2015) indicated an increase in number of gaur calves after the onset of monsoon.

8.2.4 Discussion

Gaur is a social animal with a fluid group structure (Brander 1923, Schaller 1967). The reported group size of gaur in the present study was lower than as reported in Mudumalai, Nagarhole, Bandipur, Kanha and Jaldapara (Ramesh *et al.* 2012, Karanth and Sunquist 1992, Johnsingh 1983, Schaller 1967, Bhattacharya *et al.* 1997) and higher than as reported in Trishna, Parambikulam and Pench ((Dasgupta *et al.* 2008, Vairavel 1998, Sankar *et al.* 2001) (table 8.2.4).

Group size is an optical response to the environment where the ecological factors may influence the species (Jarman 1974, Raman 1997). In the present study, the observed smaller group size in summer may be attributed to availability of food resources in patches and due to which the gaur were forced to form smaller groups. Similar observations have been reported in Mudumalai, Pench, Parambikulam and Trishna (Ramesh *et al.* 2012, Sankar *et al.* 2001, Vairavel 1998, Dasgupta *et al.* 2008) (table 8.2.4). By living in small herds, grazing ungulates may get access to extra resources that cannot sustain larger herds (Lagory 1985, Raman

1997, Marino and Baldi 2014). The observed MGS of gaur was similar in monsoon and winter which may be attributed to better quality of food resources available during these seasons in the study area. Similar observations have been reported in Mudumalai, Pench and Parambilulam (Ashokkumar *et al.* 2010b, Sankar *et al.* 2001, Vairavel 1998) (table 8.2.4).

Among the different age and sex classes of gaur, adult cow forms the highest proportion (27.8%) of the reintroduced gaur population as compared to the other age and sex classes in Bandhavgarh Tiger Reserve. No bachelor group was observed in the present gaur population in the study area which was similar to the observations on gaur in Parambikulam Tiger Reserve, Kerala (Vairavel 1998) and also in European bison, Borecka forest (Krasinska and Krasinski 1995). More solitary individuals were observed in males (n=456) than females (n=79) during the present study. In large herbivores males have the tendency to range over large areas and switch from one herd to another herd as part of their mating strategy (McHugh 1972, Clutton-Brock 1982). Similar findings on gaur were reported in India (Schaller 1967, Vairavel 1998), Malaysia (Corny 1979) and also in American and European bisons (McHugh 1972, Green and Rothstein 1991). During the study period of four years (2011-2015) in Bandhavgarh Tiger Reserve, the overall growth rate for this reintroduced gaur population was 58 % and the mortality rate was 24 %.

Table 8.2.4 Gaur mean group size (MGS ± SE) and their group size reported from different Protected Areas in India

Protected Areas	Overall MGS ± SE	Summer MGS ± SE	Monsoon MGS ± SE	Winter MGS ± SE	Group size (range)	Authors
Bandhavgarh	13.6 ± 1.9	12.4 ± 1.6	14.0 ± 1.9	14.9 ± 1.9	1-31	Present study
Mudumalai	7.5 ± 0.4	6.9 ± 0.7	8.4 ± 0.7	7.2 ± 0.7	1-42	Ramesh *et al.* 2012
Mudumalai	9.8 ± 7.6	8.7 ± 6.2	10.1 ± 8.1	10.2 ± 7.9	1-26	Ashokkumar *et al.* 2010
Trishna	5.9 ± 2.9	3.1 ± 0.5	--	4.6 ± 0.2	2-14	Dasgupta *et al.* 2008
Mudumalai	8.1 ± 0.6	--	--	--	1-47	Kumar *et al.* 2004
Bhadra	2.3 ± --	--	--	--	--	Jathanna *et al.* 2003
Pench	4.2 ± 0.1	3.9 ± 0.1	4.62 ± 0.2	5.66 ± 0.4	1-19	Sankar *et al.* 2001
Jaldapara	--	--	--	--	1-70	Bhattacharya *et al.* 1997
Parambikulam	6 ± --	5.4 ± --	5.9 ± --	6.9 ± --	1-19	Vairavel 1998
Nagarahole	6.9 ± --	--	--	--	1-47	Karanth and Sunquist 1992
Bandipur	--	--	--	--	1-60	Johnsingh 1983
Palamu	5 to 7	--	--	--	2-27	Sahai 1977
Kanha	8.8 ± 0.7	--	--	--	1-40	Schaller 1967

MGS - Mean Group Size; **SE** - Standard Error; -- Information not available.

Chapter IX

Conservation of Reintroduced Gaur

Chapter IX

Conservation of Reintroduced Gaur in Bandhavgarh Tiger Reserve

The known extinction of gaur from three protected areas in India (Thattakad Wildlife Sanctuary, Kerala; Bandhavgarh Tiger Reserve and Kanger Valley National Park, Madhya Pradesh) in the last two decades is a testimony to the fact this species is losing ground very fast and urgent measures are required to stem the decline in its population. Reintroduction and translocation of wild animal species are active management measures which help the conservation of any wildlife species in a great way. Hence, the gaur reintroduction programme in Bandhavgarh Tiger Reserve was an important conservation initiative for this vulnerable species. Thereby, the present study justifies an important rather successful ecological step towards the conservation of this large bovid.

The present study has drawn the first time information on ranging patterns, habitat use, food habits and health condition of a reintroduced gaur population in its entire distributional range. This study will be very useful for the park administration for effective conservation of this endangered species including habitat intervention, if needed. During the study period three villages (Kumarawah, Kallwah and Magdhi) were relocated outside the core area of the reserve. Gaur have been observed to use these relocated village sites intensively as these sites have transformed into grasslands thus providing abundant forage to the gaur population. Hence creation of such additional habitat space is vital for gaur conservation, by relocating the remaining 12 villages from the Tiger Reserve. In October 2014 a few gaur individuals (n=15) were affected by the Foot and Mouth disease (FMD). Regular monitoring of gaur during the present study led to an early detection of this disease and subsequently a vaccination programme for the gaur herds in which the affected individuals were seen was carried out immediately which there by did not allow the disease to spread to other gaur individuals. Since gaur are highly susceptible to cattle diseases like FMD, Rinderpest and Anthrax, there is a need to a implement a periodic vaccination programme for the domestic livestock present in and around the reserve (core and buffer) so as to prevent the transmission of any disease to the gaur population. Also it is imperative to monitor the health condition of this reintroduced gaur population on a regular basis which will help in management interventions (if needed).

Cutting and lopping of food plants species and collection of *Madhuca indica* flower and *Phyllanthus emblica* fruit, inside the buffer area should be restricted through efficient patrolling. Removal of weeds (*Lantana camara, Cassia tora, parthenium hysterophorus* and *Xanthium strumarium*) from the gaur home range areas to improve the forage quality is recommended. Since this is the first time a reintroduction programme for gaur has been undertaken in its entire distribution range it is necessary to study the different aspects of ecology of this population for a longer period of time. As the gaur population increases over the time the gaur individuals are expected to occupy new areas in the reserve (especially the Panpatha Wildlife Sanctuary). Also the relocation of villages is an ongoing process in the reserve and as more villages are relocated it will be important to monitor the food habits of gaur in Bandhavgarh. A rise in the gaur population will lead to some level of competition with other wild ungulates and the domestic (camp) elephants of the park for the available food resources (especially in the dry season).Continues scientific monitoring is recommended for the reintroduced gaur population in Bandhavgarh Tiger Reserve for future periods.

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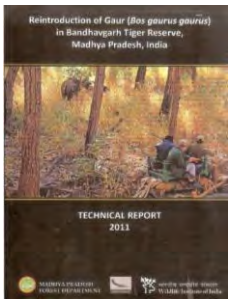
Project Outputs



1. Pabla, H.S., Carlisle, L., Cooper, D., Cooke, J., m, P., Sankar, K., Srivastav, A., Negi, H.S., Patil, C.K., Aggarwal, S., Mishra, A., Gutpa, S., Srivastav, A.B., Chauhan, K.S. and Sarath, C. 2011. Reintroduction of Gaur (*Bos gaurus gaurus*) in Bandhavgarh Tiger Reserve, Madhya Pradesh, India. Technical report. Pp-73.

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3. Parag Nigam, Sankar Kalyansundaram,Dave Cooper, Les Carlisle and Harbhajan Singh Pabla. 2014. Capture and translocation of gaur (*Bos gaurus gaurus*) in India Ecology, Evolution and Behaviour of Wild Cattle: Implications for Conservation, eds. M. Melletti and J. Burton. Published by Cambridge University Press. 393-402.

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भारतीय वन्यजीव संस्थान
Wildlife Institute of India

Madhya Pradesh Forest Department : MP Forest Department looks after the largest forest area and one of the largest protected area networks in the country. Kanha, Bandhavgarh, Pench, Panna and Satpura are their world famous tiger reserves. Madhya Pradesh has an ambitious programme to reverse all the recent local extinctions of its endangered wild animals through translocation. The gaur translocation, along with the reestablishment of tiger in Panna Tiger Reserve, is the first step in this endeavour.'

&Beyond: &Beyond (www.andbeyondafrica.com) is one of the globally recognised world's pioneering responsible luxury adventure tourism company. The company was established in 1990 and went by the name of Conservation Corporation Africa (CC Africa). The company owns and operates extraordinary lodges and camps in breathtaking parts of the world's wilderness areas in six African countries and India. &Beyond is deeply committed to responsible tourism. The company pioneered many different game (Cheetah, lion, elephant and buffalo) reintroduction techniques in Africa. Phinda Private Game Reserve was the testing ground for many of the concepts, ideas and future working models of the company and remains its flagship property to this day.

Wildlife Institute of India: The Wildlife Institute of India (http://www.wii.gov.in) was established in 1982 within the Government of India, Ministry of Environment and Forests in response to the country's need for a scientific foundation to its wildlife conservation efforts. The Institute offers training courses in wildlife management for foresters and conducts research project to help formulate priorities and guidelines for wildlife conservation. This is done from its campus in Chandrabani near Dehradun, Uttaranchal and at field sites throughout the country.

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Reintroduction of Gaur (*Bos gaurus gaurus*) in Bandhavgarh Tiger Reserve, Madhya Pradesh, India

TECHNICAL REPORT
2011

MADHYA PRADESH
FOREST DEPARTMENT

&BEYOND

भारतीय वन्यजीव संस्थान
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FOREWORD

For several years, I had been questioning the contribution of protected areas (PAs) to the preservation of our wild animals, in view of the fact that we had lost several species even from PAs. Although PAs are far richer in animal densities, compared with the surrounding forests, their richness is, primarily, inherited: we have tried to convert only richer ecosystems into PAs, in the hope that this will be helpful in preserving their richness. This has been helpful, no doubt, but losing species after species from the PAs themselves shows that something was missing from our managerial repertoire. Madhya Pradesh (MP) lost the gaur from Bandhavgarh, blackbuck from Kanha, great Indian bustard from Karera and tiger from Panna. The tiger had been lost from Madhav National Park also, in the 1960s. Nobody noticed or cried over these losses although all hell broke loose over the extinction of the tiger in Panna, following close on the heels of Sariska. As soon as Sariska happened, the country vowed to bring the tiger back. Plans for preventing the impending extinction of the tiger from Panna were already afoot even before the tragedy struck, although our bureaucratic systems did not allow a timely redress. However, nobody ever thought of bringing the gaur, bustard and blackbuck back to their earlier ranges. I was convinced that the management of PAs should not be limited to simple chaukidari (watchmanship); we should prevent local extinctions by more proactive means, such as supplementing dwindling populations; and we should re-introduce, if local extinctions do take place. I came to realize that extinctions of small populations will continue to happen, despite the best possible antipoaching actions, due to biological reasons such as predation, diseases, accidents and abnormal sex ratios, and that it is imperative for conservation that we continue to repopulate depleted habitats through translocation from other sources. Despite this conviction, I could not do anything because the country did not have any experience or expertise in the capture and translocation of herbivores at any significant scale. This shortcoming had been noticed long ago, when the Wildlife Institute of India (WII) tried unsuccessfully to develop this capability through its Indo-US collaboration, in the 1990s. Since then the country had almost stopped thinking about the re-introduction of endangered species in protected habitats, primarily because we did not have the ability to do so, until two things happened at the same time fortuitously.

In June 2005, I got posted as the Additional Principal Chief Conservator of Forests (Wildlife), and at about the same time, Conservation Corporation of Africa (now curiously renamed as '&Beyond'), a South African safari and game-management company, decided to expand their business to India, starting with wildlife lodges in MP. I met Sarath Champathi, chief naturalist of the Jungle Lodges and Resorts, Karnataka, during a visit to one of their lodges in September 2005. Sarath had already been recruited by &Beyond as their chief naturalist in India and was due to join them shortly. When he established contact with me , on joining his new job, I discovered that &Beyond did not only run wildlife lodges but also owned game reserves and had an impressive experience in wildlife management, especially the capture and translocation of large animals. &Beyond were planning to set up their first lodge in Bandhavgarh, in a joint venture with Taj Hotels, under the brand name Taj Safaris Ltd. (TSL), and I asked Sarath if his new company would help us re-introduce the gaur in Bandhavgarh. He jumped at the idea and agreed to revert to me shortly. He soon confirmed that &Beyond would be delighted to help us in our project. They offered to train our officers and veterinarians in South Africa and to provide the services of experienced capture and translocation experts, in addition to facilitating the donation of the customised vehicles and equipment through TLS. The Government of Madhya Pradesh and the Government of India (GoI) gladly approved the project. This was going to be the first significant conservation project to be implemented without financial help from the Government of India.

Other than retrieving the lost biodiversity of Bandhavgarh, the project was aimed at building the capacity of the MP Forest Department, and WII, in the field of capture and translocation large animals. It was also meant to show what public-private partnerships could accomplish. Mridula Tangirala, Director Operations at TSL, and Les Carlisle, Group Conservation Manager at &Beyond, worked tirelessly to obtain the approvals of their companies expeditiously. Les made several trips to India just to ensure that the construction of bomas and modification of trucks was exactly as required. When it seemed that the project was smoothly on its way, ominous noises started being made in the press. Reports of some gaur having been seen some 25 km from the park boundary appeared in the press in September 2008. This was used by certain quarters to brand the project as an unnecessary extravagance of the department. It was suggested that rather than translocate gaur from Kanha to Bandhavgarh, we should try to lure these animals to Bandhavgarh. The GoI, perhaps under pressure from the critics, developed cold feet on the project and cancelled the permission in February 2010, a few days before project implementation was scheduled to begin, citing non-compliance with certain conditions. However, the state government continued to persuade the GoI and, finally, a fresh permission was issued by GoI in October 2010. Everything should have been set to rest, but a fresh spate of reports, accusing the state officials of having a vested interest in the project, appeared in the press. These baseless reports were clearly aimed at subverting the project, although the motivation to harm such a win-win project still remains unravelled. It was only because the state strongly believed in the value of the project, in ushering in a new era of active conservation of wildlife, that the project could see the light of the day. However, the project could not have had a happy ending without the support of the Hon'ble Minister for Environment and Forests, Mr. Jairam Ramesh. Only his personal intervention could get the project back on track.

Encouraged by the success of this project, the state has already proposed the translocation of several other species to reverse local extinctions in Madhya Pradesh. The barasingha is set to return to Bori Sanctuary, and the blackbuck is going to return to Kanha. After the successful re-introduction of the tiger in Panna, we can even dream of creating whole new wildlife assemblages, from scratch, if secure space is available, through translocation of prey and predators from other sources, rather than waiting for ages to let it happen on its own. Let us hope that this project will prove to be a harbinger of change in our approach to conservation, which it was always meant to be. Perhaps we will no longer just wring our hands when the extinction of a particular species looms in front of us. We can now prevent or reverse such extinctions, thanks to the Gaur Project. Let us hope, however, that the next project will not take six years from conception to implementation! Adaptive and proactive management must become the hallmark of modern day PA management in India.

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DEFINING RE-INTRODUCTION

The IUCN/SSC's guidelines for re-Introductions were drafted by the Re-introduction Specialist Group of the IUCN's Species Survival Commission in response to the increasing occurrence of re-introduction projects worldwide and, consequently, to the growing need for specific policy guidelines to help ensure that re-introductions achieve their objective of conservation and do not have any adverse side-effects (IUCN, 1998). These guidelines define a 're-introduction' as 'an attempt to establish a species in an area which was once part of its historical range, but from which it has been extirpated or become extinct'.

AIMS AND OBJECTIVES OF RE-INTRODUCTION

The principle aim of any re-introduction is to establish a viable, free-ranging population in the wild of a species, subspecies or race which has become globally or locally extinct, or extirpated, in the wild. It should be re-introduced within the species' former natural habitat and range and should require minimal long-term management. The objectives of any re-introduction programme include the following:

1. Enhancing the long-term survival of a species;
2. Re-establishing a keystone species (in the ecological or cultural sense) in an ecosystem;
3. Maintaining and/or restoring natural biodiversity;
4. Providing long-term economic benefits to the local and/or national economy;
5. Promoting conservation awareness; or
6. A combination of these.

PROJECT ACTIVITIES

a. Pre-project activities

The pre-project activities for re-introduction consists of the following:

(i) a feasibility study and background research;

(ii) identification of suitable release stock;

(iii) an evaluation of the re-introduction site;

(iv) identification and elimination, or reduction to a sufficient level, of previous causes of decline; and

(v) assessing the socio-economic and legal requirements.

The planning, preparation and release stages, which have been documented well in the IUCN/SSC document, are summarized below:

- Approval of relevant government agencies and coordination with national and international conservation organizations.
- Construction of a multi-disciplinary team with access to expert technical advice for all phases of the programme.
- Identification of short- and long-term success indicators and prediction of programme duration, in the context of the aims and objectives agreed upon.
- Securing adequate funding for all programme phases.

- Design of pre- and post-release monitoring programme so that each re-introduction is a carefully designed experiment, with the capability to test the methods with scientifically collected data. Monitoring the health of individuals, as well as their survival, is important; intervention may be necessary if the situation proves unforeseeably unfavourable.
- Appropriate health and genetic screening of release stock. Health screening of closely related species in the re-introduction area.
- If release stock is wild-caught, care must be taken to ensure that (a) the stock is free from infectious or contagious pathogens and parasites before shipment and (b) the stock will not be exposed to vectors of disease agents which may be present at the release site (and absent at the source site) and to which it may have no acquired immunity.
- Development of transport plans for delivery of stock to the site of reintroduction, with special emphasis on ways to minimize stress on the individuals during transport.
- Determination of release strategy (acclimatization of release stock to release area; group composition, number, release patterns and techniques; timing).
- Development of conservation education for long-term support; professional training of individuals involved in the long-term programme; public relations activities using the mass media and in the local community; and involvement where possible of local people in the programme.
- The welfare of the animals to be released is of paramount concern through all these stages.

b. Post-release activities

- Post-release monitoring is required for all (or a sample of) the individuals. This most vital aspect may be by direct (e.g. through tagging, telemetry) or indirect (e.g. spoor, informants) methods, as suitable.
- Demographic, ecological and behavioural studies of released stock must be undertaken.
- Studying the processes of long-term adaptation by individuals and the population.
- Collection and investigation of mortalities.
- Interventions (e.g. supplemental feeding; veterinary aid) when necessary.
- Decisions for revision, re-scheduling or discontinuation of programme where necessary.
- Habitat protection or restoration to continue where necessary.
- Continuing public relations activities, including education and mass media coverage.
- Evaluation of cost-effectiveness and success of re-introduction techniques.
- Regular publication in the scientific and popular literature.

GAUR RE-INTRODUCTION PROGRAMME

SPECIES INFORMATION

The gaur *(Bos gaurus gaurus),* commonly referred as the Indian bison, is the largest living bovine, confined to the Oriental bio-geographic region. The gaur belongs to the group of wild oxen, which includes the Asiatic buffalo, African buffalo, true cattle and bison, and has been classified as follows:

Classification:

Kingdom	:	Animalia
Phylum	:	Chordata
Class	:	Mammalia
Order	:	Cetartiodactyla
Family	:	Bovidae
Scientific name	:	*Bos gaurus*
Species authority	:	C.H. Smith, 1827
Common names	:	Gaur, Indian bison

BIOLOGY AND BEHAVIOUR

Gaur bulls are larger than the cows and weigh between 600 and 1000 kg; they measure 1.6 to 1.9 m at the shoulder, whereas the cows are shorter and weigh much less (Morris, 1947). Both sexes are horned, the horns being larger with more swath in the males (Sanderson, 1968). Adult males have two prominent dewlaps, a small one at the chin and a large one hanging below the throat. There is a shoulder hump which is more pronounced in the males. Newly born calves are light golden yellow in colour. The colour darkens with age, and adult females are dark brown whereas adult males are black. Both hind legs and forelegs are white to tan below the knees. Gaurs reach sexual maturity at 3 years of age and usually produce one and rarely two calves after a gestation period of 275 days. Weaning takes place at 7-9 months. Breeding takes place throughout the year. The gaur is known to have a maximum longevity of 30 years (Gad and Shyama, 2009; Srivastav and Nigam, 2010).

Gaurs are social animals, living in herds ranging in size from 2 to 20 individuals (Mustill, 1939; Belsare et al., 1984). Herds typically comprise a few cows, calves and one or two adult bulls and sub-adults. Solitary bulls occasionally associate to form bachelor herds which break up with the onset of the rut. The group leadership is dependent upon the size and age, and family groups are led by the eldest female, whereas bachelor groups are led by the largest male. Solitary males and all-male herds move to herds with females with the onset of the rutting season. Size rather than actual fighting is used by adult males to assert dominance. The dominant males isolate cows in oestrus by tending to them and use a range of behavioural patterns typical of ungulate reproductive behaviour, such as flehmen, rutting, tending and mounting, to successfully mate with the cows. A variety of vocalizations are used for communication.

Gaur are diurnal in their activity; however, human disturbance forces them to more nocturnal activity. They feed during the early morning and late evening or even throughout the night. They

have typical local and seasonal movements which are influenced by the availability of resources. They are obligatory drinkers and require to drink at least once every day. The frequency may increase during the peak of summer. Gaur are both grazers and browsers that feed on a variety of plant species. Gaur are known to de-bark trees and to frequent salt licks (Choudhury, 2002b).

CONSERVATION STATUS

The global population of the gaur is estimated at 13,000-30,000 animals; of these, only 5200-18,000 are reproductively active individuals (Duckworth et al., 2008). The population has declined overall by at least 30% during the last three generations. As a consequence, the gaur is categorized as Vulnerable (criteria A2cd+3cd+4cd ver. 3.1) in the IUCN Red List of Threatened Species, 2009. It is listed in Schedule I of the Indian Wildlife (Protection) Act of 1972 and is included in Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).

THREATS

Gaurs face different threats in each of the landscapes that they occupy. Poaching is an omnipresent threat, be it for consumption, crop protection, medicinal use or trophy hunting. Habitat loss and fragmentation are threats which are ubiquitous. In North-east India the species is threatened with habitat degradation brought about by shifting cultivation (Choudhury,2000a; Imam,1985). In the rest of the gaur's range, conversion of forest areas to agricultural use or commercial plantations is another serious threat. The species is closely related to domestic livestock and is vulnerable to all the diseases that infect cattle. Rinderpest has been a serious threat to wild populations in the past; foot and mouth disease (FMD), anthrax and haemorrhagic fever have also been responsible for mortality. Gaur populations are also vulnerable to predation, especially at the calf and sub-adult stages.

GLOBAL DISTRIBUTION:

Historically, the distribution of the gaur covered the entire mainland of South and South-east Asia and Sri Lanka (Duckworth et al., 2008). The current distribution is restricted to scattered pockets in India, Nepal, Bhutan, Cambodia, China, the Lao PDR, peninsular Malaysia, Myanmar, Thailand and Vietnam. The actual distribution of the gaur is highly fragmented, and the species exists in small pockets within the areas of presence shown **(Figure 1).** Within the areas of actual occurrence, gaur densities are highly variable, with only a few places harbouring high-density populations.

Figure 1: Distribution range of Bos gaurus

DISTRIBUTION IN INDIA:

Gaur inhabit a wide variety of habitats ranging from tropical wet, semi-wet evergreen and bamboo forests, tropical moist deciduous, tropical dry deciduous forests in central India and shola forests and tropical thorn forests on the eastern slopes in the Western Ghats (Hussain,1969, Johnsingh,1979, Khader,1969). In these habitats the species exists up to an altitude of 2500 m. The species, which is generally associated with idyllic, dense bamboo-rich forests, mixed with open glades and plenty of water, was once widespread throughout India, except the drier northern and north-western parts. With the decline in the health of our forest wealth, this species has also suffered grave losses in its numbers and range. According to Schaller (1967), gaurs were distributed in three widely separated geographical areas that corresponded to the major mountain systems in India: the Western Ghats, the central Indian highlands and the foothills of the Himalayas, including the hills south of the Brahmaputra River. A study carried out by the Wildlife Institute of India (WII) (Sankar et al. 2001) suggests that the gaur population in India is approximately 23,500. The gaur occurs in 101 existing and 27 proposed protected areas (PAs), in 15 states. The gaur range represents approximately 7.12% of the geographical area and 30% of the forested area of India. Of the gaur's range, 14.3% falls within PAs. The probable distributional range of the gaur in the country is given in **Figure 2.**

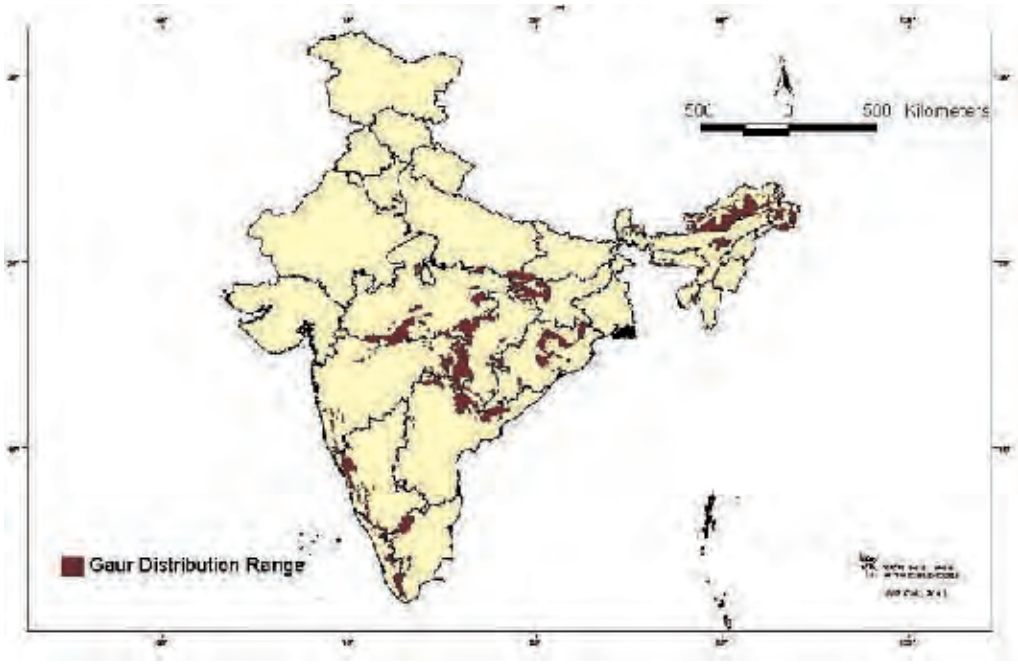


Figure 2: Probable distribution range of the gaur in India

However, the studies cited above have not documented the fragmentation and local extinction of the gaur. One recent instance of extinction is from Bandhavgarh Tiger Reserve (BTR), of Madhya Pradesh, which supported a small population consisting of 20-50 animals up to 1995. This population disappeared between 1995 and 1998 for unknown reasons. Brander (1923) reported

that the gaur had an extensive presence in the Betul and Khandwa districts of Madhya Pradesh at the beginning of the 20th century; the species is either extinct or unrecorded there at present. The species is possibly already extinct in Sanjay National Park, in eastern Madhya Pradesh, which earlier had a gaur population connected with the populations in Chhattisgarh and Jharkhand. The disappearance of the species has also been reported from Thattakad Wildlife Sanctuary, in Kerala, and Kanger Valley National Park, in Chhattisgarh (Sankar et al., 2001). At present, central India harbours approximately one fourth of the gaur population surviving in the country (Sankar et al., 2001). In Madhya Pradesh, the fragmented gaur population is found in 10 districts. There are unconfirmed reports of the existence of gaur in Katni and a small area called Kali Bhit at the junction of Betul, Harda and Khandwa districts.

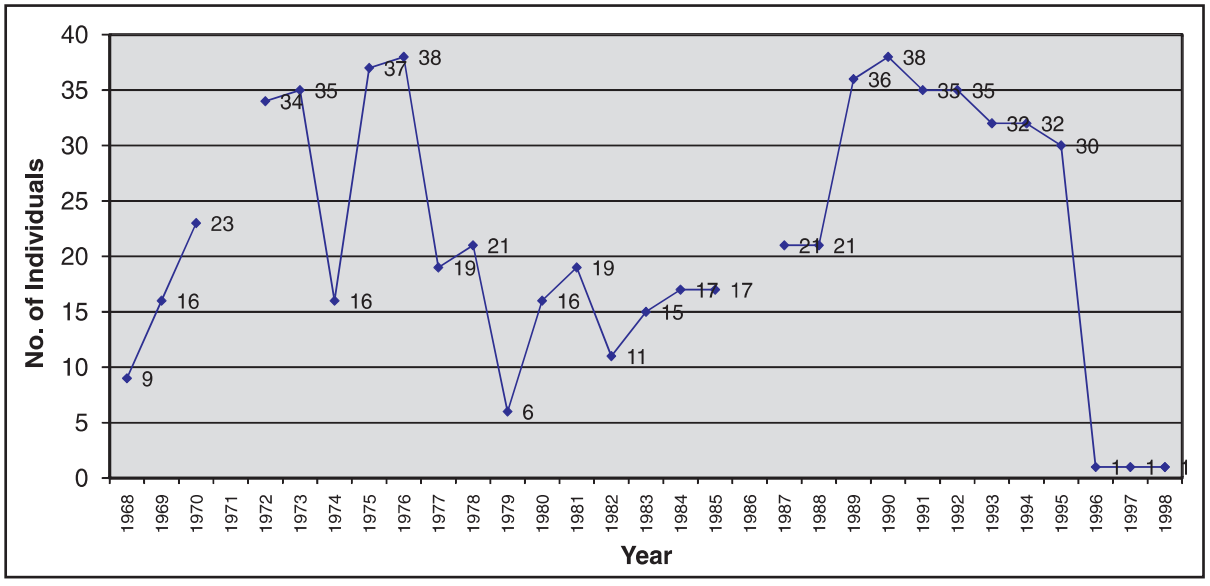
The known extinction of the gaur in three PAs in India, in a relatively short span of time, is a testimony to the fact that this species is losing ground very fast and urgent measures are required to stem this process. As this march of habitat destruction and poaching continues unabated, especially outside PAs, the decline of populations outside PAs is likely to continue in the foreseeable future. However, the dispersal of the species from PAs into the adjoining forests and inter-PA corridors may slow this process to some extent. Therefore, it is extremely important that suitable PAs continue to support gaur populations to replenish the losses outside. The loss or serious reduction of a population inside a PA, especially if the loss has happened as a result of some unexpected calamity, as appears to have happened in BTR, Madhya Pradesh, can be tackled by re-introduction or replenishment, but nothing much else can be done directly to bolster the existing population. The same applies to all the species which are showing trends of declining populations or local extinctions. Therefore, rather than watching helplessly and rueing the loss, conservation requires active programmes for re-introduction and re-establishment of important species from the areas where they have been recently lost, with or without habitat-related interventions. The IUCN/SSC guidelines strongly recommend such re-introductions.

The factors leading to the reduction in the range of this species are the usual ones: loss and degradation of habitat, poaching and diseases. The gaur is perhaps more prone than other species to losses from diseases due to its genetic proximity to domestic livestock. The past records indicate that populations of gaur have succumbed to epidemics of FMD, rinderpest and anthrax in many areas of its distribution. The obvious shrinkage in the range, number and densities of this magnificent species is a cause for serious concern and calls for urgent recovery and restoration plans.

HISTORY OF GAUR PRESENCE IN BANDHAVGARH TIGER RESERVE (BTR)

The gaur was historically found in BTR in small numbers. The population here was considered to be the only population to the north of Narmada River, in central India. According to the management scheme prepared by Sh. M. Dixit (1975), gaurs were localized in the hilly tract around the Bandhavgarh fort and were generally seen in Compartment No. 324 during summers after sunset

and before sunrise, when they came to drink water in the Charanganga River. According to the management plan prepared by Sh. A.K. Sonakiya (1992), the gaur population of Bandhavgarh National Park was considered threatened. The gaur was identified as an important target species for the management, but nothing, except the provision of general protection, has ever been done specifically for this species. Estimates of the gaur population in BTR from 1968 onwards are given in **Figure 3.**



*** *Population estimates for 1971 and 1986 are not available.**

Figure 3: Population Estimates of Gaur in BTR

Gaurs were usually seen in the Rajbahra, Bathan, Bhadrashila and Chakradhara areas of Tala Range, only in the open season. There is no definite information regarding where the species spent the rainy season. It was generally believed that they migrated to the Ghunghuti and Amarkantak areas (south-west of Bandhavgarh) during the monsoon, but they were occasionally recorded within the extended park area (Kallwah and Magdhi ranges) during the rainy season as well. The 1988 monitoring programme conducted by the forest department confirmed their presence in the Kaliwah/Magdhi area in the monsoon. However, the animals did not return to their post-monsoon range in 1995. According to the management plan prepared by Dr. U. Prakasam (2006), the last gaur, a male, was seen in Bandhavgarh in 1998. There have also been unconfirmed reports of some stray animals having been seen in rather unlikely places outside the park after 1995, but whether these animals were from the Bandhavgarh population, or not, is difficult to confirm.

CAUSE OF LOCAL EXTINCTION

It is well accepted that the disappearance of the species from BTR was sudden, not gradual. If the decline had been gradual, predation by tigers, degradation of habitat, disruption of the migratory route, etc. would have been the probable causes. Till recently, it was believed that something

happened to the population during its so-called migration season, when it was believed to migrate out of the park, in 1995. The construction of a thermal power plant near Pali, along with other associated developments, and the consequent disruption of the traditional migratory route (presumed), was believed to be one of the major reasons for the extinction of the species in Bandhavgarh. However, the sudden disappearance of the entire population, which in fact had been growing for the previous 15 years or so, cannot be explained by this factor. The only other possible factors can be a disease or an accident. There is no record of any epidemic of anthrax, rinderpest or any other livestock disease in the region during the relevant period, and no gaur deaths were reported then. Until a meeting of all the directors and assistant directors of the park of the period 1990-2000, serving or retired, was called in the office of the Chief Wildlife Warden in 2006, when this project was being planned, the most popularly accepted theory was that the species suffered some major setback in its monsoon range in 1995 as it did not return to the popular areas of the park after the monsoon. However, now it is confirmed that the animals did return after the 1995 monsoon as a herd of 13 was seen near the Tala gate on 1 November 1995 by the then Assistant Director of BTR. A few animals were also seen by the new Field Director in the subsequent December-January period. No animal was seen in the park after March 1996. The tragedy confirms the fact that small, isolated populations are vulnerable to local extinctions.

JUSTIFICATION FOR RE-INTRODUCTION IN BANDHAVGARH TIGER RESERVE

The loss of the gaur from Bandhavgarh National Park has had three main implications: (1) local extinction of an endangered species (Schedule I of the Wildlife Protection Act, 1972), (2) loss of gene flow and (3) fragmentation.

Bandhavgarh continues to be an excellent habitat and can therefore still support a reasonable gaur population. The proposal to re-introduce gaur into BTR was in conformity with the definition of 're-introduction' in the IUCN/SSC guidelines. The guidelines propose the establishment of 'a viable, free-ranging population in the wild of a species, subspecies or race, which has become globally or locally extinct' as the goal for re-introduction programmes. As per the guidelines, there can be one or multiple objectives for re-introduction. The proposal to re-introduce the gaur in BTR was in conformation with the following objectives, stated in the guidelines: (a) to enhance the long-term survival of a species and (b) to maintain and/or restore natural biodiversity. The proposal was also consistent with another recognized objective, namely, 'to provide long-term economic benefits to the local and/or national economy' to some extent. The re-introduction of the gaur into Bandhavgarh would enhance tourist satisfaction, resulting in better incomes for the park, local people and park-dependent businesses. The guidelines recommend a multi-disciplinary approach and prefer wild stock for the founder population. The guidelines also recommend that 'where the security of the re-introduced population is at risk from human activities, measures should be taken to minimize these'. Other elements of the guidelines, related to selection of stock, legal requirements, policies of the relevant governments, etc. were to be complied with as and when required.

FEASIBILITY STUDY

The ecological requirements for re-introduction of gaur at BTR were established and included the following:

1. a diversity of habitats with a variety of plant species needed by the gaur (based on a study carried out by the WII at Pench Tiger Reserve on the ecology of the gaur, 2001);
2. availability of ample cover and water, especially in summer; and
3. protection from anthropogenic factors (human disturbances, interaction with domestic livestock, poaching).

FOOD AND WATER REQUIREMENTS OF GAUR AT BANDHAVGARH TIGER RESERVE

The gaur is a generalist feeder but prefers to browse in the dry season and predominantly graze in the monsoon. Its diet chiefly includes shoots and the foliage of trees and shrubs and the buds and fruits of species such as *Diospyros melanoxylon* and *Aegale marmalos,* tender seeds of bamboos, herbs, grasses and the bark of trees such as *Adina cordifolia* and *Tectona grandis*. Gaurs visit salt licks periodically. Being an obligatory drinker, the gaur needs water every day and may visit water bodies twice a day during the hottest periods. During the hot hours of the day gaurs retire to the shelter under thick tree cover and ruminate. Feeding is more predominant during the early morning and evening hours. On average they feed for 15-18 hours a day. During the study carried out by the WII in Pench Tiger Reserve, a total of 78 species of plants belonging to 28 families were recorded as being eaten by the gaur (Sankar et al., 2001). Of the food plants recorded, the family Leguminoseae accounted for the highest number of individuals (18%), followed by the family Gramineae (15%). Direct feeding observations showed that the browse formed a major proportion in the diet of the gaur during summer (grass:browse ratio, 1:3). A total of 11 tree species, 3 shrubs, 3 climbers, 4 grasses and 1 herb species were recorded as summer food plants of the gaur. The availability of food plants of the gaur in BTR is given in **Table 1.**

In the year 1982-1983, gregarious flowering of the bamboo (*Dendrocalamus strictus*) took place in Bandhavgarh National Park. As a result, there was profuse regeneration of the bamboo. It provided adequate forage to almost all herbivorous species. As bamboo is a preferred food plant of the gaur, abundant food is available for it in BTR.

The long, prehensile tongue of the gaur is well adapted for browsing. The gaur prefers green grass when it is available, but it even feeds on coarse leaves, buds and fruits of trees such as *Aegle marmelos, Bauhinea* spp., *Cassia fistula, Cordia myxa, Diospyros melanoxylon, Emblica spp., Gmelina arborea, Terminalia bellerica* and *Randia dumetorum* (Krishnan, 1972; Brander, 1923; Schaller, 1967; Pasha, 1999). The tender seeds of the bamboo and herbs also contribute to the diet of the gaur. It also feeds on the bark of many tree species. In central India, the gaur is reported to feed on the bark of *Adina cordifolia* (Brander, 1923; Schaller, 1967), and in Mysore it feeds on the bark of *Wendlandia natoniana.* Sanderson (1968) reports that the gaur eats the bark of

Phyllanthus emblica. During the summer, teak (*Tectona grandis*) de-barking by the gaur is a well-known phenomenon in the central Indian highlands (Ranjitsinh, 1997; Pasha et al., 2001).

Table 1: Food plants of the gaur available in BTR

S. No.	Species	S. No.	Species
1	*Ougenia dalbergioides*	26	*Casearia tomentosa*
2	*Diospyros melanoxylon*	27	*Adina cordifolia*
3	*Bauhinia racemosa*	28	*Mitragyna parviflora*
4	*Grewia tiliaefolia*	29	*Randia uliginosa*
5	*Flacourtia ramontchii*	30	*Randia dumetorum*
6	*Aegle marmelos*	31	*Nyctanthes arbor-tristris*
7	*Bridelia retusa*	32	*Holarrhena antidysenterica*
8	*Cordia myxa*	33	*Vitex spp.*
9	*Zizyphus xylopyra*	34	*Lantana camara*
10	*Kydia calycina*	35	*Emblica officinalis*
11	*Abutilon indicum*	36	*Euphorbia hirta*
12	*Indigofera arborea*	37	*Ficus hispida*
13	*Millettia auriculata*	38	*Madhuca latifolia*
14	*Desmodium spp.*	39	*Curcuma reclinata*
15	*Abrus precatorius*	40	*Asparagus racemosus*
16	*Butea superba*	41	*Phoenix spp.*
17	*Dalbergia paniculata*	42	*Dicanthium spp.*
18	*Bauhinia vahlii*	43	*Andropogon spp.*
19	*Cassia tara*	44	*Sorghum haplense*
20	*Albizzia odoratissima*	45	*Apluda mutica*
21	*Albizzia procera*	46	*Cynodon dactylon*
22	*Anogeissus latifolia*	47	*Chloris dolycostachya*
23	*Terminalia arjuna*	48	*Cyperus spp.*
24	*Terminalia tomentosa*	49	*Themeda spp.*
25	*Syzygium cumini*		

The park authorities at BTR had initiated re-location of villages from in and around the reserve and focused on minimizing interctions with livestock. Various protection measures were taken by the park officials to ensure that the potential threats for the long-term survival of the re-introducted population were addressed.

KANHA TIGER RESERVE

Kanha Tiger Reserve (KTR) forms a part of the central Indian highlands, sprawling across Madhya Pradesh from west to east. The park is situated in the Mandla and Balaghat districts. Kanha Tiger

Reserve is located between 80° 26' 10" E and 81° 04' 40.00" E and between 22° 01' 5.00" N and 27° 27' 48.00" N and is situated in the Maikal Hills of the Satpura Range. It lies in the Deccan Peninsula-Central Highland zone (6E) of the bio-geographic classification of India (Rodgers and Panwar, 1988). The tiger reserve comprises two divisions, namely a core zone (940 km^2) and a buffer zone of (1009 km^2). Besides , Phen Wildlife Sanctuary, with an area of 110 km^2, serves as a satellite micro-core. The core area has seven ranges, namely the Kisli, Kanha, Sarhi, Mukki, Bhaisanghat, Supkhar and Phen Wildlife Sanctuary ranges, while the buffer area has five ranges, namely the Ghari, Khatiya, Khapa, Sijhora and Samnapur ranges. The reserve is an excellent interspersion of dadars (flat hill tops), grassy expanses, dense forests and riverine forests. It occupies most of the northern slopes of the main Maikal ridges of the Satpura Range. The valleys are encompassed by spurs of varying elevations extending from the main hill ranges. Halon Valley and Banjar Valley constitute the eastern and western halves, respectively, of the core of Kanha Tiger Reserve. The reserve prides itself in successfully conserving endangered species such as the tiger (*Panthera tigris*), central Indian barasingha (*Cervus duvaucelli branderi*) and the wild dog (*Cuon alpinus*). The park has a considerable population of gaur (*Bos gaurus*) spread over a vast ladscape. The gaur population as estimated in 2006 by the traditional block count method in Kanha Tiger Reserve included 1605 animals in the national park area, 46 in the buffer zone and 50 in Phen Wildlife Sanctuary.

PREPARATORY PHASE

Preparations for translocation of gaurs started in 2006-2007, with the Madhya Pradesh Forest Department initiating the following:

1. **Permissions for translocation of gaurs:** The gaur being a Schedule I animal under the Wildlife Protection Act, 1972 (as amended in 2006), permissions were required from GoI for its capture and translocation **(Annexure II).**

2. **Procurement of licence for import of drugs and equipment:** Narcotics are the drugs of choice for immobilizing wild bovids. They have short induction periods and have been successfully used in gaur capture operations in Nepal. The necessary clearances were obtained from the Drug Controller General of India, Ministry of Agriculture (Department of Animal Husbandry and Dairying) and the Narcotic Commissioner (Ministry of Finance, Central Bureau of Narcotics). Additionally, licences for importing a syringe projector (Dan Inject), donated by &Beyond (formerly known as CC Africa), were also obtained.

3. **Training of personnels:** With a view to establishing appropriate capture, handling, transport and translocation techniques and to training personnel in these operations, a training programme on the capture and translocation of wild animals was organized at Phinda Game Reserve, and a visit to national parks and game reserves in South Africa was organized during 15-30 May 2008 funded by & Beyond. Sh. Aseem Shrivastava, Field Director, BTR, Sh. Subaranjan Sen, Deputy Director, KTR, Sh. A.K. Nagar, Deputy Director, Panna Tiger Reserve, Dr. Sandip Agarwal, Veterinary Officer, Panna Tiger Reserve, Dr. Parag Nigam, Scientist, WII, Mr. Sarath Champati, Chief Naturalist & Head-Training, Taj Safaris and Mr. Kartikeya Singh, Head Naturalist, Mahua Kothi, Taj Safaris, were part of the training team. The visiting team was hosted by Les Carlisle and exposed to various techniques used to capture wild animals, along with live demonstrations of black rhino and

wild buffalo capture. Discussions were had with various South African wildlife experts including Dr. Dave Cooper (KZN Wildlife), Mr Jeff Cooke (Head, Game Capture, KZN Wildlife) and Dr. Douw Grobler, wildlife veterinarian. An action plan was prepared at Mountain Lodge Phinda to define each step of the translocation **(Annexure III).**

4. **Simulation of gaur population viability at BTR:** The action plan as prepared by the Madhya Pradesh Forest Department envisaged the capture and translocation of 20 gaurs (15 adult females and 6 adult males) from Kanha Tiger Reserve, Madhya Pradesh, and their introduction in BTR, Madhya Pradesh. The plan also envisaged bringing in more gaurs to Bandhavgarh, on a later date/stage, to maintain a viable population of approximately 50+ animals. Accordingly a simulation of the viability of the gaur population was carried out at WII **(Annexure IV).**

5. **Designing of transport trucks/containers:** Transport trucks **(Figure 4)** and containers were designed according to the animals' needs. The design was based on the specifications used in South Africa. The details are provided below:

- Standard container length of ±6.7 m.
- Roof of the container: minimum internal height of 2.2 m.
- Two external doors, one on the right rear side and one on the front right side of the front compartment.
- Doors 1.2 m wide suspended from a 2.4 m rail with rubber stoppers to prevent over-opening or over-closing.
- Each door provided with a U-shaped locking mechanism.
- Each door suspended by two 500 kg (minimum) rollers.
- Bottom of each door runs behind a 6 mm steel flat bar.
- 'D' rubber attached below each door, extending beyond the opening.
- Four hatches provided at the centre of the roof, 75 cm wide.
- Hatches raised and made waterproof.
- Latches to lock the hatches open.
- One adjustable partition with sliding door in each compartment.

Figure 4: Truck fabricated for transportation of gaurs

- Sliding door of central compartment operated from outside.
- All sliding doors 1.2 m wide, made of solid steel.
- Four side hatches, 30 cm × 70 cm, on both sides [Specify whether four hatches on each side or two hatches on each side] just above the base of the wall; front right compartment alone with only one hatch to facilitate the opening of the sliding door.
- Lower container wall with 4 mm gap to allow free flow of urine.
- Floor of solid checkered steel plate with 100 cm^2 grids made of round iron bars.
- Outer surface of the roof painted white and with anti-skid surface (sprinkle sand on wet paint) applied.
- Roof tapered by 5 cm from raised centre to side walls.
- Hollow tube (50 mm) welded between verticals to form a ladder to climb onto the roof.
- Mechanical louvers (75 cm) along both sides.

6. **Designing of stretcher:** A stretcher was specially designed for carrying immobilized animals from the site of capture to the vehicle and had a suitable provision for weighing the animals. The details are as follows:

- Outside width of the stretcher not more than 110 cm.
- A pipe of diameter 3 cm as a holding rail along the entire length on both sides.
- Four 4 cm hollow pipe cross members, equally spaced.
- Six 3 cm extensions to fit into the 4 cm cross members, 3 m in length.
- 90 cm wide double canvas covers for the full length of the internal 90 cm wide poles. This canvas has eyeholes along the full length on both under sides to allow stitching of canvas.
- Runners of 4 cm diameter pipe welded underneath the 90 cm bearers on 10 cm supports.
- Two stretcher rails made of 5 cm channel iron, 90 cm centres braced at 1 m from each end, designed to fit into the door slots under the door's lower rail.
- Length of the stretcher 2 m.

7. **Design of holding *boma* at KTR:** The holding *boma* was constructed of steel sections 2.5 m high by 3 m long made out of 50 mm × 75 mm × 3 mm rectangular hollow tubes. 1.5 m of the steel section was of solid 2 mm pressed steel plate. Each steel section had a total height of 2.5 m, with three verticals at 750 mm (50 mm × 50 mm × 3 mm) intervals and one horizontal at 1.5 m (50 mm × 50 mm × 3 mm). A 1 m expanded metal mesh above the steel section was welded to the front of the frame above the solid steel, with the smooth section facing inside the *boma*. This included 6 mm flat bar brackets with 30 mm holes reinforced with 6 mm gusset welding at 300 mm from the top and bottom of the frame on the left hand side and at 400 mm from the top and bottom of the frame on the right hand side. The connecting bolts were made of 25 mm round bars, 300 mm long and tapered on one end. Approximately 30 sections were used in the *boma.*

Sliding gates: Three sliding gates 1.5 m wide sliding on a 3 m rail and 2.5 m high were part of the *boma*. The gates were made of 50 mm × 50 mm hollow square tubes with three rollers. The gates were made of solid 2 mm pressed steel. They were provided with locks

that could be operated from outside. A provision was made for fitting a solid shade cloth above the gate to the same height as the rest of the *boma*. Provision was made for the walkways to be attached to a few steel sections 300 mm wide and extending along the entire length of the section, 1.5 m thick and 2 m high. This was done to facilitate the loading of animals into the truck.

Loading ramp: The loading ramp was a 3 m section, of solid pressed steel at 2.5 m height. The same specifications applied to the walkway of the other sections. The floor was attached at the base of 3 m sections. Three supporting arches were attached at the top, made of 25 mm round bars. The loading ramp was of 3 mm solid pressed steel plate with iron rods. The loading ramp was filled with soil. Two sections were tapered from a 3 m base at an angle of 65° to accommodate the loading ramp. The *boma* was teardrop shaped and installed at a location with some shade. The height of the *boma* was increased by 1 m using 80% agrimesh. Wooden poles were used to reinforce the steel sections. The steel sections beyond the double door sliding gate were covered using the agrimesh all the way up to the entrance of the truck. Since gaurs are forest animals, this was done to give them a sense of having a space to hide in. The holding *boma* was further divided into two compartments with the help of bamboo mats and a sliding gate. This partition was covered with agrimesh to avoid any sharp edges protruding out in the *boma*. Branches with foliage were hung on the wires running across the *boma*. A provision for giving food, water and salt was made in the last compartment of the *boma*. Shade was provided using agrimesh at the far end of the *boma*. Transport trucks (TATA LPT 1615) in standard container flat bed configuration with twist locks set at standard 6 m container distances. A transport truck (TATA 407 four by four) was kept as a recovery vehicle for transport from the field to either the big truck or the holding *boma.*

8. **Design of enclosure at BTR:** A survey for a suitable site for a soft release of the gaur in BTR was carried out by the MPFD officials. A site with good vegetation, cover and water was selected at the borders of Tala and Magdhi ranges. A 50 hectare plot was selected, power fenced and prepared for the release **(Figure 5)**. An off-loading ramp was prepared at the

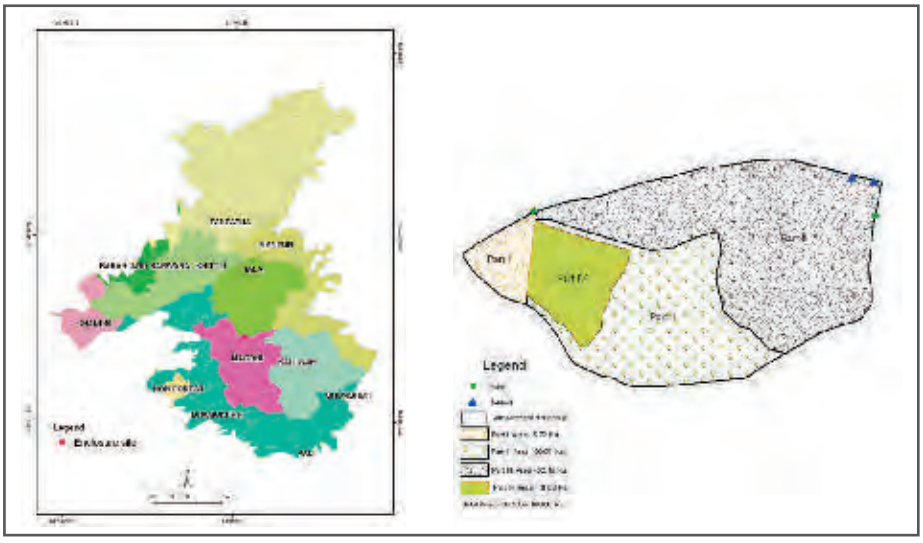


Figure 5: (A) Gaur reintroduction enclosure site in BTR and **(B)** enclosure design at Magdhi Range

site **(Figure 6)**. A small 2.5 hectare plot was fenced inside the larger enclosure. This was done to facilitate closer observations of the animals during the initial few days.

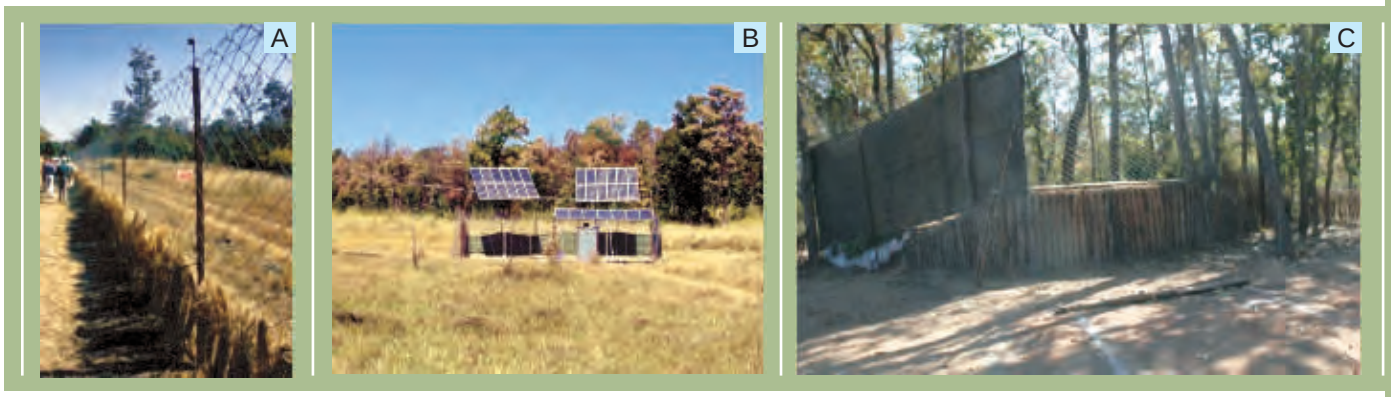


Figure 6: Enclosure at Tala range in BTR (A) Power fencing at enclosure (B) Solar Panel at the site (C) Off-loading ramp

9. **Procurement of radio-collars:** A total of 15 radio-collars were procured for the project. These included two Telonics (USA) satellite/GPS/VHF collars and 13 Telonics (USA) VHF radio-collars. The WII was accorded responsibility for procurement of collars and monitoring of the re-introduced gaur at BTR.

10. **Development of veterinary protocols for capture and translocation:** A detailed plan of operation (veterinary protocols) for capture and translocation of gaurs from Kanha to BTR for the purpose of re-introduction was prepared by Dr. Parag Nigam, Scientist, WII, and Dr Dave Cooper, EKZN wildlife veterinarian, South Africa, and reviewed and vetted by the Madhya Pradesh State Forest Department **(Annexure V).**

11. **Training of field staff:** Training was provided to the field staff at Kanha and Bandhavgarh tiger reserves on various aspects between 6 and 19 January 2011 as summarized below.

a. Teams for monitoring animal herds, capture and darting, loading/off-loading of immobilized animals, emergency management, weighing **(Figure 7)**, transport, logistics/support, off-loading at Bandhavgarh and post-release monitoring were identified, and specific roles were assigned.

b. The darting team was trained to dart from the back of an elephant and from a vehicle at variable distances before the actual operation.

Figure 7: Checking functionality of weighing balance before the operation

12. **Reconnaissance of the route:** A dry run of the transport truck was carried out between Kanha and Bandhavgarh to assess the road condition, suitability of the vehicle and halting points during the journey and to optimize the vehicular speed. Dr Les Carlisle, along with Mr. Kartikeya Singh and the field staff, carried out the reconnaissance survey. Based on the reconnaissance, it was proposed to commence the journey with the animals late in the evening so as to avoid human and vehicular disturbance and to ensure that the journey was during the cooler hours.

13. **Checking veterinary supplies and equipment:** A thorough check of drugs (immobilization and emergency), accessories and functioning of the equipment was done **(Figure 8)** according to the veterinary protocols **(Annexure V).**

Figure 8: (A) Medicine box (B) Checking veterinary supplies prior to operation

CAPTURE, TRANSPORT AND RELEASE: FIELD OPERATION

The team assembled at Kanha Tiger Reserve on 18 January 2011 before the final operation. The entire sequence of events for the field operation was discussed at length. Specific duties were assigned; medicines and equipments re-checked and a mock field trail with ground staff carried out. The field operation started on 21 January 2011. A total of 22 immobilizations were carried out at Kanha between 21 and 27 January 2011, of which 19 animals were successfully translocated to BTR.

Selection of animal and site: The patrolling team headed by Sh. H.S. Negi, Field Director, Kanha Tiger Reserve, was assigned the responsibility for locating a gaur herd. Nine captive elephants were used for the search operations at different areas based on the information provided by the patrolling party. Once a herd was located, the size, composition, terrain conditions for darting and distance from the road were considered prior to the actual operation. In case the herd characteristics were appropriate but the herd was not in suitable terrain (undulating and thick cover), the herd was gently pushed to suitable terrain with the help of elephants. The selection of an individual for capture was done on the basis of its condition, age and weight **(Figure 9)**. The final selection of the animal was made after detailed discussions amongst the team members.

Figure 9: Selecting suitable animal from herd

Immobilization: The selected animal was approached on the back of an elephant for darting. Etorphine hydrochloride (Captivion, Wildlife Pharmaceuticals (Pty) Ltd., 9.8 mg/ml) mixed with

azaperone (Stressnil, Janssen Pharmaceutica NV, 40 mg/ml) at appropriate doses was remotely injected employing 3.0 ml nylon darts using a Dan Inject projector (model JM). The animal was left undisturbed till it reached a condition safe for handling.

All the information collected during the field procedure was recorded in the format provided in the veterinary protocols. A total of 22 immobilizations were carried out at Kanha Tiger Reserve **(Figure 10).** The details of the immobilizations are summarized in **Table 2.**

Of these 19 animals were successfully translocated to BTR though one adult female was revived immediately after capture as a young calf was seen following her after darting (Sr. No. 6). Another female (Sr. No. 8) had to be immobilized again (Sr. No. 17) for loading on to the container as she resisted leaving the boma even after repeated efforts. A sub-adult female (Sr. No. 2) died due to shock resulting from aspiration pneumonia. The details of the captured and radio-collared gaurs are given in **Table 2.**

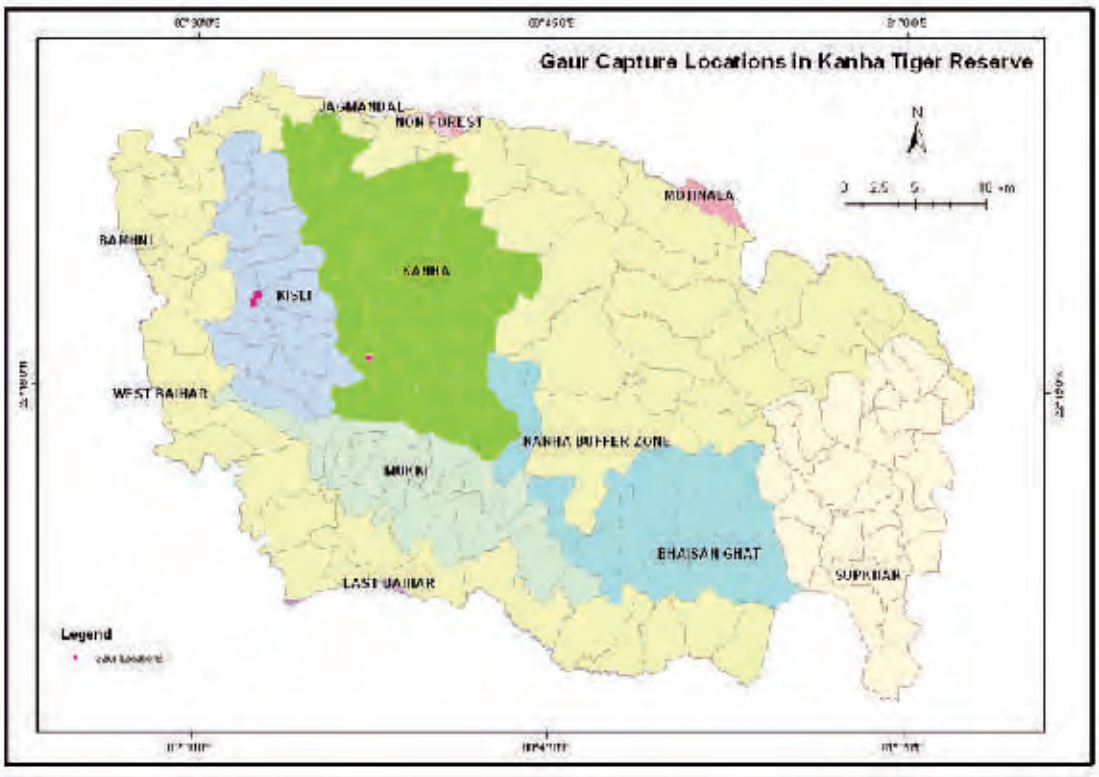


Figure 10: Capture locations in Kanha Tiger Reserve, Madhya Pradesh (Kanha and Kisli ranges)

Table 2: Details of gaur capture, collaring and release

Sr. No.	Date	Range	Sex	Approximate age (years)/ ed weight (kg)	Etorphine HCl (mg)	Naltrexone (mg)	Collar type and frequency	Remarks
1	20-01-11	Kisli	Female	3-4/400	5	100	VHF 150.28	Translocated to BTR
2	20-01-11	Kisli	Female	3-4/400	4	80	-	Died (aspiration pneumonia)
3	20-01-11	Kisli	Male	3-4/350	3	60	VHF 150.80	Translocated to BTR
4	20-01-11	Kisli	Female	3-4/300-350	3	60	VHF 150.90	Translocated to BTR
5	20-01-11	Kisli	Male	3-4/300-350	3	60	-	Translocated to BTR
6	21-01-11	Kisli	Female	5-6/600	5	100	-	Released after capture (animal seen with a calf)
7	21-01-11	Kisli	Male	4-5/500	4	80	(GPS) 150.00	Translocated to BTR
8	23-01-11	Kisli	Female	6-7/>600	5.5	120	VHF 150.60	Translocated to BTR
9	23-01-11	Kisli	Male	>1.5/150	1.5	30	-	Translocated to BTR
10	24-01-11	Kanha	Female	4/400-450	4	80	VHF 150.22	Translocated to BTR
11	24-01-11	Kanha	Female	4-4.5/400-450	4	80	VHF 150.4	Translocated to BTR
12	24-01-11	Kanha	Female	4-4.5/500	3.5	70	VHF 150.24	Translocated to BTR
13	24-01-11	Kanha	Female	5-5.5/350-400	2.5	90	VHF 150.30	Translocated to BTR
14	25-01-11	Kanha	Female	5-6/500	5	100	VHF 150.20	Translocated to BTR
15	25-01-11	Kanha	Female	6-7/550	5.5	110	-	Translocated to BTR
16	25-01-11	Kanha	Female	>1.5/150-200	2	40	-	Translocated to BTR
17	25-01-11	Kanha	Female	6-7/600	5	100	-	Immobilized for loading onto container
18	27-01-11	Kanha	Female	3-3.5/300-350	3	60	-	Translocated to BTR
19	27-01-11	Kanha	Female	5-6/500	4.5	90	VHF 150.26	Translocated to BTR
20	27-01-11	Kanha	Female	2.5-3/200	1.75	35	-	Translocated to BTR
21	27-01-11	Kanha	Female	2-2.5/200	1.4	30		Translocated to BTR
22	27-01-11	Kanha	Male	6.7/>600	5.5	110	(GPS) 150.10	Translocated to BTR

Summary of Immobilization:

1. Induction time (time from darting till animal attaining lateral recumbency) : 2.5-11 minutes
2. Approach time (time from darting till animal finally approached) : 3-13 minutes
3. Operation time (time after approach till animal given antidote) : 4-38 minutes
4. Recovery time (time after giving antidote till animal stood) : 1-5 minutes
5. Total time for operation : 15-47 minutes

Procedures Post-immobilization: After ensuring that the animal had been sedated sufficiently so that it was safe to handle it, the animal was immediately blindfolded and maintained in sternal recumbency **(Figure 11).** Proper positioning of the animal was critical during the entire operation as it ensured patent airways and normal eructation of ruminal gases and fluids. After ensuring that the physiological parameters were stable, the immobilized animal was shifted onto the stretcher and loaded onto the small vehicle for taking it to the boma or directly loaded onto the transport truck **(Figure 11).** All the animals captured at Kisli range were brought to the boma, whereas the animals captured at Kanha range were directly shifted into the transport truck **(Figure 12).**

Figure 11 : (A) Animal in sternal recumbency (B) Loading of immobilized animal onto small truck

The condition of the animal and level of sedation were assessed continuously during the operation. Where needed, supplemental anaesthesia with ketamine HCl (Ketamil, Troy Laboratories, 100 mg/ml) was given intravenously to the animal, and in case of respiratory depression, partial antagonism with butorphanol tartarate (Butrum, Aristo Pharmaceutical Pvt. Ltd., 2mg/ml) was effected.

Figure 12 : Animal properly restrained on the small truck

Trimming of horns: So as to avoid any chance of injury during transport, the tips of the horns of selected animals (adults) were trimmed and rounded.

Collaring: The animals were collared for monitoring subsequent to their release at Bandhavgarh **(Figure 13).** Two Telonics (USA) satellite/GPS/VHF collars and 10 Telonics (USA) VHF radio-collars were deployed on the animals. The details are summarised in **Table 2.** The satellite radio-collars are programmed to give animal locations every day through ARGOS satellites for the initial three months and subsequently every third day.

Figure 13 : Radio-collar being fitted onto the animal at the boma

Biological sampling and laboratory investigations:

Biological samples were collected from the immobilized animals and subjected to detailed analyses at the Centre for Wildlife Forensic and Health (CWF&H), Madhya Pradesh, and Pashu Chikitsa Vigyan Vishwavidyalya, Jabalpur **(Table 3 and 4).**

Figure 14 : Laboratory investigation at CWF&H, Jabalpur

Table 3: Haematology and serum biochemistry of Gaur (n=18)

A. Haemogram	Ranges Obtained	Normal Ranges* (Cattle)
Total erythrocyte count (Million/µl)	4.0-9.81	6.3-11.55
Haemoglobin (g/dl)	8.8-13.8	8.7-14.5
Packed cell volume (%)	31-43	33-47
Erythrocyte sedimentation rate (Wintrobe) mm./hrs	0-3	0
Total leucocyte count (Thousand/µl)	6.1-16.8	5-12
Neutrophils (%)	30-67	10-52
Lymphocytes (%)	27-57	39-77
Monocytes (%)	2-10	1-18
Eosinophils (%)	2-10	0-14
Basophils (%)	0-0	0-1
Mean corpuscular volume (fl)	25.6-60.3	30.5-46.5
Mean corpuscular hemoglobin (pg)	6.5-19.2	8.50-13.3
Mean cell hemoglobin concentration (g/dl)	12.9-39.4	10.50-28.7
B. Biochemical Analysis		
Glucose (mg/dl)	31.4-120.6	45-75
Phosphorus (m.mol/L)	4.2-13.4	3.2-12.4
Calcium (mg/dl)	3.6-8.4	9.7-12.4
Chloride (m.mol/L)	82.9-88.9	97-111
Cholesterol (mg/dl)	149.6-200	80-120
Creatinine (mg/dl)	0.2-3.1	0.8-2.0
Total protein (g/dl)	5.3-9.2	6.74-7.7.4
Albumin (g/dl)	2.3-3.8	3.03-3.55
Total bilirubin (mg/dl)	0.4-3.3	0.2-1.2
Direct bilirubin (mg/dl)	0.1-0.6	0.1-0.6
Blood urea nitrogen (mg/dl)	21.3-54.1	20-30
Uric acid (mg/dl)	1.9-3	0.0-2.0
Alanine Aminotransferase (u/L)	19.1-45.9	14-38
Aspartate transaminase (u/L)	18-124.4	78-132
Alkaline phosphatase (u/L)	49-263.8	40-160

*Normal values of cattle*Benjamine, M.M.1978. Outline of veterinary clinical pathology, pp-44 Edn III in Iowa University Press IOWA, USA

Table 4: Sero-Diagnosis: Gaur (n=18)

S. No.	Disease	Tests	Results
1	Brucellosis	Rose bengal plate agglutination test, Standard tube agglutination test	Negative for Brucellosis
2	Tuberculosis	Single intra-dermal test for tuberculosis	The animals were observed for 48 hours; however none of the animals showed reaction to tuberculin.
3	Foot and Mouth Disease	Haemagglutination (HA) / Haemagglutination inhibition test (HI)	Under investigation
4	Blue Tongue	Enzyme-linked immunosorbent assay	No antibodies found
5	Endo-Parasites	Sedimentation/Flotation method	No significant level of parasitic ova observed.

Genetic studies: Understanding genetic diversity has been one of the important aspects of conservation planning and re-introduction programmes. Information obtained from studies carried out to this end is valuable for correlation with changing land use matrices and as baseline data for re-introduction in the future of more individuals. Biological samples (blood, dung and hair) were collected for genetic analysis from immobilized animals. Of these, blood samples (n=19) were subjected to genetic analysis using mitochondrial genes (12S rRNA, 16S rRNA, cytB and control region) and nuclear markers (microsatellite DNA) at the forensic facility at WII, Dehradun. Eleven highly polymorphic microsatellite loci developed for bovids for mutli-locus genotyping were used in the study. Preliminarily analysis indicates a relatively high genetic diversity (0.578) among the gaurs translocated from Kanha as compared with other studies undertaken on gaurs in Vietnam (mean observed heterozygosity, 0.269) (Nguyen et al., 2007). Further analysis is required and will provide information regarding the genetic diversity of the population, allele sharing among individuals and parent-offspring relationships. This information will form the basis for the selection of individuals in future translocation programmes.

Medication and drug reversal: A short-acting tranquilizer, azaperone (Stressnil, Janssen Pharmaceutica NV, 40 mg/ml) was used with the primary immobilizing drug (etorphine HCl) in the immobilization dart. Subsequently medium- and long-acting tranquilizers were used to attain the desired level of tranquilization during transport and at the release site. These included haloperidol (Talendol, Morvel Laboratories (P) Ltd., 5 mg/ml) and perphenazine enanthate (Perphenazine 100, Kyron Laboratories, South Africa, 100 mg/ml). Additionally a long-acting antibiotic and supplemental drugs (multi-vitamins, etc.) were also administered to the animals.

After all the procedures were carried out, the animals were given an antidote Naltrexone (Trexonil, Wildlife Pharmaceuticals, 50 mg/ml) in the ratio of 20:1 of etorphine either intravenously or intramuscularly. The details of recovery are provided in **Table 2.**

Release into *boma*: All the animals captured at Kisli range (same herd) in Kanha Tiger Reserve were brought into the *boma* prior to transport to Bandhavgarh. This was done to ensure that the animals recovered from the effects of capture and that the proper level of tranquilization had been achieved. Since these are herding animals, it was presumed that animals in a group would be subjected to minimal stress during loading and transport.

Loading of animals: The captured animals in the boma were coaxed into the transport truck. Though the initial lot could be loaded comfortably, one of the females (Sr. No. 17) could not be loaded into the transport truck despite all efforts. The animal had to be immobilized again and was subsequently loaded onto the truck. It was ensured that a female with a calf and a mature bull were not mixed with other animals in the truck and taken independently.

Figure 15: Loading of immobilized gaur into the transport truck

Direct loading onto transport truck: Animals captured from the Kanha range were directly loaded onto the transport truck **(Figure 15).** This was done since the animals captured were from same herd and moreover the distance from the boma was great. It was ensured that the animals had the proper level of tranquilization prior to transport.

Transport Considerations: The distance between Kanha and Bandhavgarh was approximately 220 km, and it took on average 6 hours to reach Bandhavgarh. The journey was commenced in the late evening so as to avoid any human and vehicular disturbance and to reach the release site during the early morning hours. Special care was taken to maintain a uniform speed during the journey, with the speed adjusted according to the local road conditions. The animals were monitored throughout the journey.

Figure 16: Release of first lot of gaur at BTR on 22 January 2011

Release of animals: The truck with the animals was placed appropriately at the off-loading ramp at the release site (enclosure at Magdhi range). On reaching Bandhavgarh, after an initial stabilization and after the fitness of the animals was verified, they were released into the 2 ha enclosure **(Figure 16 & Table 5).**

Table 5: Details of release of gaur at BTR

Sr. No.	Date of capture at Kanha Tiger Reserve and number of animals captured	Date of release at BTR and number of animals released	Remarks
1 2	20/1/11 (05) 21/1/11 (02)	22/1/11 at 0235 hours (3 males and 2 females)	One died and one adult female was released at Kanha itself.
3 4	23/1/11(02) 24/1/11 (04)	25/1/11 at 0638 hours (4 females)	An adult female with a calf could not be loaded and hence was left at Kanha.
5	25/1/11 (03)	26/1/11 (1 male and 4 females)	An adult female that did not get into the truck was immobilized again and loaded manually with the other animals.
6	27/1/11 (05)	28/1/11 (1 male and 4 females)	

The age classes of the gaur reintroduced in BTR are given in **Table 6.**

Table 6: Age classes of re-introduced gaur at BTR

	Age class (years)			
	1.5-3.5	3.5-5	>5	Total
Male	1	2	2	5
Female	2	5	7	14
Total	3	7	9	19

The animals were maintained in the smaller enclosure till 30 January 2011, after which a small part of the enclosure was opened for the animals to move into the bigger (50 ha) enclosure. The herd was monitored intensively in the enclosure by the joint team of WII and frontline staff of BTR. On 9 March 2011, an adult cow (GF 14) delivered a calf inside the enclosure. The animals were released from the enclosure on 20 March 2011.

Monitoring the re-introduced herd: Intensive monitoring of the gaur herd will be carried out to understand their movements, home range, activity, population structure and food habits. The radio-collared gaurs will be monitored for three years by a research team of WII research fellows and forest officials in Bandhavgarh using the homing-in and triangulation techniques. Approximately 40 radio-locations of each radio-collared individual will be collected per season (summer, winter and monsoon) to study the home range and movement pattern of the gaurs. At

each animal location, the major vegetation types, terrain, other habitat variables, distance to water, distance to human habitation, distance to road, etc. will be recorded. The food plants eaten by the gaurs will be recorded to study their food habits.

LESSONS LEARNT

Unexpected things can happen during capture operations. It is important to be alert and confident when handling animals. Small efforts can save potentially dangerous situations. A brief on some of the incidents that happened during the gaur capture and translocation operation is given below.

Maintenance of sternal recumbency: Maintenance of sternal recumbency was the most critical, urgent and important aspect of immobilization of gaurs. Proper positioning ensures normal eructation of ruminal gases that would otherwise result in bloat and can lead to further complications. Also it ensures that the regurgitated rumen contents flow out of the mouth and are not aspirated. The first animal moved for a distance after being darted and came to sternal recumbency close to a *nallah.* As the sedation progressed, the animal slipped into the *nallah* **(Figure 17 A).** The animal was saved by a timely dash by Mr. Les Carlisle and Mr. H.S. Negi, who immediately brought the animal to sternal recumbency. Similarly, another animal was brought down physically to sternal recumbency by Mr. Les Carlisle when it was moving around aimlessly for a long time and could have injured itself **(Figure 17 B).**

Figure 17. (A) Animal slipping into the dry *nallah* during drug induction
(B) Gaur being physically restrained

Altered behaviour following darting: Animals behave differently under sedation during induction. Narcotics, being potent drugs, produce rapid induction in 3 to 5 minutes before the animal can be approached safely for handling. The sequence of events following darting includes incoordination, aimless walking, a high stepping gait and staggering prior to coming to sternal recumbency. One of the animals (a large female) chased people and elephants during induction

and moved out of the herd (200 m) into an open area and ended up under the transport truck. Such erratic inductions need to be envisaged and appropriately addressed. The animal was closely monitored by Mr H.S. Negi from the back of an elephant, and it was ensured that the animal was not disturbed till the sedation was deep enough for safe handling.

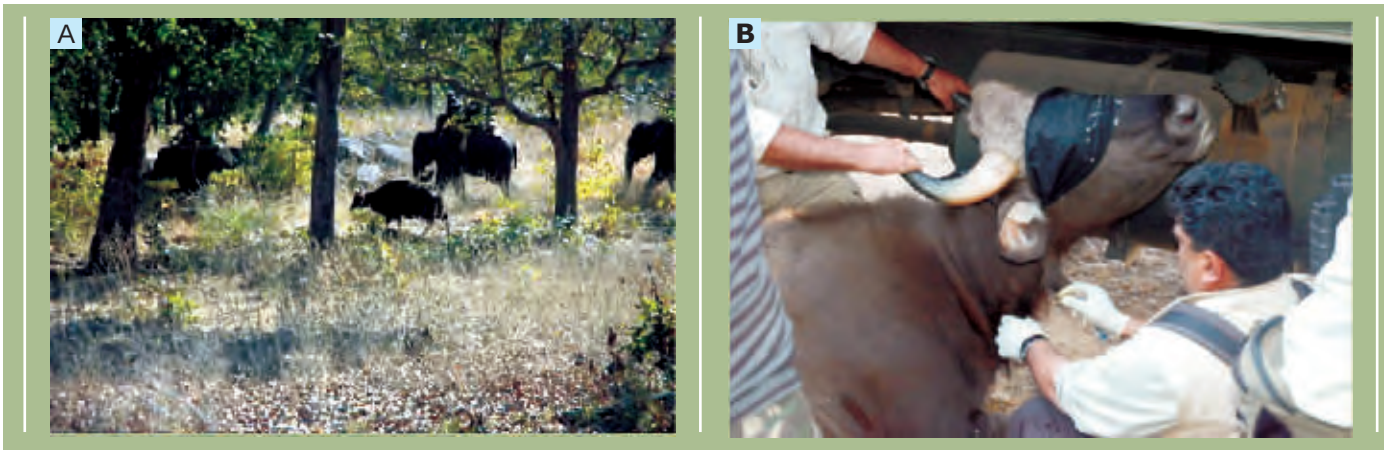


Figure 18: (A) Gaur being prevented from straying out using captive elephants
(B) Animal resting under the truck being sampled

Emergency management: One of the animals, though immobilized properly, displayed muscular tremors and respiratory distress (laboured breathing) on approach. This emergency was immediately responded to by administering a partial antagonist (butorphanol) intravenously, and the animal was stabilized almost immediately.

Salient Points:

1. This translocation of gaurs from Kanha to Bandhavgarh is the first successful mass translocation of gaurs ever attempted in its entire distributional range in South Asia.
2. A narcotic, namely etorphine hydrochloride, has been found to be suitable for immobilization of gaurs.
3. The use of short and long-acting tranquilizers in the translocation operation has proved to be effective in minimizing stress in the animals.

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Project Proposal : A Plan for Re-introduction of Gaur in Bandhavgarh Tiger Reserve

1. INTRODUCTION

Gaur *(Bos gaurus gaurus)*, popularly known as bison or the Indian bison, is the largest species of cattle on the Indian sub-continent and is one of the most majestic and beautiful creations of nature. The species, which is generally associated with idyllic, dense bamboo rich forests, mixed with open glades and plenty of water, was once wide spread throughout India, except the drier north and northwest. With the decline in the health of our forest wealth, this species has also suffered grave losses in its numbers and range. As per Schaller (1967), gaur was distributed in three widely separated geographical areas that corresponded to the major mountain systems in India: the Western ghats, the Central Indian highlands and the foothills of the Himalayas, including the hills south of Brahmaputra River. As per a study done by the Wildlife Institute of India (Ecology of Gaur in Pench Tiger Reserve, M.P., 2001), the gaur population in India is currently estimated at approximately 23,500. It occurs in 101 existing and 27 proposed Protected Areas, covering 15 states. The gaur range covers approximately 7.12% of the geographical area and 30% of forest cover of India. The Protected Areas cover 14.3% of the area of distribution of gaur. The present distribution range of gaur as prepared by WII, Dehradun is given as **Annexure-I.**

However, these studies have not documented the fragmentation and much local extinction of the species, which may ultimately result in eliminating it from one or more of the ranges indicated by Schaller and WII. One such recent extinction has been from Bandhavgarh National Park of Madhya Pradesh, which supported a small population consisting of 20-50 animals up to 1995 but disappeared between 1995 and 1998 for unknown reasons. Similarly, Dunbar Brander (1923) reported the extensive presence of gaur in Betul and Khandwa districts of Madhya Pradesh in the beginning of the 20th century, where the species is either extinct or unrecorded at present. The species is perhaps already extinct from Sanjay National Park in eastern Madhya Pradesh, which earlier connected it with the populations in Chhattisgarh and Jharkhand or it is just on the brink. Disappearance of the species has also been reported from the Thattakad Wildlife Sanctuary in Kerala and the Kanger Valley National Park in Chhattisgarh.

At present Central India (MP, Chhattisgarh and Maharashtra) harbours approximately one fourth of the present gaur population surviving in the country (Ecology of Gaur in Pench Tiger Reserve, M.P., 2001). In Madhya Pradesh, fragmented gaur population is found in 10 districts. There are unconfirmed reports of its existence in Katni and a small area called Kali Bhit at the junction of Betul, Harda and Khandwa districts.

The factors leading to the reduction in the range of this species are the usual ones: Loss and degradation of habitat, poaching and diseases. This species is perhaps more prone to losses from diseases due to its genetic proximity with the domestic livestock. Past records

indicate that populations of gaur have succumbed to epidemics of foot and mouth diseases (FMD), rinderpest and anthrax in many areas of its distribution. The obvious shrinkage in the range, number and densities of this magnificent species is a cause for serious concern and calls for urgent recovery and restoration plans. Otherwise, we may reach a crisis which we now associate with the other important symbols of Indian natural heritage, such as the tiger, lion, elephant etc.

2. HISTORY OF GAUR PRESENCE IN BANDHAVGARH TIGER RESERVE

Gaur was historically found in Bandhavgarh National Park in small numbers. This population was considered to be the only population to the north of Narmada river, in Central India. As per the Management Scheme prepared by Shri M. Dixit IFS, (1975) gaurs were localized in the hilly tract around the Bandhavgarh Fort and were generally seen in compartment No. 324 during summers after sunset and before sunrise when they came to drink water in Charanganga river and grazed in the green grassy patch. As per the Management Plan prepared by Shri A.K. Sonakiya IFS, (1992) the gaur population of Bandhavgarh National Park was considered threatened. The gaur was identified as an important target species for the management, but nothing, except general protection, has ever been done specifically for this species. The population estimates of gaur in Bandhavgarh National Park from 1968 onwards are given:

S. No.	Year	No. of Gaur	S. No.	Year	No. of Gaur
1	1968	9	17	1984	17
2	1969	16	18	1985	17
3	1970	23	19	1986	0
4	1971	0	20	1987	21
5	1972	34	21	1988	21
6	1973	35	22	1989	36
7	1974	16	23	1990	38
8	1975	37	24	1991	35
9	1976	38	25	1992	35
10	1977	19	26	1993	32
11	1978	21	27	1994	32
12	1979	6	28	1995	30
13	1980	16	29	1996	1
14	1981	19	30	1997	1
15	1982	11	31	1998	1
16	1983	15			

Gaurs were usually seen in Rajbahra, Bathan, Bhadrashila and Chakradhara areas of Tala range only in the open season. There is no definite information where the species spent the rainy season. It was generally believed that they migrated to Ghunghuti and Amarkantak areas (south west of Bandhavgarh) during the monsoon, but were occasionally recorded within the extended park area (Kallwah and Magdhi anges) during the rainy season as well. The 1988 monitoring program confirmed their presence in the Kaliwah/Magdhi area in the monsoon. However, the animals did not return to their post monsoon range in 1995. As per the Management Plan prepared by Dr. U. Prakasam in 2006, the last gaur, a male, seen in Bandhavgarh was in 1998. There have also been unconfirmed reports of some stray animals having been seen in rather unlikely places outside the park after 1995, but whether these animals were from the Bandhavgarh population, or not, is difficult to say.

3. CAUSE OF LOCAL EXTINCTION

Unfortunately there has been no study to understand the causes of the extinction of the species from Bandhavgarh. Therefore, we can now make only a reasonable guess as to what led to this tragedy. As the disappearance of the species was almost sudden, it appears something happened to the population during its so-called migration season out of the park. If the decline had been gradual, predation by tigers and degradation of habitat, disruption of the migratory route etc. would have been the probable causes. The construction of a thermal power plant near Pali, along with other associated developments, and the consequent disruption of the traditional migratory route (presumed), is believed to be one of the major reasons for the extinction of the species from Bandhavgarh. However, the sudden demise of the entire population, which in fact had been growing for the previous 15 years or so, cannot be explained by these factors. The only other possible factors can be a disease or an accident. There is no record of any epidemic of anthrax, rinderpest or any other livestock diseases in the region during the relevant period and no dead bodies were reported. Although it is unlikely that nearly 30 animals could have died in an accident, but such a thing can happen if the accident is related to a natural calamity, such as a flood. As the disappearance happened during the monsoon season, which happens to be the migratory season as well, the chances of the population having been wiped out in a flood look reasonable. However, the only river that crossed their presumed migratory path is Johilla, which is not a large river, although flash floods are possible even in small rivers, especially where they descend from the hills. As the migratory route is only a guess, the actual migration may also have been happening across larger rivers such as Son or Narmada. If that is correct, then the flood theory will look more plausible. However, the tragedy confirms the fact that small, isolated, populations are too vulnerable to be taken for granted and urgent safeguards must be taken to protect them well in time.

4. JUSTIFICATION FOR RE-INTRODUCTION

The loss of gaur from Bandhavgarh National Park has had three main implications: Local extinction of an important species (schedule I of the Wildlife Protection Act, 1972), increasing the chances of further extinctions, loss of gene flow and fragmentation.

(a) Loss in biodiversity of the National Park

(b) Decline in tourist satisfaction,

As mentioned above, the gaur range has been shrinking continuously over the last century. Despite the success of the conservation efforts of the 20th century, we have no records of

any species reoccupying its traditional range. If this is allowed to continue, the vulnerable species are likely to become gradually further endangered.

The known extinction of gaur in three or four Protected Areas, in a relatively short span of time, is a testimony to the fact that this species is losing ground very fast and urgent measures are required to stem this process. As the march of habitat destruction and poaching continues unabated, especially outside protected areas, decline of populations outside protected areas is likely to continue in the foreseeable future. However, the dispersal of the species from protected areas into the adjoining forests and inter-PA corridors may slow this process to some extent Therefore, it is extremely important that suitable protected areas continue to support gaur populations to replenish the losses outside. The loss or serious reduction in population inside PAs, especially if the loss has happened as a result of some stray calamity, as appears to have happened in BNP, can be tackled by reintroduction or replenishment but nothing much can be directly done to bolster the intervening populations. The principle applies to all the species which are showing trends of declining populations or local extinctions.

Therefore, rather than watching helplessly and rueing the loss, conservation requires active programs for reintroduction and reestablishment of important species from the areas where they have been recently lost, with or without habitat related interventions. IUCN/SSC guidelines strongly recommend such reintroductions. Bandhavgarh continues to be an excellent habitat for the species therefore can still support a reasonable gaur population.

The IUCN/SSC guidelines define re-introduction 'as an attempt to establish a species in an area which was once part of its historical range, but from which it has been extirpated or become extinct'. The proposal to reintroduce gaur into Bandhavgarh National Park is fully in conformity with this definition. The guidelines propose establishment of 'a viable, free ranging population in the wild of a species, subspecies or race, which has become globally or locally extinct' as the goal for reintroduction programs. As per the guidelines, there can be one or multiple objectives for re-introduction; this proposal conforms with the following objectives stated in the guidelines: a) to enhance the long-term survival of a species; b) to maintain and/or restore natural biodiversity. The proposal also meets another recognized objective, viz. 'to provide long-term economic benefits to the local and/or national economy' to some extent. The reintroduction of gaur into Bandhavgarh will enhance tourist satisfaction, resulting in better incomes for the Park, local people and Park dependent businesses. The guidelines recommend a multidisciplinary approach; prefer wild stock as the founder population. The guidelines also recommend that 'where the security of the re-introduced population is a risk from human activities, measures should be taken to minimize these'. Other elements of the guidelines, related to selection of the stock, legal requirements, policies of the relevant governments etc. shall be complied with as and when required.

5. ACTION PLAN

The reintroduction process shall involve the following steps:

(a) Capture nearly 20 animals through chemical immobilization in Kanha National Park and put them into a loading and recovery pen for one or two days.

(b) Transportation to Bandhavgarh, in specially modified vehicles.

(c) Holding in a small pen (100m by 100m), called Boma, for pre-release observation and treatment.

(d) Release into a large enclosure for approximately 2 months, approximately 100- 150 ha, for acclimatization and social bonding.

(e) Final release into the national park.

(f) Monitoring.

(I) Source Population: The gaur population of Kanha National Park appears to be the best source, Kanha is the nearest Park with sufficiently large gaur population. Both the Parks are situated in the same climatic belt and have similar vegetation. Both the Parks have nearly similar predator densities and the same species, namely, tiger, leopard and wild dog. The Parks are only around 200 km apart, which is a convenient distance for the transportation of the animals. However, subsequently a few individuals can also be brought from Pench' and Satpura Tiger Reserves to augment genetic diversity.

(II) Herd Size for Re-introduction: As per the study done by Schaller in Kanha National Park, the sex ratio of adult animals was found to be around 40 bulls per 100 cows. Approximately the same sex ratio was noticed in the Bandhavgarh population also. Hence it is proposed that initially a herd of 15 adult cows between ages 3-5 years and 6 bulls, between ages 3-5 years may be reintroduced during rainy season. Efforts shall be made to get as many animals from a single herd as possible. After careful monitoring of the reintroduced population, more animals can be reintroduced as per requirement, to improve the gene pool, so that a viable population of about 50+ animals is established on a long-term basis. Minimum number of 20-21 animals is based on the premise that a large herd shall be able to cope with high levels of predation. This is also based on the empirical observation that the Bandhavgarh population remained relatively stable and grew to more than 30, when its size reached 15 or more animals.

(III) Food and Water Requirement of Gaur: Since gaurs were present in Bandhavgarh, their food and water requirements can be easily fulfilled here. The details are provided in **Appendix-I.**

(IV) Release Site: The gaur population of Bandhavgarh lived mainly in the Tala range, although it is believed to have regular migration into other parts of the park, especially during monsoon. Therefore, the ideal release site shall be in Tala range. The only constraint in Tala range is the extremely high tiger density, which will be a major threat to survival of the species, especially in the beginning. Therefore, a suitable site on the southern side of the Tala range or on the northern side of the Magdhi range, with sufficient water and forage shall be selected for the construction of the release facilities. Adjoining compartments 259 (270.000 ha.) and 260 (220.500 ha.) of

Magdhi Range and 249 (364.500 ha.) of Kallwah range, have been tentatively selected this purpose and shall be finalized in consultation with other experts. These areas were previously used by gaurs (Pabla H.S., 1998 - Development of a user friendly wildlife monitoring methodology for Protected Areas in India) and the tiger density is comparatively low in this patch. After the animals are released from the enclosure, they will, hopefully, discover a suitable location for settlement. There is the possibility of the animals settling down outside the park or close to the fringes of the park. Even that should be acceptable. If the animals stray too far from the park, necessity and measures to bring them back shall be considered.

(V) Legal Requirements: The gaur is included in Schedule-I of Wildlife (Protection) Act, 1972. As per Section 12 of Wildlife (Protection) Act, 1972, the permission of Government of India shall be required before undertaking the capture operations. As there is likely to be some mortality during the operations, GOI permission for capturing and transporting 25 animals shall be obtained.

(VI) Capture Methodology: There is no experience in capture and translocation of big herbivores, over long distances in India, except the rhino introduction from Assam to Dudhwa National Park in UP. However, translocation of big game is a common practice in Africa. Therefore, technical support of African experts shall be enlisted in implementing this project.

In India, a mixture of ketamine and xylazine (HBM Mixture) is usually considered the drug of choice for most carnivores and herbivores. With the availability of an antidote, the convenience of this mixture has increased. However, etorphine is the most popular drug used for chemical immobilization of most species in Africa and other countries. As the project is aiming to access technical support from Africa, it will be wiser to go for etorphine in this project. In African buffalo, the dosages of 1mg of etorphine per 100 kg of buffalo is being used, allowing group dosage decisions of 6-9 mg for adults, 3-6 mg for sub adults and 1-2 mg for juveniles. The African experts have suggested starting doses of the same level for gaur as well. If the required knock down times is less than 10 minutes after administration of the drug, then these dosages could be considered. A knock down time averaging no more than five minutes shall be attempted.

The experience of the African scientists also has been that with a reversible drug it is better to go slightly heavy on the dose than it is to go light because in that case the animal can be got quickly and could be reversed if required. If dosage is light the animal could run too far too quickly and capture myopathy is inevitable. It is expected that the gaur being a black skinned animal will also overheat really quickly. Animals under a light dose typically

have stiff legs and necks rendering them very difficult and dangerous to handle for loading purposes.

(VII) Recovery from the Field Procedure: After immobilization the gaur is dragged or rolled onto an aluminum sled/stretcher and lifted onto the back of the 4x4pick up truck. A recovery team of at least 12 men with one specialist and team leader is required per gaur. Some mechanical assistance for the loading procedure will be useful, with sliding rails and winches attached to each recovery vehicle and then winching the sled/stretcher straight onto the recovery vehicle. Men are still required to get the gaur onto the sled and clear any obstructions etc.

The gaur is then driven to the recovery and loading pen and off loaded and the antidote administered. The recovered gaur is then moved into the holding and loading section of the pen. A short acting tranquillizer must always be administered with any long acting tranquillizer at the start of the required tranquilization period. The short acting drug then initiates the sedative effect until the long acting one can maintain the sedation.

Once all the gaurs are in the pen, the decision to load for transport can be taken. This decision will include two things:

- Full recovery from the effects of the capture process.
- Sufficient time for the long acting tranquillizer to have taken effect on all of the animals before the loading can take place.

This period is typically 24-48 hrs.

(VIII) Transportation : The gaurs are now coaxed down the chute and up the loading ramp into the transport trucks. Two transport trucks are needed with capacity to fit five gaurs per truck. The drivers and escorts are then in control until their destination. One specialist, one vet and one support or recovery vehicle should accompany each truck. One departmental vehicle to provide escort and communication at all times is required to follow the convoy.

It is important that the drivers do not swerve and brake hard all the time as this will knock the gaur off their feet and cause real problems for their well-being.

Sudden noise such as hooting is also really stressful for animals in transit and these issues will have to be addressed locally on the road.

(IX) Release: The gaurs are off loaded into the post-transport pens for recovery from the effects of the transport. Once all the gaurs are in the pen and have

completely recovered from the sedation they are ready for release into the enclosure. The pen gates (at least 4) are opened early in the morning and the animals left to find their own way out. Hidden photographers and cameras will record this historic event.

(X) Risks and Threats: The operation has to contend with the following procedural as well as post procedure uncertainties:

1. Some mortality or injury during chemical capture and transportation is possible either from the effect of drugs or from accidents.
2. The gaur population has been susceptible to various contagious diseases such as anthrax, rinderpest and foot and mouth disease. Hence the reintroduced animals can be vaccinated during capture operation so that the threat of losing this population to diseases is considerably reduced.
3. Wherever gaurs and tigers are found together, tigers are known to predate upon gaurs, especially the young calves. This is another major threat. But since the source population is from Kanha National Park, it is adapted to co-exist with tigers and hence capable of surviving in the presence of tigers.
4. The reintroduced stock may disperse, with or without herd formation, and disappear without reproducing in the new surroundings. Also they may breed for a few years then stop breeding and gradually disappear. Or else, they breed but do not spread and eventually disappear entirely.
5. The reintroduced population may need addition of new animals at different intervals to maintain a viable population over a long-term basis.

6. MONITORING

Monitoring of the reintroduced population is a must to analyze the factors associated with success or failure of its survival. The most common method for monitoring the individuals would be collaring both by radio and satellite collars of all the adult bulls and a selected number of cows and calves, if breeding takes place.

The health, behaviour, movements, interaction with other species shall be continuously monitored through a team of wildlife biologists, who will be part of the team to be constituted for project implementation. The Wildlife Institute of India or some other institution involved in wildlife research, shall be approached to become partners in the project to provide scientific inputs both for planning and implementation of gaur reintroduction, as well as for monitoring and establishment of reintroduced animals. Latest equipments and techniques shall be used for monitoring.

Based on results of monitoring, corrective measures can be taken for the welfare of the reintroduced stock.

7. PROJECT COST

The estimated cost of the plan is around Rs. 335.00 lakh. The details are provided in **Appendix-II.** These are very broad, indicative estimates, mainly to understand the scale of operations. Actual estimates, based on detailed planning, may be significantly different from these estimates.

8. TECHNICAL AND FINANCIAL COLLABORATION WITH & BEYOND AND TAJ SAFARIS

As mentioned above, there is limited, if any, experience available in India in undertaking such ambitious reintroduction programs, while translocation of big game is a routine management activity in Africa. Therefore, technical collaboration with experienced experts in Africa will be required to implement the project successfully. The estimated cost of the project is too high for the department to be able to finance it conveniently out of its own resources. &Beyond (previously known as The Conservation Corporation of Africa (CC Africa), which is a well known wildlife tour operator in South Africa, has informally indicated its interest in the project. The company owns its own private game reserves in Africa and has vast experience in such operations. One of their experts has already visited India for consultations with the department. They have offered to provide on-the-job training to the forest department staff, advise the department in the technical specifications of the infrastructure and equipment required, provide expert services during actual operations etc. free of cost. They have even offered to finance the project substantially, in partnership with their Indian partners, the Tata Group, through donation of vehicles etc. However, their formal participation shall be discussed, after the project is approved by the government. A letter of support from &Beyond previously known CC Africa and partner Taj Safaris, on the project is attached as **Appendix-III.** Mr. Les Carlisle is likely to be the technical advisor for the project.

9. MAN POWER AND TRAINING

The department has recently constituted regional wildlife rescue squads, equipped with immobilization facilities etc., to respond to emergencies related to wildlife. On the same lines a Central Wildlife Capture and Transportation Unit shall be constituted to undertake such operations in future. The unit shall be trained in all aspects of the job by the &Beyond (CC Africa) and Taj Safaris experts. It will consist of one senior park manager, one veterinarian and two or three technical officers (Assistant Conservator of Forests or below). As the department does not have its own cadre of veterinarians, an officer on long-term deputation to the department from the Department of Veterinary Services shall be deputed for the purpose.

10. PROJECT DURATION

The project is proposed to be implemented over 3 years, including the monitoring period. The operation is proposed to be carried out in the month of June-July 2007.

FOOD AND WATER REQUIREMENT OF GAUR

Gaur is a generalist feeder but prefers to browse in dry season and predominantly graze in monsoon. Their diet chiefly includes shoots and foliage of trees, shrubs and buds, fruits of species like *Diospyros melanoxylon* and *Aegale marma/os*, tender seeds of bamboo, herbs, grasses and bark of trees like *Adina cordifolia* and *Tectona grandis*. They visit salt licks periodically. Being an obligatory drinker, gaur needs water every day and may visit water bodies twice a day during the hottest periods. During the hot hours of the day gaur retire to the shelter under thick tree cover and ruminate. Feeding is more predominant during the early morning and evening hours. On an average they feed for 15-18 hours a day.

During the study done by WII in Pench Tiger Reserve, a total of 78 species of gaur food plants belonging to 28 families were recorded. Of the food plants recorded, family Leguminoseae accounted for the highest number of individuals (18%) followed by Gramineae (15%). Direct feeding observations showed that the browse formed a major proportion in the diet of gaur during summer (grass: browse ratio, 1:3). A total of 11 tree species, 3 shrubs, 3 climbers, 4 grasses and 1 herb species were recorded as summer food plants of gaur. The availability of food plants of gaur in Bandhavgarh Tiger Reserve is given below.

In the year 1982-83, the gregarious flowering of bamboo (*Dendroca/amus strictus*) took place in Bandhavgarh National Park. As a result, the regeneration of bamboo came up profusely. At present, the regenerated bamboo plants have become shrubby and bushy. They provide good and ample forage to almost all herbivores species. As bamboo is a preferred food plant of gaur, there is abundant food availability for gaur in Bandhavgarh Tiger Reserve.

The long, prehensile tongue of gaur is well adapted for browsing. Gaur prefers green grass when available but even feeds on coarse, and buds, fruits of trees like, *Aegale marma/os, Bauhinea spp., Cassia fistula, Cordia myxa, Diospyros melanoxylon, Emblica spp., Gmelina arborea, Terminalia bellerica* and *Randia dumetorum* (Krishnan 1972, Brander 1923, Schaller 1967, and Pasha 1999). The tender seeds of bamboo and herbs also contribute to the diet of gaur. The gaur also feeds on bark of many tree species. In central India the gaur is reported to feed on the bark of *Adina cordifolia* (Brander 1923 and Schaller 1967) and in Mysore on the bark of *Wendlandia natoniana*. Sanderson (1983) reports gaur of eating the bark of *Phyllanthus emblica.* During the summer season teak (*Tectona grandis*) debarking by gaur is a well-know phenomenon in central Indian highlands (Ranjitsinh 1997 and Pasha et. al. 2000 a).

Food Plants of Gaur Available in Bandhavgarh Tiger Reserve

S.No.	Species	S.No.	Species
1	*Ougenia dalbergioides*	26	*Casearia tomentosa*
2	*Diospvros melanoxvlon*	27	*Adina cordifolia*
3	*Bauhinia racemosa*	28	*Mitragyna parviflora*
4	*Grewia tiliaefolia*	29	*Randia ulignosa*
5	*Flacourtia ramontchii*	30	*Randia dumetorum*
6	*Aegle marmelos*	31	*Nyctanthes arbortristris*
7	*Bridelia retusa*	32	*Holarrhena antidysenterica*
8	*Cordia mvxa*	33	*Vitex spp.*
9	*Zizyphus xylopyra*	34	*Lantana camera*
10	*Kvdia calycina*	35	*Emblica officinalis*
11	*Abutilon indicum*	36	*Euphorbia hirta*
12	*Indigofera arborea*	37	*Ficus hispida*
13	*Millettia auriculata*	38	*Madhuca latifolia*
14	*Desmodium spp.*	39	*Curcuma reclinata*
15	*Abrus precatorius*	40	*Asparagus racemosus*
16	*Butea superba*	41	*Phoenix spp*
17	*Dalbergia paniculata*	42	*Dicanthium spp.*
18	*Bauhinia vahlii*	43	*Andropogon spp.*
19	*Cassia tara*	44	*Sorghum haplense*
20	*Albizzia odoratissima*	45	*Apluda mutica*
21	*Albizzia procera*	46	*Cynodon dactylon*
22	*Anogeissus latifolia*	47	*Chloris dolycostachya*
23	*Terminalia ariuna*	48	*Cyperus spp.*
24	*Terminalia tomentosa*	49	*Themeda spp.*
25	*Syzygium cumini*		

Appendix-II

BROAD COST ESTIMATES

Particulars	Cost (Rs. in lakhs)	Remarks
A- Development of Infrastructure		
Construction of reinforced chain link fencing 5 kms @ Rs. 15.00 lakh/km /	75.00	100 to 150 ha
Path along the chain link fencing 5 kms Rs. 5000/km	0.25	
Construction of Recovery/Loading pen in Kanha NP	1.00	50 by 50 m
Construction of Temporary Holding Pen *(Boma)* in BNP	5.00	100 by 100 m
Construction of Temporary quarters for watch and ward	4.00	Two units
Sub Total A	**85.25**	
B- Equipment, Vehicles etc.		
4x4 pick-up trucks 3 Nos.@ Rs. 10.00 lakh	30.00	To be suitably modified
Transport vehicles 2 Nos. @ Rs. 20.00 lakh	40.00	To be suitably modified
Escort cum field Vehicle 1 No. @ Rs. 10.00 lakh	10.00	
Immobilization equipment, Accessories and Drugs	10.00	
Radio/Satellite Telemetry Equipment	20.00	
Computers, accessories and software	10.00	
Misc. Equipment and Consumables	0.75	
Sub Total B	**120.75**	
C- Personnel		
Field assistances 2 @ Rs. 10000/month	7.20	
Labourers 4 @ Rs. 5000/month	7.20	
Drivers 1 @ Rs. 10000/month	3.60	
Sub Total C	**18.00**	
D- Other expenses		
POL and maintenance of vehicle	30.00	POL costs shall vary between and active and passive phases of the project
Training and international travel of	10.00	
Indian staff Consultancy Technical Support	10.00	
Seminars and Conferences	5.00	
Research and Monitoring	20.00	
Habitat Improvement	20.00	
Casual Labour	1.00	
Unforeseen Expenses @ Rs. 5.00 Lakh/annum	15.00	
Sub Total D	**111.00**	
GRAND TOTAL	**335.00**	

PERMISSION LETTER FROM GOVT. OF INDIA

NATIONAL TIGER CONSERVATION AUTHORITY

(STATUTORY BODY UNDER THE MINISTRY OF ENVIRONMENT & FORESTS, GOVT. OF INDIA)

Dr. RAJESH GOPAL
Addl. P.C.C.F. & Member Secretary

Bikaner House, Annexe-V,
Shahjahan Road, New Delhi-110011
Tele Fax: 011-23384428
Email: dirpt-r@nic.in

No.1-17/2010-NTCA Dated the October 6, 2010

To

The Chief Wildlife Warden,
Madhya Pradesh,
Van Bhavan,
Bhopal.

Subject: Translocation of gaur from Kanha Tiger Reserve to Bandhavgarh Tiger Reserve regarding..

Reference: (1) Letter No.1-4/2007/WL-I, dated 19-9-2007 from the Wildlife Division, Ministry of Environment & Forests, Govt. of India.
(2) Letter No.1-4/2007/WL-I, dated 3-2-2010 from the Wildlife Division, Ministry of Environment & Forests, Govt. of India.
(3) Endorsement No. Tech-I/2010/3363, dated 13-7-2010 from the CWLW, Madhya Pradesh.
(4) Letter No. Estab/4806, dated 5-10-2010 from the CWLW, Madhya Pradesh.

Sir,

Reference is invited to the correspondence cited above. In view of the steps taken by the State for complying with the preconditions laid by the Ministry of Environment & Forests for translocation of gaur from Kanha to Bandhavgarh Tiger Reserve, I am directed to convey the permission for carrying out the said translocation in accordance with the approval granted vide reference first cited, subject to the conditions contained therein.

Yours sincerely,

(Dr. Rajesh Gopal)
APCCF & Member Secretary (NTCA)

Copy to : (1) APS to MEF
(2) PPS to Secretary (E&F)
(3) PPS to DGF & SS
(4) IG (Wildlife), MoEF

(Dr. Rajesh Gopal)

Copy for information to:

(1) PS to the Chief Secretary, Govt. of Madhya Pradesh, Bhopal.
(2) PS to Addl. Chief Secretary, Forest Department, Govt. of Madhya Pradesh, Bhopal.
(3) PS to PCCF, Madhya Pradesh, Bhopal.
(4) Field Director, Kanha/Bandhavgarh Tiger Reserves.

(Dr. Rajesh Gopal)
APCCF & Member Secretary (NTCA)

ACTION PLAN FOR GAUR TRANSLOCATION

As agreed on the 26th May 2008 at Phinda Mountain Lodge, South Africa

Team Members: Aseem Shrivastava, Field Director Bandhavgarh Tiger Reserve Umaria, MP. (Team Leader), Subharanjan Sen, Deputy Director Kanha Tiger Reserve, Mandla, MP., Mr. A. K. Nagar, Deputy Director, Panna Tiger Reserve, Panna, MP., Dr. S.K. Gupta, Veterinarian, Panna Tiger Reserve, Panna, MP., Dr. Parag Nigam, Veterinarian, Wildlife Institute of India, Dehra Dun, Les Carlisle, Group Conservation Manager, andBeyond, Sarath Champati, Chief Naturalist & Head-Training, Tajsafaris and Kartikeya Singh Chauhan, Head Naturalist, Mahua Kothi.

Inputs From: Dr. Dave Cooper (KZN Wildlife), Mr Jeff Cooke (Head Game Capture, KZN Wildlife), Dr. K. Sankar (WII Dehradun)

- **Pre-capture Requirements**

  Man Power

  1. Identify the capture team and external resource persons
  2. Assign roles to each of the members of the capture team
  3. Scenario training and drills
  4. Check lists and sequencing of events
  5. Amount of man power required will be determined by the above points
  6. Recruitment of research personnel by July 2008

- **Pre-capture Process**

  1. Pre-capture workshop to be held in Kanha in August.
  2. Three or four animals to be immobilised and loaded to test the feasibility of drugs, team and the technique (This is to validate the current procedures to be applied in context to parks in Madhya Pradesh). These animals may be selected from different herds and different areas.
  3. These three or four animals to be deployed with radio transmitters for gathering behaviour information and movement patterns pre and post capture. (MP forest dept. to fund telemetry equipment procured through Wildlife Institute of India)
  4. Licences to import drugs to be procured ASAP.
  5. Health, Genetic and Disease samples to be taken when the animals are immobilized, and would inform the translocation decisions.
  6. Additional equipment required for monitoring immobilized animal to be procured (Pulse oxy-meter, Suction unit, laser thermometer, endo-tracheal tube)

List of drugs suggested by Dr. Dave Cooper, Wildlife Veterinarian, Kwazulu Natal Wildlife Services, agreed by the team, necessary procurement policies to be followed.

ITEM	REQUIRED Units
LENTRAX 100 ml @ 20 ml/gaur	6vlx100 ml
STRESNIL 100 ml @ 3 ml/Gaur	2vlx100 ml
PERPHENAZINE 20 ml @ 3 ml/Gaur	3vlx20 ml
NALORPHINE 10 ml	1vlx10 ml
NALTREXONE 20 ml	1vlx20 ml
DOPRAM	2
A3080 100 mg @ 6 mg/Gaur	3 mg
Diprenorphine HCL	6

Alternatively use of existing capture drugs to be used.

- **Capture Process**

1. Thorough pre-operation briefing to be conducted.
2. Darting will be done from the vehicles/elephant back.
3. The immobilised gaur will be loaded on to stretchers and pulled by the elephants to the nearest road when in inaccessible position.
4. The gaur will be revived in the recovery vehicle if required.
5. The gaur will then be offloaded in the holding boma.
6. This process will be duplicated until we have sufficient gaur for translocation.

- **Release Quarantine Pens at Bandhavgarh National Park**

1. Pen will be 100 hectares
2. The pen will be electrified on the inside and the outside
3. On the inside the electrics will be two strands set at 1 m and 50 cm above the ground, and offset at a 15 cm from the fence
4. The electric fence on the outside will be tiger proof and will consist of four strands, 20 cm, 75 cm above the ground and top of the fence with the last strand running along the top of the poles.
5. The offloading ramp will be at a 30^0 slope, 1.4 m high and 2.5 m wide.
6. The pen will have water for the animals.

7. Feed will be supplemented if necessary.

8. The fence will duplicate boundary chain link fence of Bandhavgarh.

9. The pen will have patrolling roads on the inside and outside of the boundary.

10. Boundary fence to be patrolled by the management vehicles at least twice in a day.

11. Two gates at two different places 3 m wide to access the release pens (Gates to open inside the release pens)

12. Final release of the gaur into Bandhavgarh to be accomplished by removing 60 meters on one side of the pen.

13. The final drive must be undertaken slowly and carefully to allow the gaur to walk out and not run out.

14. Access will be limited to authorized people only.

- **Holding *Boma* at Kanha National Park**

1. *Boma* will consist of steel sections 2.5 m high by 3m long made out of 50 mm x 75 mm x 3 mm rectangular hollow tubes

2. 1.5 m of the steel section will be solid 2 mm pressed steel plate horizontal steps to be pressed into each steel section.

3. Each steel section will consist of full 2.5 m high 3 verticals at 750 mm (50 mm x 50 mm x 3 mm) and one horizontal at 1.5 m (50 mm x 50 mm x 3 mm) intervals.

4. 1m expanded metal above the steel section welded to the front of the frame above the solid steel, with the smooth section facing inside the *boma*.

5. 6mm flat bar brackets with 30 mm holes reinforced with 6 mm gusset to be welded at 300mm from the top and bottom of the frame on the left hand side and 400 mm from the top and bottom of the frame on the right hand side.

6. The connecting bolts will be made of 25 mm round bar, 300 mm long and tapered on one end.

7. 15 sections to be made.

8. **Sliding gates:** Three sliding gates to be supplied 1.5 m wide sliding on a 3 m rail and 2.5 m high.

9. Gates will be made of 50 mm x 50 mm hollow square tubes with three rollers

10. Gates will be solid with 2 mm pressed steel

11. Provision to be made for solid shade cloth above the gate to the same height as the rest of the *boma*.

12. Provision to be made for the walkways to be attached to every section 300 mm wide and full length of the section, 1.5 m and 2 m high.

13. **Loading ramp:** To be two 3 m sections, solid pressed steel full 2.5 m height. The same walk way to be specified for the other sections. Floor to be attached at the base of 3 m sections. Three supporting arches to be attached at the top, made of 25 mm round bar.

14. Woven rubber mat floor bolted with flat iron stripes.

15. Two section to be tapered from a 3 m base at an angle of 65^{0} to accommodate the loading ramp.

16. Transport Trucks (LPT 1615) in standard container flat bed configuration with twist locks set at standard 6 m container distances.

17. Transport Truck (407 4x4) to be fitted in standard container flat bed configuration with twist lock set at 3 m container distance.

- **Transport Trucks/Containers**

1. Standard container length of ±6.7 m.

2. The roof of the container to be minimum of 2.2 m internal height.

3. Two external doors, one on the right rear side and one on the front right side of the front compartment.

4. Doors to be 1.2 m wide suspended from 2.4 m rail with rubber stoppers to prevent over opening or over closing.

5. Each door to be provided with U shaped locking mechanism.

6. Each door to be suspended by two 500 kg (minimum) rollers

7. Bottom of each door to run behind 6 mm steel flat bar.

8. 'D' rubber to be attached below each door extending beyond the opening

9. 4 hatches to be provided in centre of the roof, 75 cm wide.

10. Hatches to be raised and waterproof

11. Latches to be provided to lock the hatches open.

12. 1 adjustable partition with sliding door to be provided in each compartment

13. Centre compartment sliding door to be operated from the outside.

14. All sliding doors to be standard at 1.2 m wide made of solid steel.

15. Four side hatches 30 cm x 70 cm to be provided on both sides just above of the base of the wall, except for the front right compartment, only one hatch to facilitate the opening of the sliding door.

16. Lower container wall to be cut by 4 cm to allow free flow of urine.

17. Floor to be woven rubber mat bolted down with flat bar at 1.5 m interval or alternative non slip surface.

18. Outside of the roof to be painted white and anti-skid surface (sprinkle sand on wet paint) applied.

19. Roof to be tapered by 5 cm from raised centre to side walls.

20. 50 mm hollow tube to be welded between verticals to form a ladder to climb onto the roof.

21. 75 cm mechanical louvers to be provided along both sides

22. 50 mm high density foam to be attached to the roof between supports to insulate the roof

- **Recovery Truck Design (Tata 407 4 x4)**

1. Container half the size of the main truck 3.35 m

2. 1 rear door and one side door as per above

3. 1 adjustable internal partition as per above

4. Roof as per above

5. Side walls as per above

6. All as per above

- **Stretcher**

1. Outside width of the stretcher not to be more than 110 cm.

2. 3 cm diameter pipe holding rail full length on both sides

3. Four 4 cm hollow pipe cross members, equally spaced.

4. Four 3 cm extensions specified to fit into the 4 cm cross members, 3 m in length.

5. 90 cm wide double canvas cover to be provided for the full length of the internal 90 cm wide poles. This canvas to have eyeholes along the full length on both under sides to allow stitching of canvas.

6. Runners of 4 cm diameter pipe, to be welded underneath the 90 cm bearers on 10 cm supports.

7. Two stretcher rails made of 5 cm channel iron, 90 cm centres braced at 1 m from each end, designed to fit into the door slots under the doors lower rail.

8. Length of the stretcher to be 2 m.

- **Calendar of Activities**

June

- 407 (4x4) truck flat bed with twist lock in the corners to be appropriated (Sarath)
- Big truck flat bed with twist lock to be ordered (Sarath)
- Recruitment of researchers by the end of month (Dr. Nigam, WII)

- Stretcher to be fabricated by end of month (Mr. Sen, KTR)
- Process for drug procurement licence to be initiated ASAP (MPFD & WII)
- Fabrication of holding boma steel sections and loading ramp (Mr. Sen, KTR)
- Holding bomas to be finished by end of August.

July

- Fabrication of containers on 407 and Big truck.

August

- Release boma to be completed in Bandhavgarh
- Pre-capture workshop to be held in Kanha.
- Trial immobilization and radio collaring of 3-4 animals to be completed before 20th August.

September

- Monitoring of gaur to continue

October

- Assess whether project is possible in November

November

- If conditions and location of gaur is unsuitable postpone operation till February 2009.

Mr. Aseem Shrivastava _____

Mr. Shubaranjan Sen _____

Mr. A K Nagar _____

Dr. Parag Nigam _____

Dr. S K Gupta _____

Mr. Les Carlisle _____

Mr. Sarath Champati _____

Mr. Kartikeya Singh _____

SIMULATION OF GAUR POPULATION VIABILITY AT BANDHAVGARH TIGER RESERVE

The action plan as prepared by the Madhya Pradesh Forest Department envisaged capture and translocation of 20 gaurs (15 adult females and 6 adult males) from Kanha Tiger Reserve, Madhya Pradesh and re-introduction in Bandhavgarh Tiger Reserve, Madhya Pradesh. It was proposed to hold the animals in to a small pen (100 X 100 m), called *Boma* in Bandhavgarh, for pre-release observations and subsequently release them in to a large enclosure (100 X 150 ha) for approximately 2 months, for acclimatization and social bonding. After 2 months, the animals will be released in to the National Park (southern side of the Tala range or on the northern side of the Magdhi range). The plan also envisages, after careful monitoring of the reintroduced stock, to bring in more gaurs to Bandhavgarh, on a later date/stage, to maintain a viable population of approximately 50+ animals.

In view of the above proposal, a simulation of gaur Population Viability in the re-introduced population in Bandhavgarh was assessed in 2 scenarios at the Wildlife Institute of India, Dehradun:

1. Reintroduction of 50 animals with a sex ratio of 60% females and 40% males.
2. Reintroduction of 20 animals with the same sex ratio and subsequent supplementation of 30 more animals at an interval of 10 animals/2years.

The results of the analysis are shown in **Analysis report 1.** The simulation of scenarios indicate that reintroduction of 50 gaurs will survive well with natural predation (Fig 1, Analysis report 1). In case a small population is introduced (20 or less), care needs to be taken to reduce excess predation. Simulation indicates that excess predation of just one adult female in initial population of 20, that has shown an initial growth rate of 3.5% and later -5.4% (Fig. 3, Analysis report 1) with an extinction probability of 97% thereby the population going extinct in 14-16 years time (Fig. 3, Analysis report 1). The scenario with predation of one adult female and supplementation of 30 animals at an interval of 10 animals/2years (6 females and 4 males) has shown growth rate 5.04% and the probability of survival is 99%. Thus, it is important to have predator-proof fencing and maintain population of 15 to 20 animals in fence for future supplementation. The supplementation of 5 to 10 animals at an interval of 2 to 4 years will reduce any predation or disease related catastrophes. The gaur population is susceptible to most of the livestock related diseases and local extinctions in Indian sub-continent have been ascribed to diseases and habitat loss.

The reported Male: Female ratio in gaur in Kanha (Schaller 1967) and Pench (Sankar *et al* 2000) is 80:100 and 60:100 respectively. The reported Female: Calf ratio in gaur in Kanha (Schaller

1967) and Pench (Sankar *et al* 2000) is 100:42 and 100:24 respectively. Hence it is suggested that the male:female:calf ratio of gaur to be translocated to Bandhavgarh from Kanha to be 70:100:30. This may be further amplified as 7 males (3 adult males, 4 adult females), 10 females (6 adult females, 4 sub-adult females) and 3 calves.

The percentage frequency of gaur remains in tiger scats varied from 8.3% to 17.4% in Kanha (Schaller 1967) and Nagarhole (Karanth and Sunquist 1995) respectively. Since, there may be predation on the re-introduced gaur population by tiger and leopard, it is suggested that not all the 20 gaurs should be released in to wild. Instead, it is proposed to release 2 adult males, 2 sub-adult males, 4 adult females, 2 sub-adult males, and 2-3 calves in the beginning. It is recommended to keep an adult bull, 4 adult females and 2 sub-adult females in the enclosure to maintain a breeding stock, and the same may be released in 2-3 installments in to wild over a period of 1-3 years, to make the re-introduction programme a success.

The Wildlife Institute of India (WII) has been recommended by the Madhya Pradesh Forest Department to become a partner in the project to provide scientific inputs both for planning and implementation of gaur re-introduction, as well as monitoring and establishment of re-introduced animals. The MoEF, Govt. of India, endorsed the recommendation of Madhya Pradesh Forest Department, to involve WII in the entire translocation and re-introduction of gaur.

It is proposed to fit 2 adult male gaurs with satellite collars and 13 adult females with VHF collars (make Telonics, USA). Studies conducted by WII in Pench Tiger Reserve, Madhya Pradesh revealed that an adult male gaur traveled in a day up to 19 km and had annual home range of 300 km^2. Hence, it is proposed to fit satellite radio-collars on 2 adult gaur males. The radio-collared gaurs (n=15), may be monitored for 3 years by a research team of WII comprising of 2 research fellows, 2 field assistants and 2 forest officials in Bandhavgarh by homing-in and triangulation techniques. Approximately 40 radio-locations of each radio-collared individual may be collected per season. On each animal location, major vegetation types, terrain, other habitat variables, distance to water, distance to human habitation, distance to road etc., may be recorded. While monitoring, the food plants eaten by gaur may be recorded to study their food habits.

GAUR POPULATION VIABILITY ANALYSIS

The simulation was run for following scenarios:

1) Reintroduction of 50 animals with a sex ratio of 60% females and 40% males.

2) Reintroduction of 20 animals and subsequent supplementation of 30 more animals at an interval of 10 animals/2years.

All scenarios were simulated with option of predation and no predation proof options.

1) Reintroduction of 50 animals with a sex ratio of 60% females and 40% males :

In 100 simulations of Population all survived, with a probability of success of 1.0000 **(Figure 1)** with adult sex ratio of 73 males/100 females in 100 years. Mean growth rate (r) was 0.0459 (0.0006 SE; 0.0590 SD). The deterministic growth rate was 5.3.

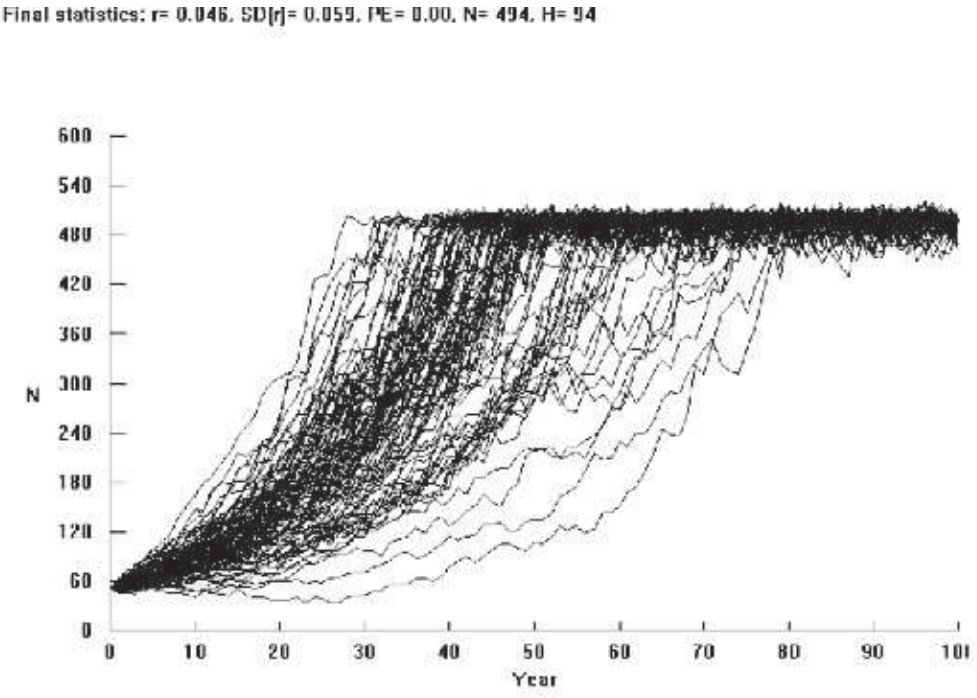


Figure 1: Simulations (100) for 50 reintroduced gaur over 100 years.

We added one adult female predation every year, this scenario gives a probability of extinction of 0.2900 (0.0454 SE).

2) Reintroduction of 20 animals and subsequent supplementation of 30 more animals at an interval of 10 animals/2years:

In 100 simulations of Population for 100 years, the population recorded growth rate of 3.5% (SE 0.08) **(Figure 2)**. Six went extinct with a probability of over all survival being

0.9400 (0.0237 SE) and adult sex ratio of 76 males/100 females. Mean time to first extinction was 56.50 years (7.24 SE, 17.73 SD).

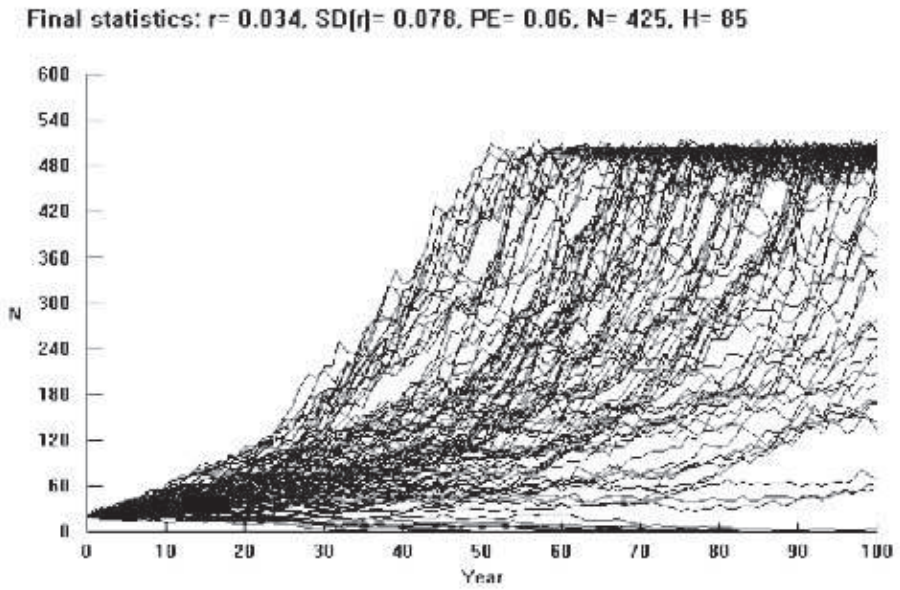


Figure 2: Simulations (100) for 20 reintroduced gaur over 100 years.

Predation

The predation scenario of one adult female every year in 100 simulations has shown probability of extinction of 97% (1.71 SE) the growth rate was -5.4% (SE=0.032) **(Figure 3)**. Median time to first extinction was 14 years and mean was 15.90 years (0.73 SE, 7.22 SD).

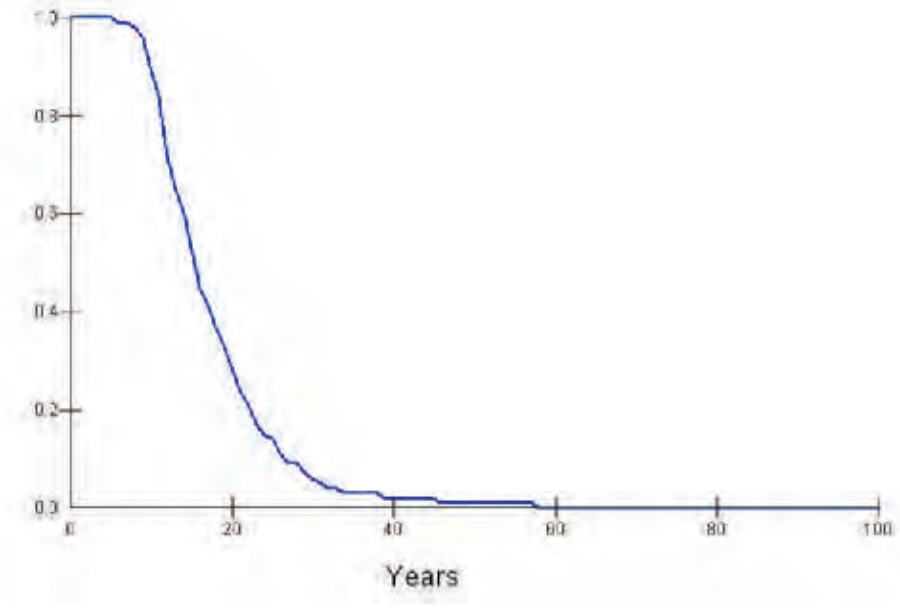
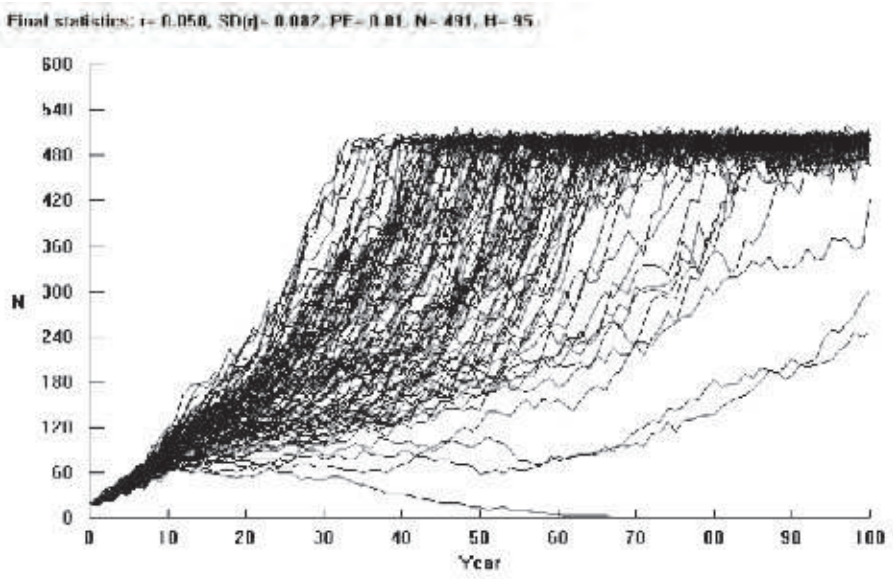


Figure 3: Probability of survival of gaur with a scenario of 1 adult female is predated every year with initial growth rate of 3.5 %.

Supplementation

The scenario with predation of one adult female and supplementation of 30 animals at an interval of 10 animals/2years (6females and 4 males) has shown growth rate 5.04% (0.08% SE, 8.17 SD). The probability of survival is 99%. The female biased ratio of supplementation will further improve the situation.



The simulation of scenarios indicate that reintroduction of 50 gaurs will survive well with natural predation (Fig 1). In case small population is introduced 20 or less care need to be taken to reduce excess predation. Simulation indicate that excess predation of just one adult female in initial population of 20 with a growth rate of 5% cause high extinction rate (29%). The extinction rate was 97% in initial population of 20. Thus it is important to have predator proof fencing and maintain population of 15 to 20 animals in fence for future supplementation. The supplementation of 5 to 10 animals at an interval of 2 to 4 years will reduce any predation or disease related catastrophes. The gaur population is susceptible to most of the livestock related diseases and local extinctions in Indian sub-continent has been ascribed to diseases and habitat loss.

Parameters used for simulating various scenarios.

1. population(s) simulated for 100 years, 100 iterations

Extinction is defined as no animals of one or both sexes.

Inbreeding depression modeled with 3.14000 lethal equivalents per individual, comprised of 1.57000 recessive lethal alleles, and 1.57000 lethal equivalents not subject to removal by selection.

EV in reproduction and mortality will be concordant.

First age of reproduction for females : 3 for males: 4

Maximum breeding age (senescence) : 15

Sex ratio at birth (percent males) : 50 and 20

Population 1: Population 1

Polygynous mating;

% of adult males in the breeding pool = 40

% adult females breeding = 60

EV in % adult females breeding: SD = 10

Of those females producing progeny, ...

Mean number of progeny per breeding female per year = 1

SD in number of progeny = 1

% mortality of females between ages 0 and 1 = 40

EV in % mortality: SD = 5

% mortality of females between ages 1 and 2 = 10

EV in % mortality: SD = 2

% mortality of females between ages 2 and 3 = 8

EV in % mortality: SD = 2

% mortality of adult females (3<=age<=15) = 4

EV in % mortality: SD = 1

% mortality of males between ages 0 and 1 = 40

EV in % mortality: SD = 10

% mortality of males between ages 1 and 2 = 20

EV in % mortality: SD = 5

% mortality of males between ages 2 and 3 = 10

EV in % mortality: SD = 2

% mortality of males between ages 3 and 4 = 8

EV in % mortality: SD = 1

% mortality of adult males (4<=age<=15) = 4

EV in % mortality: SD = 1

EVs may be adjusted to closest values possible for binomial distribution.

Initial size of Population 1: 50

(set to reflect stable age distribution)

Age	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total	
	3	3	2	2	2	2	1	2	1	1	1	1	1	0	1	23	Males
	3	3	3	2	3	1	2	2	1	2	1	1	1	1	1	27	Females

Carrying capacity = 500

EV in Carrying capacity = 50

VETERINARY PROTOCOLS FOR CAPTURE & TRANSLOCATION OF GAUR *(Bos gaurus gaurus)* FOR THE PURPOSE OF REINTRODUCTION FROM KANHA TIGER RESERVE TO BANDHAVGARH TIGER RESERVE

JANUARY 2011

Partners: Madhya Pradesh Forest Department, &Beyond (formerly known as CC Africa) and Wildlife Institute of India

Compiled by:

Dr. Parag Nigam, Scientist, Wildlife Institute of India, Dehradun, U.K., India

Dr Dave Cooper, EKZN Wildlife Veterinarian, South Africa

1. **Location of the animal and observation for selection and suitability:** The herds identified for translocation will be tracked by the MP Forest Department team. This will be done employing captive elephants, vehicles as well as foot patrolling teams. Due consideration will be given for terrain and habitat where visibility is maintained for 10-15 minutes in case the animal moves following darting. GPS locations of the herds/ animal following darting would be recorded. Trackers will also be deployed to observe the movement of the animal following darting. Behavioral aspects such as excitement etc will also be considered. High ambient temperature will be avoided and the operation will be preferred in the early forenoon hours or as deemed fit by the capture team taking due precautions. Visual examination of health any apparent physical injuries of the animal will be done using a binocular. Approximate weight will be assessed for calculation of drug doses. Decision to immobilize animal will be jointly taken by Madhya Pradesh Forest Dept. in consultation with other experts and the veterinary experts.

   Note: All equipment for radio collaring, dealing with emergencies, collecting samples, crating the animal, for transporting the animal and any other procedures would be in place before the animal is darted.

2. **Approach to the target animal:** Captive elephants will be used to approach the animal approximately 25-30 meters with care/caution and an overriding degree of patience. Hindquarters will be preferred for tele-injection as it is a well muscled area. The dart will be projected perpendicular to the target surface to prevent deflection and to ensure deep intramuscular injection.

3. **Equipment and drugs:** Aluminum darts 5-7 ml/Light weight plastic darts of 3-5 ml. capacity using gun powder/air powered projector (Dist Inject Mod 60 N and Dan Inject Mod JM) will be used for remote I/M injection on the hindquarters from a distance of 25-30 meters. Appropriate sized needles would be used. CAPTIVION (Etorphine hydrochloride 9.8 mg/ml) will be used as a drug of choice for sedation and immobilization. Due care will be taken while handling drug to avoid any chance of spillage or accidental exposure. The human drug emergencies during field immobilization is summarized below. The teams will ensure availability of human antidote (Naloxone hydrochloride/ Naltrexone) at all times and in case of any eventuality below mentioned steps would be taken. TREXONIL

(Naltrexone 50 mg/ml) would also be used as an antidote to revive animals off sedation following crating.

Emergency and supportive drug will be kept handy at all times.

A complete immobilization record, particularly including each drug given, amount given, time of administration and physiological parameters would be maintained during the procedure. These details will be recorded in the format provided. It would be appropriate to ensure human safety considerations to meet any eventuality at all the time.

Emergency drugs and equipment would be available during the entire operation. These may include following:

Drugs& Medicaments

Immobilization drugs: Etorphine and Naltrexone-(Available in kit), Xylazaine HCl, Ketamine HCl, Yohimbine HCl

Antibiotics: Fortified Procaine penicillin, Ampicillin-cloxacillin parentral and intra mammary infusion

Emergency drugs: Butorphanol tartrate, Doxapram, Atropine sulphate, Hyaluronidase, Haloperidol, Fluphenazine, Naloxone ,Epinephrine, Prednisolone, Dexamethasone besides haemostyptics, antiseptics, antipyretics, NSAIDs , vitamin-mineral supplements (Details may be worked out in conjunction with veterinarian),

Medical supplies: Oxygen cylinders, Disposable syringes, tuberculin syringes, gloves, surgi-pads, needles, gauze etc.

Equipments

Drug delivery equipment-Projectors/ Jab stick etc.

Thermometer, Stethoscope,

Pulse oximeter with tongue probe

Cattle electric prodder

Suction pump to remove any obstruction in pharyngeal cavity

Endo tracheal tubes with inflatable cuffs size 16,18 mm

Stomach tube, trochar & cannula

Ropes, Torches, swiss tool, water sprayers

Radio-collars, GPS, Binoculars, measuring tapes

Generator/ electric supply at base camp

Communication system

Laboratory equipments : Would be provided by Jabalpur Veterinary College

Sample collection kit: Sample collection vials, vaccutainers (plain and EDTA), storage/ shipment boxes, ice packs, tapes, Zip lock bags etc

Human Drug Emergencies During Field Immobilization

Accidents during drug handling: Wildlife immobilization involves handling and use of drugs Immobilizing drugs are potent poisons and dangerous to both humans and animal if not appropriately used or handled. A person may accidently inject the drug (either to self or to other persons) during loading of syringes/darts or may accidently come in contact with drug during extracting or mixing and even as a result of drug spillage. It is important to avoid spraying, squirting, or spilling drugs when loading. Certain drugs (Fentanyl) can be absorbed through intact skin (as it is often made up in Dimethylsulfoxide); certain drugs (narcotics- etorphine, carfentanil) gain entry through break in continuity of skin (cuts and abrasions) while most of them can be readily absorbed through intact mucous membranes of eye, nose and mouth. All the drugs used in immobilization must always be handled with the greatest of care taking due personal protection. Use of eye protectors and gloves while handling narcotics should always be practiced. It is important that the individuals using or handling immobilizing drugs have a clear understanding of the drug protocols, the dangers associated and the emergency response required. Entire team involved in the operation should also be briefed about the potential hazards of immobilization beforehand.

Accidents during use and handling immobilization equipment and accessories: Accidents may happen during handling of remote drug delivery equipments and the accessories either as a result of their malfunctioning, improper use or even due to operators fault. There are frequent reports though unpublished of individual being exposed to various hazards resulting from improper handling. For example, incorrect placement of syringe charge/improper dart assembly may result in squirting or spilling of drug leading to accidental poisoning; handling of equipment and accessories by inexperienced individual or casual and careless approach on part of experienced operator may result in accidental injection or injury. It is important that only authorized personnel should be allowed to carry loaded and unprotected darts. While handling narcotics, metal darts should only be used to avoid accidental release/squirting of drugs. Metal syringes should be handled with care as accidental bursting of syringe charges has been occasionally encountered. Additionally, the loaded syringes should always be properly marked and appropriately carried to avoid any confusion, inappropriate handling or accidental injuries. Proper care should be taken while handling used darts, syringes and needles to avoid any accidental injection/injury.

Therefore, all darting equipments and projectile syringes/ darts should be used with the utmost care, cleaned and maintained well and used by authorized individuals having necessary skills and experience in handling equipments and accessories.

Prevention and Management

Accidents during field immobilization can be effectively avoided by having a thorough knowledge of the drug protocol and the procedures, awareness on hazards associated with drug immobilization and undertaking preventive measures for personal protection (eye and hands) and during handling (drugs, loaded darts, immobilized animal). A first aid kit is an important component of any immobilization operation to meet any eventuality and should have following:

FIRST AID KIT

Emergency drugs: When narcotics are used atleast 20 mg Naloxone and Naltrexone should be part of the first aid kit besides 250 mg hydrocortisone, 40 mg diazepam (VALIUM), 5 mg atropine, 20 mg adrenalin.

Other medical supplies: Stethoscope, thermometer, intravenous saline (0.9%) solution-2 litres, IV drip set -2, disposable syringes-2,5 & 10 ml, hypodermic needle, 18g & 21g, adhesive plaster and scissors, sterile bandage/gauge 2"& 4", antiseptic lotion and haemostyptics

Medical supplies to meet respiratory depression
Portable Oxygen cylinders with mask, Doxapram HCL (CAROPRAM/ DOPRAM)-4vials and muscle relaxants.

Besides above, communication, transport and medical support aids in responding to any emergencies.

In the event of any accident, the basic principles of management include keeping the patient calm and comfortable, arranging for medical support, limiting drug absorption by washing any contact surface with large quantities of water or application of tourniquet, administering antidotes if symptoms of poisoning are noted, proper positioning of the patient (horizontal sideways position to prevent choking in case the patient vomits or on his back to provide cardiopulmonary resuscitation CPR). A person needs to be trained in providing CPR before hand.

Note: *Antidotes should be given only if there is certainty of administration of etorphine or similar substance and symptoms of poisoning appears. The antidote for narcotic substances can aggravate the condition if given for compounds against which they have no effects, or produce misleading symptoms in subjects who have no need for them. If the symptoms of poisoning do not appear within three minutes after the injection of a narcotic substance or mixture, it is unlikely that treatment with a specific antidote is required.*

Morkel, 1993 suggested mnemonic HAD-ABC as a sequence for responding in case of emergency.

H	Help	Immediately call for help
A	Absorption/Antidote	Limit absorption and give antidote if required
D	Drip	Establish drip as soon as possible if indicated
A	Airway	Establish and maintain adequate airway
B	Breathing	Monitor breathing and apply artificial respiration if needed
C	Circulation	Administer cardiac massage if there is heart failure

Table: Likely drug accidents during field immobilization (Adapted from Morkel, 1993)

Name of drug	Symptoms of poisoning in human	Prevention and Care	Management of accidental poisoning	Remarks
Etorphine hydrochloride M-99, Etorphine + ACP = Large Animal IMMOBILON	Dizziness, in-coordination, nausea, vomiting, pinpoint pupil, slow, shallow or stertorous breathing, cyanosis of mucous membranes, clammy cold skin, sweating, weak or imperceptible pulse due to fall in blood pressure, loss of consciousness, and ultimately coma. Note: As little as 0.1 mg of etorphine may be fatal to an adult man. The depressant effect may be enhanced if combined with sedative	General field precautions as above Always handle drug in presence of another person who is qualified and aware of providing first aid in case of accident. Prior to loading of narcotic into the dart, load Naloxone HCL (NARCAN) in a separate syringe to meet any emergency, if any.	Immediately make the second person aware of the problem and ensure medical supervision at the earliest. If etorphine has come in contact of skin, wash immediately but if it has come in contact with mucous membrane, treat with antidote and wash thoroughly. In case the drug has been absorbed, immediately inject 0.8 mg naloxone (2 ampoule of NARCAN) into the most available muscle, and 0.8 mg into a vein of the forearm. In case of non-availability of naloxone, 5mg naltrexone can give positive results. This may be repeated every three minutes (up to 4 times) until improvement occurs. Keep the patient calm and in shade. The patient should be made to lie on his side in a horizontal position. Take the patient to nearest medical facility at the earliest	Drugs used in wild animals are different from the ones used in human. The medical practitioner may not be aware or knowledgeable about these drugs. It is relevant to provide all the knowledge and information, including package inserts etc.

4. **Induction phase:** The time interval between injection (darting) and the point when the animal is rendered immobile is induction period. The total time for the completion of induction may vary from 7-15 minutes. A close observation will be kept by the team for any movement of the animal.

5. **Handling and care of the immobilized animal:** The animal will be approached quietly and following steps will be followed:

- Approach animal from behind and remove the dart.
- Blindfold the eyes to protect the cornea from direct sunlight, dust and injury
- Assess the state of animal, the degree of relaxation and the rate and depth of respiration. If the respiratory depression is pronounced, a partial dose of antagonist will be used to correct respiration. Signs of immobilization include stumbling, vocalization, sagging of the hid quarters and animal coming in sternal recumbency. It should be ensured that animal is subjected to no disturbance during induction.
- Position of body, head and neck. The animal will be placed in sternal recumbency. This will help prevent the development of ruminal tympany. Ropes may be used to assist in processing the animal. The head and neck will be extended to maintain patent airways.
- Age of the animals will be estimated by standard tooth-wear ptrocedure
- Clear any obstruction, if any from the mouth using suction pump or manually and entubate the animal till collaring and biological samples have been taken.
- Monitoring vital signs. Vital signs such as respiration, heart rate and body temperature will be taken and monitored. Rectal temperatures >40 °C are cause of concern and attempts should be made to cool the animal. The animal has to be specifically monitored for signs of bloat/ tympany. In case of emergency necessary veterinary protocols for management will be ensured. The animal should be monitored for hypoxemia, ideally with a pulse oximeter.
- The animal will be examined for any wounds and injuries and appropriate medical measures will be taken.
- Animals would be subjected to Tuberculin testing in immobilized state. Intra-dermal tuberculin test will be performed following immobilization using PPD.
- Tagging of animals destined for translocation. This would also help in identifying animals showing reaction to tuberculin.

6. **Radio collaring and biological sampling:** This step will involve radio collaring of the immobilized animal and taking all body measurements. Complete physical examination of the animal will be done at this stage followed by collection of biological samples for reference. Following samples would be collected: Blood in vaccutainers (both plain and EDTA) for haematology, serum biochemistry, serology and genetic studies, dung sample in 10% formalin for assessing parasitc load and diet analysis, hair sample without preservatives for genetic and forensic study, nasal swab for culture.

7. **Laboratory Investigations**

   a. **Routine haematology:** at site

   b. Serum biochemistry and serology- to be carried out at Jabalpur Veterinary college

   c. **Disease screening :** FMD, Blue tongue, T.B, H.S, B.Q, Brucellosis, Salmonellosis, endo and ectoparasites, haemoprotozoans- to be carried out at Jabalpur Veterinary college.

   d. **Microbiological examination:** at Jabalpur Veterinary college

   e. **Genetic studies:** at WII

   (Separate budget would be required to carry out laboratory investigations)

8. **Shifting of the animal to stretcher:** The animal will be shifted to a stretcher and placed on sternal recumbency. In case a need is felt, acaricides would be poured/ sprayed on the animal to remove ecto-parasites. Efforts would be made to weight of the animal subsequent to which the animal will be shifted to a transport vehicle placed at road head.

9. **Assessment of anesthesia:** After shifting the animal to a transport vehicle, assessment of anesthesia will be done using following methods:

   - **Monitor tissue perfusion:** Anesthetic drugs frequently depress the contractile force of the heart and vasodilatation results in decreased tissue perfusion. Evaluation of tissue perfusion will be done by observation, auscultation, palpation and capillary refill time. Bison anaesthetized with carfentanil-xylazine have been reported to have slightly higher heart rate (Average heart rates of 75 beats per minute). This information would form a basis in the present case i.e. similar trends may be encountered with Etorphine anaesthesia.
   - **Monitor gas exchange:** Respiratory rates are highly variable during anesthesia. The animal should be monitored for hypoxemia, ideally with a pulse oximeter. Normal hemoglobin saturation is 95-98%; below 85% is considered hypoxemic. Mucus membranes need to be monitored for cyanosis
   - Quality of respiration will be evaluated by observing animal's chest movement.
   - **Monitor CNS depression:** Most effective monitors of CNS depression are evaluation of muscle tone, anal and eye reflexes.
   - Monitor for signs of bloat

   [Caulkett,N. (2001). Bison (Artiodactyla:Bovidae) In: Heard,D (Ed.) Zoological restraint and Aneasthesia. International Veterinary information service (www.ivis.org) Ithaca, New York, USA)].

10. **Managing post immobilization emergencies:** The major emergencies reported include development of bloat, capture myopathy, trauma, aspiration, hyperthermia and hypoxemia. These needs to considered prior to intervention and appropriately addressed.

11. **Reversal of anesthesia:** Specific drugs TREXONIL will be used to reverse the anesthesia once animal is crated.

12. **Transport of animal:** The animal will be transported by specially designed vehicle to holding bomas where they would be released.

13. **Holding animals in Kanha:** The animals will be held in the holding bomas till the result of tuberculin testing and laboratory reports are received. Moreover the animal would be out of any drug effect as re-narcotization has been reported following use of narcotics. Re-

narcotization is not usually a problem if naltrexone is used to antagonize as it has a long half life. It is important to ensure adequate fodder and water in the holding bomas. Animals need to be kept undisturbed in the holding boma. Minimum time for which the animals need to be maintained in holding bomas should range from 48-72 hrs. This would ensure receipt of laboratory results as well as enable to interpret the results of tuberculin test, that may depending on circumstances require immobilization. Animals deemed fit would be crated in the transport vehicles.

14. Transport to Bandhavgarh: Transportation of animals would be initiated during late evenings.Approximate distance between Kanha and Bandhavgarh is 250 km and road journey would take 8-10 hours. The vehicles will be moved at a constant speed avoiding sudden brakes and jerks as far as possible. Animal will be monitored intensively inside the container. Proper measures and equipment will remain in place to deal with any emergencies and management for the best care of the animal.

15. Release of Animal at Bandhavgarh: Once the animals reach destination, they would be released in specially designed enclosures and maintained till they are out of transportation stress, anesthetic effect and show signs of normalcy as evident behaviorally. Subsequently the animals would be released into the wild and monitored intensively as per the proposal/action plan.

16. Additional information:

a. Arrangement for documentation of entire operation (cameras) and necessary press/media briefing will be coordinated by MPFD.

b. MPFD will identify various teams for carrying out the operation.

(Tracking, darting, collaring, biological sampling, laboratory investigations, loading and offloading, logistic upkeep and maintenance, monitoring animal in holding bomas, transport)

c. MPFD will Meeting budget demands for carrying out the laboratory investigations

Darting Area for Gaur

Stepwise details of the proposed operation is as follows:

Plan of operation

Location and selection of the animal. Approach to the target animal, assessment of terrain, visibility and ambient temperature.Visual health examination and observation on behavioural aspects

↓

Remote injection of narcotic and observation on the induction phase close observation for any movement of the animal

↓

Handling and care of immobilized animal, monitoring of sedation physical measurement, biological sampling, radio collaring and measurement of weight

↓

Shifting to transport vehicle using a stretcher and transportation to holding Bomas

↓

Holdling animal in Boma till results of tuberculin testing and laboratory investigations are recieved

↓

Animal transport by Road

↓

Journey time

↓

Animal released in enclosure at Bandhavgarh
(complete examination of the animal, injection of any medicaments if needed)

↓

Monitoring of the released animal in the enclosure

↓

Release into the open forest and monitoring

Note : 1. Medical and first-aid support to be arranged by Madhya Pradesh Forest Dept. throughout the operation

2. Security, law and order during the translocation operation as may be required (civil administration to be arranged by FD, Kanha)

3. Management of communication and public relation by Madhya Pradesh Forest Dept.

DATA SHEET FOR RECORDING AND MONITORING IMMOBILIZED ANIMAL

Area Details Date .....

Location ..... GPS Lat.....Long.....

Collar Frequency/make/colour.....

Purpose of capture .....

Ambient temperature ..... Day (cloudy, bright) .....

Animal Details

Species ..... Physical condition .....

Emotional state before drugging ..... Sex .....

Approximate age ..... Breeding status .....

Weight (kg) Estimated ..... Actual .....

Body Measurements

Nose tip to Base of tail ..... Nose tip to base of horns .....

Tail length..... Dentition/wear & tear .....

Neck girth (U).....M).....(L)..... Chest girth .....

Height (Shoulder blade to heel) ..... Hind limb length .....

Any other signs:

Immobilization Details

Sr. No.	Name of Immobilizing Drug(s)	Time of Injection	Total volume	Route & site	Mg used
1.					
2.					
3.					

Behaviour at the time of darting
(running, walking, standing, excited) .....

Induction time when animal goes down .....

Sequence of events following darting

.....

.....

.....

Animal Monitoring

Time	Signs shown following immobilization	Respiration Shallow/ deep/ irregurlar & rate	Temperature (^{o}F)	Pulse (rate)

Name of reversal Drug (s)	Time of Injection	Drug dose & volume given	Route	Site

Details about recovery event till animal regains consciousness /shows signs of recovery

.....

.....

Name of other supportive Drug(s)/ antibiotic(s) etc. given	Volume used	my used	Route & site

Biological Sampling

Name of sample	Preservative used	Examination required	Handed over to	Remarks

Team Members & Signature

RAPID HEALTH SURVEY PRIOR TO ACTUAL OPERATION

Veterinary Officer, Kanha would carry out a rapid health survey of the different Gaur herds at Kanha. The survey would include body condition evaluation as per the format provided. The location of each herd would be marked and plotted on a map. Additionally dung samples (with GPS locations) would be collected for parasitological and microbiological examination that would be carried out at Jabalpur Veterinary college. VO would liase with the college to get the tests done. The information so collected would help in guiding selection of herds for translocation. The work needs to be carried out during early December so that results are available timely.

Generalized description and evaluation of different parts of ungulates (Adapted from Riney et al, 1960)

BODY PART	POINT=0	POINT-1	POINT-2	SCORE
FLANK AREA	Depression barely visible. Flank area outline is indistinct	Flank area slightly concave & outline visible	Depression concave and tucked in	
RIBS	Thoracic surface is smooth and ribs are difficult to see	Ribs are visible but not all can be counted with ease	Ribs prominent with distince inter-costal depression	
PELVIC GIRDLE	Bony projections of pelvic girdle are barely visible	Pelvic girdle outline slightly visible	Bony projections of pelvic girdle are clearly visible	
VERTEBRAL COLUMN	When seen laterally, it runs smooth without any breaks. Lumbar process visible	Lateral processes of lumbar vertebrae are visible but not prominent	Lateral processes of lumbars very prominent. Dorsal processes of vertebrae seen	
LUMBAR SHELF	No depression in shelf. Appears almost round from behind	Slight depression on either side	Depression deep and concave	
Skin and coat	Smooth and shiny	Skin dry and rough	Haggard appearance, rough and dry	
			Body Condition Index	

Interpretation: 0-4= 'Good'; 5-7= 'Fair'; 8-10= 'Poor'

Body Condition Evaluation form

Protected Area_____ Species_____

Date	Locality	Age & Sex	Scores for different body parts									BCI	Remarks
			1	2	3	4	5	6	7	8	9		

1-FLANK 2-RIBS 3-PELVIC GIRDLE 4-VERTEBRAL COLUMN 5-TAIL CONTOUR 6-LUMBAR SHELF
7-TEMPORAL DEPRESSION 8-SKIN 9-SHOULDER SPINE

Investigator/Signature

LIST OF OFFICIALS INVOLVED IN GAUR REINTRODUCTION

(1) International Experts

No.	Name	Designation
1.	Mr Les Carlisle	Group Conservation Manager, & BEYOND, South Africa
2.	Dr. Dave Cooper	Senior Wildlife Veterinarian, Ezemvelo ,KwaZulu-Natal Wildlife Game Capture Unit
3.	Dr. Jeff Cooke	Head, Game Capture Unit, Ezemvelo KZN Wildlife

(2) MP Forest Department Officials

No.	Officer/Staff Name	Designation
1.	Dr. HS Pabla	PCCF (Wildlife), MP
2.	Shri Dharmendra Shukla	APCCF (Wildlife), MP
3.	Dr. HS Negi	Field Director, Kanha TR
4.	Shri NS Dungriayal	Field Director, Satpura TR
5.	Shri JS Chouhan	Director, Van Vihar NP, Bhopal
6.	Shri Alok Kumar	Field Director, Pench TR
7.	Shri CK Patil	Field Director, Bandhavgarh TR
8.	Shri HS Mohanta	Deputy Director, Kanha TR
9.	Shri KS Alawa	Deputy Director, Buffer, Kanha TR
10.	Shri AK Nagar	Deputy Director, Satpura TR
11.	Shri M Pathak	Deputy Director, Bandhavgarh TR
12.	Shri RK Mishra	Deputy Director, Bandhavgarh TR
13.	Shri K.S.Alwa	Deputy Director, Bandhavgarh TR
14.	Shri VS Parihar	Deputy Director, Panna TR
15.	Shri OP Tiwari	Deputy Director, Pench TR
16.	Shri RS Uikey	ACF, Bandhavgarh TR
17.	Shri DP Shukla	ACF, Bandhavgarh TR
18.	Shri HP Shukla	ACF, Bandhavgarh TR
19.	Shri BS Gaur	ACF, Bandhavgarh TR
20.	Dr. Sandeep Agrawal	Veterinary Doctor, Kanha TR
21.	Dr. Akhilesh Mishra	Veterinary Doctor, Pench TR
22.	Dr. Sanjeev Gupta	Veterinary Doctor, Panna TR
23.	Dr Atul.K. Gupta	Veterinary Doctor, Van Vihar national Park, Bhopal
24.	Dr. J.P. Tripathi	Veterinary Doctor, Bandhavgarh
25.	Dr. Nitin Gupta	Veterinary Doctor, Bandhavgarh TR
26.	Dr. Rakesh Shukla	Research Officer, Kanha TR

27.	Shri LL Uikey	Assistant Director (Halon), Kanha TR
28.	Shri Anand Goswami	Assistant Director (Phen), Kanha TR
29.	Shri VK Kankaria	Assistant Director (Malanjkhand), Kanha TR
30.	Shri Raghavendra Bisen	Park Superintendent, Kanha TR
31.	Shri Surendra Kumar Khare	Range Officer Mukki
32.	Shri Sunil Kumar Sinha	Range Officer Kisli
33.	Shri Sudhir Kumar Mishra	Range Officer Kanha
34.	Shri Om Prakash Patel	Range Officer Sarhi
35.	Shri Vikram Singh Solanki	Range Officer Khatia
36.	Shri M.K. Mishra	Range Officer Magdhi
37.	Shri S.C. Pandey	Range Officer. Magdhi
38.	Shri L.K. Pandey	Range Officer Magdhi
39.	Shri K.K. Suhaney	Range Officer Magdhi
40.	Shri R.K. Tripathi	Range Officer Tala
41.	Shri Tarendra Kumar Tiwari	Dy. Ranger, RA Kisli
42.	Shri N.K. Gautam	RA Milli, Bandhavgarh
43.	Shri R.S. Paraste	RA Magdhi, Bandhavgarh
44.	Shri B.B. Pandey	RA Magdhi, Bandhavgarh
45.	Shri Ramlal Maravi	Forest Guard, Kopedabari
46.	Shri Mahesh Markam	Forest Guard, Kisli
47.	Shri Birjhu Lal Khairwar	Orderly, Digdola
48.	Ku. Laxmi Maravi	Forest Guard, Rest House In-charge
49.	Shri Sangram Singh	Forester
50.	Shri Gajraj Singh	Beat guard Magdhi
51.	Shri Saroj Kumar Patle	Computer Operator, Kanha
52.	Shri Sandeep Singaur	Computer Operator, Kanha
53.	Shri Ashish Upadhyay	Computer Operator, Bandhavgarh
54.	Shri Rajkumar Gadhewal	Range Clerk
(3)	**Wildlife Institute of India, Dehradun**	
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27.	Shri Shivlal Maravi	28.	Shri Birsingh Parte
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35.	Shri Surendra Patta	36.	Shri Beeran Yadav
37.	Shri Tikaram Yadav	38.	Shri Rameshvar Yadav
39.	Shri Indal Singh Maravi	40.	Shri Ram Prasad Yadav
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3.	Shri Santosh Baiga
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5.	Shri Mani Ram Yadav
6.	Shri Mahendra Singh
7.	Shri Dunna Baiga

(4)

सूचना का
अधिकार
RIGHT TO
INFORMATION

Reminder-2

RTI –URGENT

From Office of the
Central Public Information Officer (CPIO)
Wildlife Institute of India, Dehradun

No. WII/RTI/CPIO/2020-21 (Qtr-IV)/83

Date: 18 January, 2021

Sub.: Information under RTI Act, 2005–reg.

Ref. (i) Note of even No. and dated 04 December 2020

(ii) Reminder-1 of even No. and dated 11 January 2021

Kindly arrange to provide the point-wise information **in two copies duly certified by the concerned authority** of the Institute **WITHIN 7 DAYS** receipt of this note, so that the information can be furnished to the applicant u/s 7(1) of RTI Act, 2005.

The details of RTI application (**Annexure-I**) are given below:

Applicant Name	Pandit Ajay Gautam
RTI No.	WLIOI/R/E/20/00073
Application Date	31.12.2020
Application Receipt Date and No.	App. S.No. 83 31 Dec, 2020
Information pertains to Section/ Department	Research/ Academics

NO & CPIO (RTI)

Dean, FWS

Please respond with available documents / Project reports.

Dr. P. Nigam / Dr. K. Ramesh / Dr. S. Mondol

Dhula
19/1/21

P.T.O.

RTI REQUEST DETAILS

Registration No. :	WLIOI/R/E/20/00073	**Date of Receipt :**	31/12/2020
Type of Receipt :	Online Receipt	**Language of Request :**	English
Name :	Pandit Ajay Gautam	**Gender :**	Female
Address :	26/127a Sidhharth Gali No 10, Vishwas Nagar, Delhi, Pin:110032		
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Email :	panditajaygautam@gmail.com		
Status(Rural/Urban) :	Urban	**Education Status :**	Graduate
Is Requester Below Poverty Line ? :	No	**Citizenship Status**	Indian
Amount Paid :	10)	**Mode of Payment**	Payment Gateway
Does it concern the life or Liberty of a Person ? :	No(Normal)	**Request Pertains to :**	P.K.Aggarwal

Information Sought :

May kindly furnish details via email or by Post as deem fit Certified Copy of the Documents u/s 6 and Section 6(1) of the RTI Act 2005 is requested, In case the reply is ready its not necessary to wait for 30 days information disposal to speed up the process of disposal of information

1. List of targeted animals for Radio Collaring relevant documents
2. List of Animals Radio Collared with relevant Documents
3. Whether Purpose of Radio Collaring Animals Reached-Yes /No, If yes kindly furnish years wise research report.
4. Current Status of All Animals Radio Collared and their available current/last/fresh report
5. Periodic fund Utilisation Certificate report for Radio Collar program Last, Fresh, Current
6. Any Other Information related to
7. Cost of one Radio Collar
8. Cost Involved in Installation of One radio collaring on one animal
9. Detailed Sales and Purchase Drug Inventory utilised in Radio Collaring Tiger

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Monitoring of Re-Introduced Tigers (*Panthera tigris tigris*)

SARISKA TIGER RESERVE
RAJASTHAN

Phase II

FINAL REPORT

भारतीय वन्यजीव संस्थान
Wildlife Institute of India

Rajasthan Forest Department

Monitoring of Re-Introduced Tigers (*Panthera tigris tigris*)

SARISKA TIGER RESERVE
RAJASTHAN

Phase II

FINAL REPORT

APRIL 2015 – JUNE 2018

भारतीय वन्यजीव संस्थान
Wildlife Institute of India

Rajasthan Forest Department

Monitoring of Re-Introduced Tigers in (*Panthera tigris tigris*) in Sariska Tiger Reserve, Rajasthan- Phase II

Final Report
April 2015 – June 2018

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Wildlife Institute of India
Technical Report No. 2019/08

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CHAPTER 1
INTRODUCTION

1.1 Introduction

The Indian sub-continent is home to 60% of the global tiger population with a diverse array of large, meso and small carnivores occurring across diverse habitats. These habitats are compacted in 2% of the global landmass that harbors approximately 18% of the global human population. This high density of human population has an ever-increasing demand for land and other natural resources. Moreover, poor land-use policies coupled with socio-economic necessities and political reasons has resulted in protected areas becoming increasingly porous, fragmented, isolated with high anthropogenic pressures. One such protected area is Sariska Tiger Reserve (STR) situated in the semi-arid landscape of western India along the Aravalli ranges that are the oldest hill ranges in the world. Sariska Tiger Reserve lost its connectivity with Ranthambore Tiger Reserve quite recently and is now an isolated reserve with sharp boundaries and human habitation. There are 29 villages inside Sariska and about 170 villages within 3 kilometers of the reserve boundary. There are two highways which dissect the reserve. Sariska harbors fairly good population of large carnivores including the tiger, leopard and striped hyena. However, conserving large carnivores among human habitation has been a daunting task for managers and conservationists. Since, village relocation from inside the reserve is resource intensive contentious issue; identifying ecological requirements such as suitable breeding sites of large carnivores and protecting them from an ever-increasing human pressure has been the primary concern.

1.2 Reintroduction Efforts (2008 to 2018)

After the extermination of tigers in Sariska Tiger Reserve (STR) in 2004, the Wildlife Institute of India's report on `Status of tiger in Sariska' suggested building up of tiger population in Sariska through reintroduction (Sankar et al., 2005). A suggestion to translocate initial population of five tigers (two males and three females) from Ranthambhore Tiger Reserve (RTR) was made, with a supplementation of three tigers (one male and two females) every two years for a period of six years. The Population Viability Analysis (PVA) showed the probability of tiger survival as 0.9380 (0.0108 SE) in Sariska. Accordingly, in December 2005 a `Species Recovery Plan for Tigers' in Sariska was prepared. Following this scientific plan, three adult tigers (male) and five adult tigresses (female) were reintroduced from Ranthambhore Tiger Reserve and Keoladeo National Park, Bharatpur to build a self-sustaining population. These animals were fitted with radio-collars and translocated to Sariska between June 2008 and January 2013. The details are provided in Table 1.1.

Table 1.1: Details of Reintroduction of Tigers in Sariska Tiger Reserve

S. No.	Tiger ID.	Sex	Date of Reintroduction (Soft Release)	Date of Release in the Wild
1	ST1	Male	28.06.2008	06.07.2008
2	ST2	Female	04.07.2008	08.07.2008
3	ST3	Male	25.02.2009	27.02.2009
4	ST4	Male	20.07.2010	27.07.2010
5	ST5	Female	28.07.2010	01.08.2010
6	ST6	Male	23.02.2011	27.02.2011
7	ST9	Female	22.01.2013	28.01.2013
8	ST10	Female	23.01.2013	28.01.2013

The reintroduction being an intensive process required timely scientific inputs. The Wildlife Institute of India was bestowed with a responsibility of monitoring the reintroduced population with support of the National Tiger Conservation Authority since reintroduction. The animals gradually settled in Sariska, however did not breed for the first four years probably due to high stress levels and lack of inviolate space (Sankar et al., 2013). High stress levels among the reintroduced tigers was observed due to the prevailing disturbance in Sariska (Bhattacharjee et al., 2013). The first record of animal breeding was of ST2 in 2012.

Village relocation process to create inviolate space for tiger breeding was also initiated simultaneously. A total of 565 Gujjar pastoralist families were relocated from six villages.

The reintroduced population was continuously monitored over the years as part of the collaborative initiative between Rajasthan Forest Department, Wildlife Institute of India and National Tiger Conservation Authority. The report of the Phase I (2008-13) and the extended period (2013-15) were duly submitted.

The Phase II of the project was initiated in 2015 to primarily study the response of reintroduced tigers and their prey to village relocation efforts and to explore the future population management.
The objective of the Phase II were as follows:

i. To study the home range and dispersal patterns of the re-introduced tigers and cubs with respect to relocated villages
ii. To assess the habitat use by the re-introduced tigers and cubs with respect to relocated villages
iii. To study the food habits of the re-introduced tigers
iv. To estimate the population of the prey species
v. To suggest management recommendations for effective conservation of tigers in the Tiger Reserve

The findings of the influence of village relocation on tiger and prey population, and future management scope have been provided in the Annual Progress Report (2015 – 16). Findings on the ranging pattern of tigers, factors influencing breeding of tigers, diet, temporal activity, and an update on the age-sex pattern of the tiger population for active population management in Sariska were presented in the annual report (2016 – 17). Here, we summarize our project findings to formulate conservation strategies for long term survival of Sariska's tiger population.

CHAPTER 2
STUDY AREA

Sariska Tiger Reserve (STR), an isolated reserve situated in Aravalli hills in Alwar district of north western Indian state of Rajasthan between Longitude: 79° 17' to 76°34'N and Latitude: 27° 5' to 27° 33'E (Fig 2.1). The reserve presently encompasses an area of 1200 km^2 and includes 881.11 km^{2}core and 383.11 km^2 buffer (TCP, 2016).

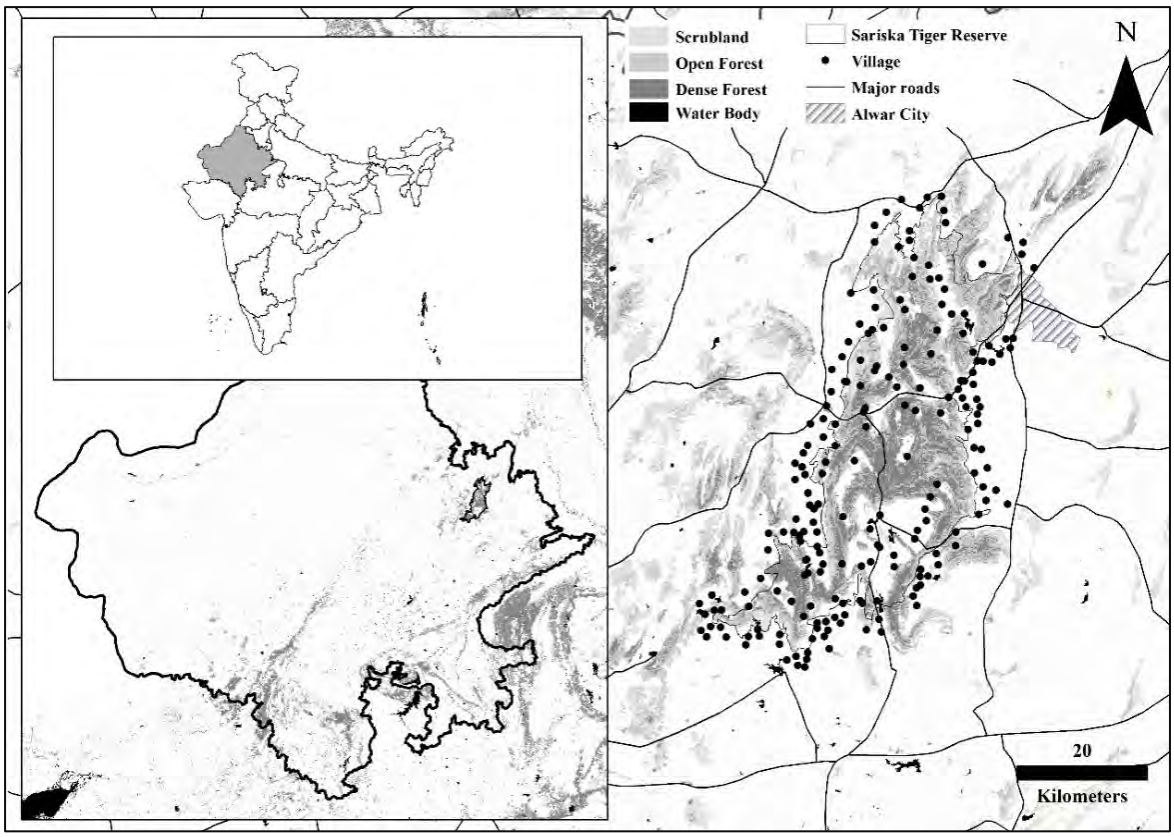


Figure 2.1: Location of Sariska Tiger Reserve with villages inside and at the periphery (within 3 km)

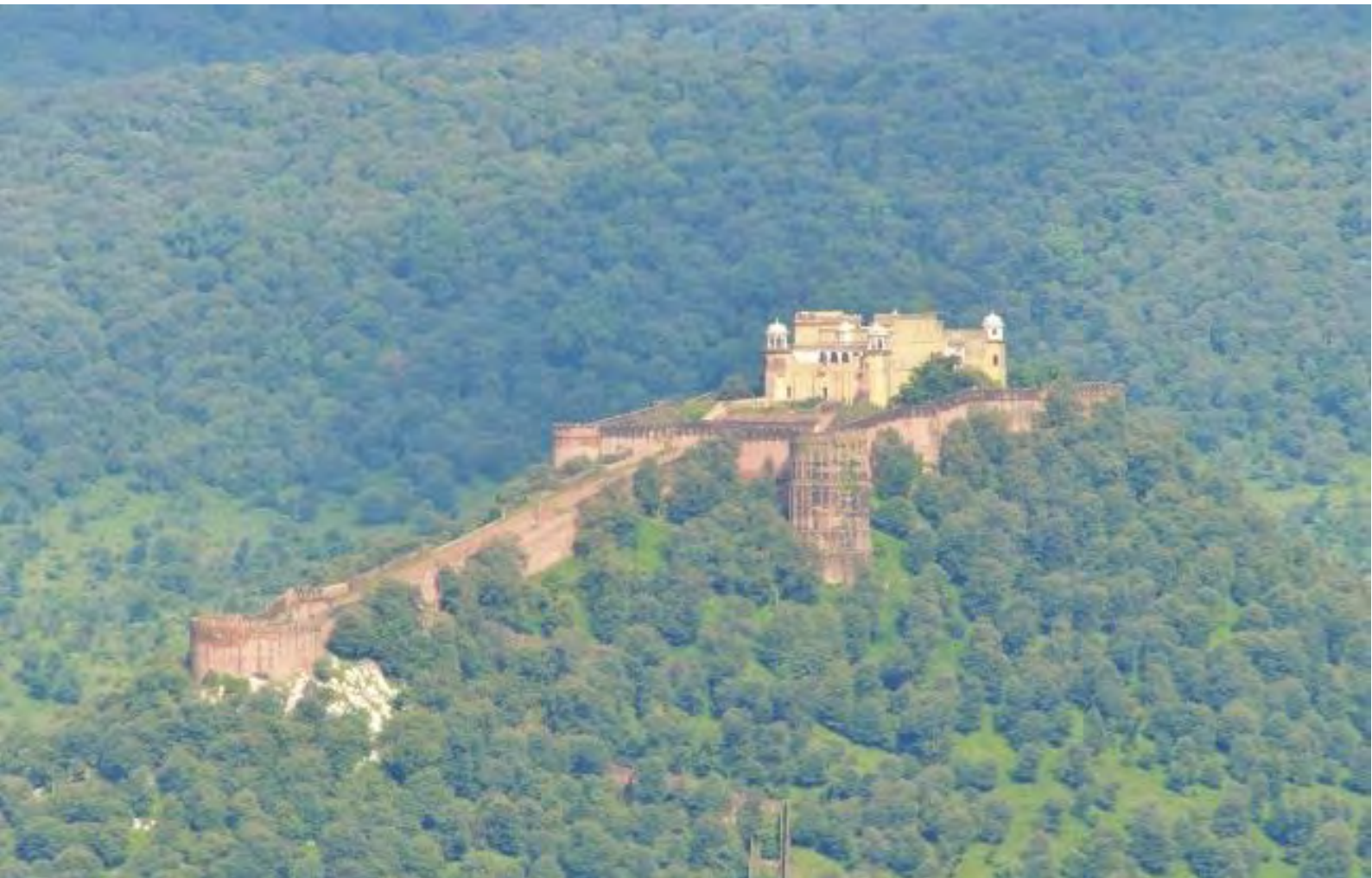
2.1. Climate

The climate is subtropical, characterized by a distinct winter, summer and monsoon. Winter commences from November with the temperature going as low as 3° C. Summer commences from mid-March and continues till end of June and followed by monsoons from south west in July and August. The study area also receives occasional winter and summer rains. Average annual rainfall recorded is 650 mm (Sankar, 1994).

2.2. History and Archaeological Richness

STR was was declared as the 11th Project Tiger Reserve by Govt. of India in 1978. In the pre-independence period, the forests within the Reserve were a part of the erstwhile Alwar State and maintained as a hunting preserve for the royalty (Johari, 2003). After independence, Sariska was declared as a Wild Life Reserve on 7th November, 1955, under the Rajasthan Wild animals and Birds Protection Act, 1951. The Reserve status was upgraded to that of a Sanctuary in 1958. STR was

included in the list of Tiger Reserves by Government of India in 1978 as the 11th Tiger Reserve. In 1982, an area of 274 km^2 was declared as Sariska National Park vide Preliminary Notification *NO. F11 (22) Raj-8/78 Jaipur Dated 27 August 1982 under Wild Life Protection Act 1972 (Central Act No. 53) section 35 (1)*.



2.3. Major Vegetation Types

The vegetation of STR correspond to (1) Northern tropical dry deciduous forests (sub groups 5B; 5/E1 and 5/E2) and Northern Tropical Thorn forest (subgroup 6B) (Champion and Seth, 1968). *Anogeissus pendula* is the dominant tree species covering over 40 per cent area of the forest (Sankar, 1994). *Boswellia serreta* and *Lannea coromandelica* grow on rocky patches. *Acacia catechu* and bamboo are common in the valleys. Some valleys support *Butea monosperma* and *Zizyphus mauritiana*. *Dendrocalamus strictus* is extremely limited in distribution and is found along well drained reaches of the streams and moist and cooler parts of the hills. *Albizia lebbeck, Diospyros melanoxylon, Holoptepia integrifolia* and *Ficus spp*. are found in moist localities (Sankar, 1994). Parmar (1985) and Rodgers (1991) have classified vegetation of Sariska as follows:

1. *Anogeissus pendula* forest
2. *Boswellia serrata* forest
3. *Acaccia catechu* forest and
4. *Miscellaneous forest,* which can be further sub-divided into three categories viz.
   a) *Butea monosperma* forest
   b) Forest along nallas and
   c) Scrub land

Nine different vegetation and land cover categories have been delineated in STR (Sankar et. al. 2008). They are *Anogeissus* dominated forest, *Boswellia* dominated forest, *Butea* dominated forest, *Acacia* mixed forest, *Zizyphus* mixed forest, Scrubland, Agricultural land, Water body and Barren land.

2.4. Terrain

The major part of the area is occupied by rocks of the Delhi system and Aravalli system comprising of quartzite, conglomerates, grits, limestone, phyllite, granites and schist (Pascoe, 1950; Sankar, 1994). STR is characterized by rugged terrain, valleys and plateau with the altitudinal variation from 340 m to 777 m (Fig 2.2). The two main plateaus are Kankawadi (524 m above mean sea level) and Kiraska (592 m above the mean sea level). The most remarkable characteristics of the hills are their homo-genetic regularity of height, level summits and uniform appearance, stretching out from northeast to south-west, in more or less parallel lines (Soni, 2000). The depth of soil layer is more than 1 m in valleys, whereas it is only a few centimeters deep on the hill slopes. The soil is sandy loam and alkaline with pH varying from 7.25 to 8.00 (Yadav and Gupta, 2006).

2.5. Co-predators and Prey

Large carnivores found are leopard (*Panthera pardus*), striped hyaena *(Hyaena hyaena),* and reintroduced tigers (*Panthera tigris*). STR sustains comparatively higher density of leopard (6.0±0.5 individuals/ 100 km^2, Mondal et al., 2012) and striped hyena (15.1±6.2 individuals/ 100 km^2, Gupta et al., 2009). Small carnivores are caracal (*Caracal caracal*), jungle cat (*Felis chaus*), common mongoose *(Herpestes edwardsi*), small Indian mongoose (*H. auropunctatus*), ruddy mongoose (*H. smithi*), palm civet (*Paradoxurus hermaphroditus*), small Indian civet (*Viverricula indica*) and ratel (*Mellivora capensis*). Ratel density was 6.43 ± 2.79 animals/100 km^2 (Gupta et al., 2012).

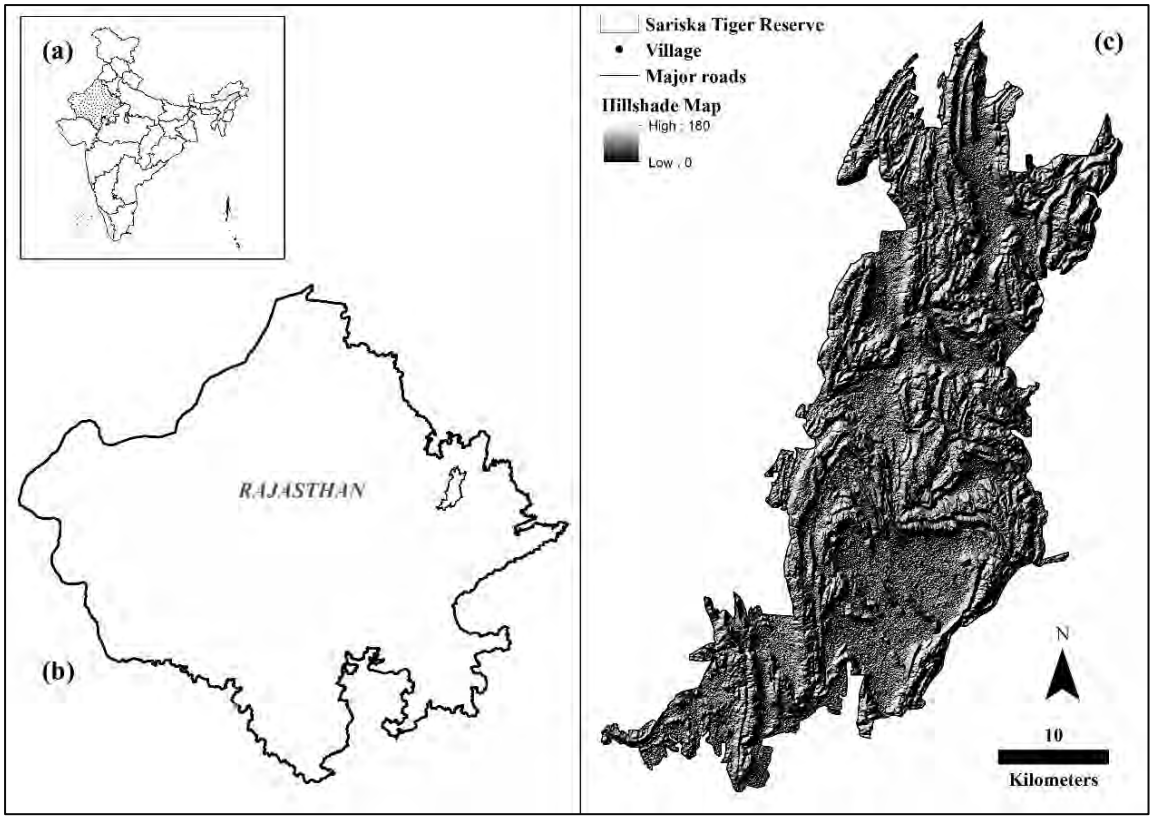


Figure 2.2: Hill shade map of Sariska Tiger Reserve showing terrain complexity

Wild ungulates found in Sariska include chital (*Axis axis*), sambar (*Rusa unicolor*), and nilgai (*Boselaphus tragocamelus)*, and wild pig (*Sus scorfa).* STR sustains comparatively higher density of wild prey and livestock. Wild ungulate density of STR is 54.49 individuals/ km^2 and livestock density is 69.31 individuals/ km^2 (Table 2.1.). Rhesus macaque (*Macaca mulatta*) and common langur (*Seminopithecus entellus*) are the two primates found here. Procupine (*Hystrix indica*), rufous tailed hare (*Lepus nigricollis ruficaudatus*). and 11 species of rodents have been recorded. The overall rodent density was 22.92 ±4.65 (SE) animals/ha in winter, and 7.81 ±2.25 (SE) animals/ha in summer. The overall rodent density was 16.15 ±2.76 animals/ha, and their estimated total biomass was 612.9 gm/ha (Gupta et al., 2013).

The most abundant galliform species was the Indian peafowl *Pavo cristatus* with an estimated density of 53.1 ± 5.6 individuals per km^2. Densities were also estimated for grey francolin *Francolinus pondicerianus* (21.6 ± 4.8 individuals per km^2), quail species (4.3 ± 1.40 individuals per km^2) and painted spurfowl *Galloperdix lunulata* (2.5 ± 0.9 individuals per km^2) in STR (Kidwai et al., 2011). Prey availability in the study area is given in Table 2.1.

Table 2.1: Availability of wild and domestic prey (Density estimates) in Sariska Tiger Reserve

Prey Species	Density (No./km^2)	Source
Wild Ungulates	54.49	Bhattacharjee, 2013
Chital (*Axis axis*)	16.25 ± 3.00	Bhattacharjee, 2013
Sambar (*Rusa unicolor)*	6.94 ± 1.27	Bhattacharjee, 2013
Nilgai (*Boselaphus tragocamelus*)	19.66 ± 1.85	Bhattacharjee, 2013
Wild Pig (*Sus scrofa*)	11.64 ± 2.11	Bhattacharjee, 2013
Medium and small sized mammal prey		
Common Langur (*Seminopithecus entellus)*	15.30 ± 2.90	Bhattacharjee, 2013
Rufous tailed hare (*Lepus nigricollis ruficaudatus*)	1.92 ± 0.4	Bhattacharjee, 2013
Rodent	0.16 ± 0.027	Gupta et al., 2013
Birds	74.7	Kidwai et al., 2011
Indian peafowl (*Pavo cristatus)*	53.1 ± 5.6	Kidwai et al., 2011
Grey francolin *Francolinus pondicerianus*	21.6 ± 4.8	Kidwai et al., 2011
Livestock	69.31	Bhattacharjee, 2013
Buffalo (*Bubalus bubalis*)	28.3 ± 4.68	Bhattacharjee, 2013
Cattle (*Bos taurus*)	41.01 ± 6.58	Bhattacharjee, 2013

2.6. Villages and Livestock

There were 29 villages within the Tiger Reserve boundary. Twelve villages are situated in the notified National Park and are due for relocation since 1984. Of these, Bhagani village was relocated during November 2007, Umri village during March 2012 and Rotkala village in March 2013.

The local communities residing within the reserve depend on the livestock for their existence while residing in the buffer are primarily engaged in agricultural sector. Large number of buffaloes and goats, cattle, sheep and a few camels are kept in the villages with the livestock density of 69.31 individuals/ km^2 (Bhattacharjee, 2013). The human population is over 8500 in the villages of Sariska TR. Additionally, there are approximately 170 villages in the periphery (within 3 km) of the reserve. These villagers depend totally on forests for their livelihood. The people inhabiting these villages are traditionally pastoralist and their main source of income is selling milk and its products like “Mawa and Ghee”.

The Alwar Thanagazi-Jaipur State Highway passes through the reserve and more than 4000 vehicles ply on it every day). Another main road passes through the reserve is Sariska- Kalighati- Pandupole road which is 20 km and along the wildlife rich valley of the reserve.

CHAPTER 3
HOME RANGE AND DISPERSAL PATTERN

3.1 Introduction

The home range of an animal is defined as the area traversed by the animal in its normal activities of gathering food, caring for young and mating (Burt, 1943). The range must satisfy the energy needs of the animal (Gittleman and Harvey, 1982) and use of the range can provide information regarding the distribution, importance and accessibility of important resource (Henschel, 1986). Though tigers are generalists (Sunquist et al., 1999), they still are vulnerable to habitat loss and fragmentation. Defining the size, shape and pattern of utilization of an animal's home range is important for studying habitat selection and spacing of individuals (Katajisto and Moilanen, 2006).

3.2 Method

Home range, daily and seasonal movement of the reintroduced tigers was determined by employing radio-telemetry. Radio locations of each animal were determined by "Homing in" and "Triangulation" from three to four known reference points (White and Garrot, 1990). Coordinates of these reference points were taken with the help of Global Positioning System (GPS). For estimating home ranges, two to three locations every day per collared animal was recorded. The movement pattern of each collared individual was monitored continuously for a week every month. Home range estimations were carried out using appropriate software like CALHOME (Kie, 1994). Two methods such as 100% minimum convex polygon (Mohr, 1947) and Kernel method (Katajisto and Moilanen, 2006; Kernohan et al., 1998) was used to analyze the home range of the tigers. The harmonic mean method (Dixon and Chapman, 1980) was used to find centers of activity and range shifts between seasons. A digital terrain model in conjunction with satellite imagery was used for estimating home range size in undulating terrain to consider the factor of the topography.

3.3 Results

3.3.1 Home Range (2014-15)

A total of 378, 409, 345, 382, 437, 359, 271, 213 and 402 locations were recorded respectively of ST2, ST3, ST4, ST5, ST6, ST7, ST8, ST9 and ST10 between April 2014 to March 2015. The annual home ranges were estimated respectively as 53.51, 125.44, 367.16, 79.20, 196.57, 39.13, 49.32, 46.98 and 111.00 sq. km. for all nine tigers in an order from ST2 to ST10. (Fig. 3.1). The information serves as a link between the Phase I and Phase II of the project, hence included in the report.

3.3.2 Home Range (2015-16)

A total of 494, 346, 501, 458, 498, 445, 267, 271 and 378 locations were recorded respectively of ST2, ST3, ST4, ST5, ST6, ST7, ST8, ST9 and ST10 between April 2015 to March 2016. The annual home ranges were estimated respectively as 47.24, 103.07, 322.75, 67.52, 213.7, 30.82, 40.15, 76.39 and 80.29 sq. km for all the nine individuals (Fig. 3 and 4). The average annual home range for adult male tiger was 268±56 (SD) sq. km and for adult female tiger was 64±24 (SD) sq. km. (Fig.3.2).

3.3.3 Home Range (2016-17)

A total of 316, 365, 450, 376, 461, 360, 301, 382, 401, 151, 116, 248 and 197 locations were recorded respectively of ST2, ST3, ST4, ST5, ST6, ST7, ST8, ST9, ST10, ST11, ST12, ST13 and ST14 between April 2016 to March 2017. Additionally, 124 locations were recorded for the cub of ST9. The annual home ranges were estimated respectively as 20.3, 128, 470, 115.40, 274, 33, 53.40, 96.20, 123.23, 520.12, 87.05, 1240 and 70 sq. km. for all 13 adult tigers in an order from ST2 to ST14 (Fig. 5 & 6). Average annual home range for adult male tiger was 626.25±183.07 (SE) sq. km and for adult female tiger was 80.30±11.10 (SE) sq. km. Estimated home range for ST9 cub was 76.38 sq. km. As ST13 (male cub) was not established and was dispersing, no home range map was prepared for it (Fig 3.3).

3.3.4 Home Range 2017-18

A total of 252, 305, 321, 268, 328, 244, 231, 265, 271, 274, 187, 261, 170 and 180 locations were recorded respectively of ST2, ST3, ST4, ST5, ST6, ST7, ST8, ST9, ST10, ST11, ST12, ST13, ST14 and ST15 during the study period. The annual home range were estimated respectively as 24.08, 103.5, 236.92, 64.73, 138.55, 32.45, 39.39, 80.08, 79.14, 163.31, 31.8, 976.12, 35.79 and 32.98 sq. km. (Fig. 7 & 8). Average annual home range for adult male tiger was 1547.88 ± 8.63 sq. km. And for adult female tiger it was 54.55 ± 1.19 sq. km. (Fig 3.4)

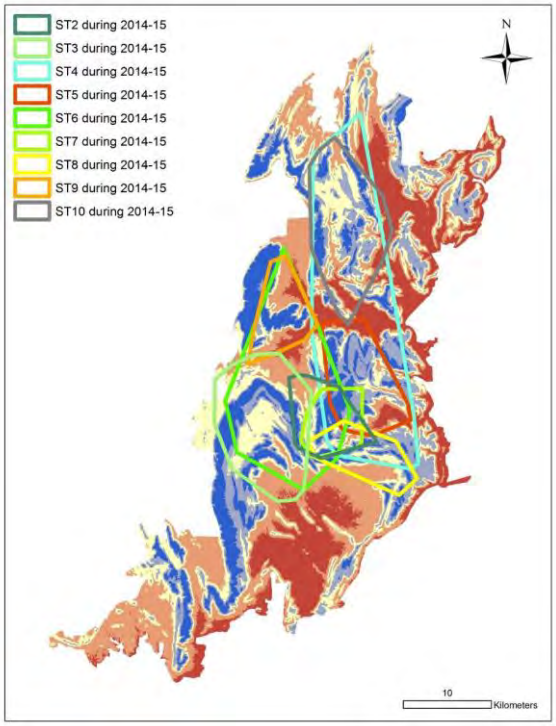


Fig. 3.1: Map showing the Home Range of tigers during 2014-15

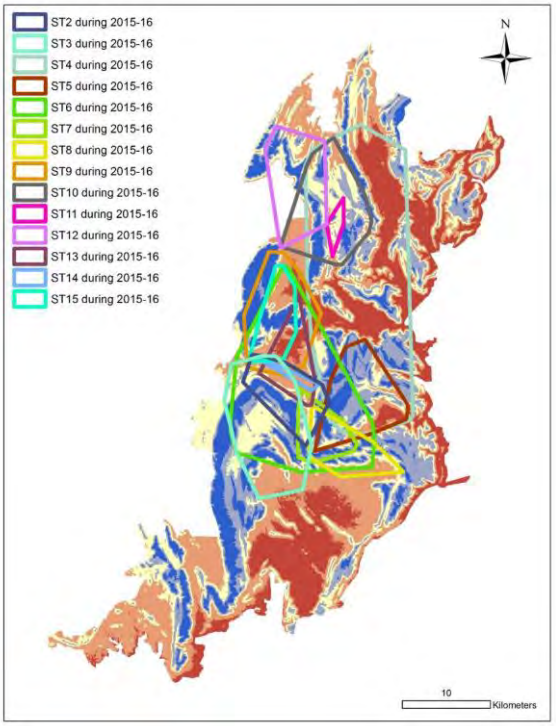


Fig. 3.2: Map showing the annual home range of tigers during 2015-16

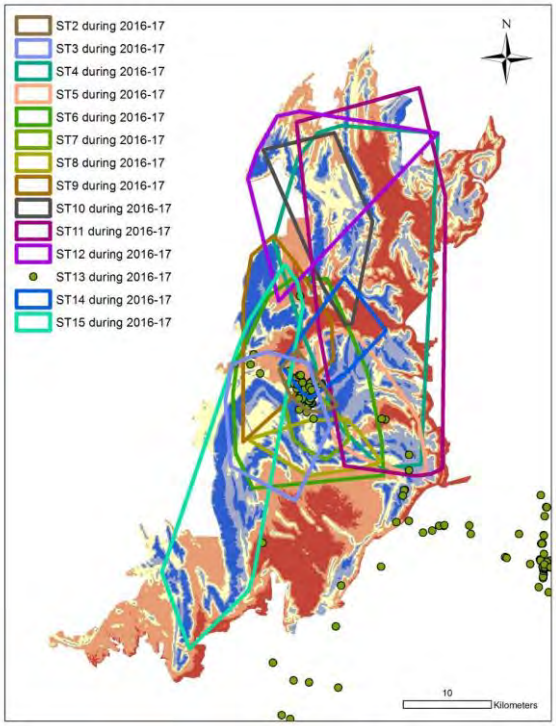


Fig. 3.3: Map showing the annual home range of tigers during 2016-17

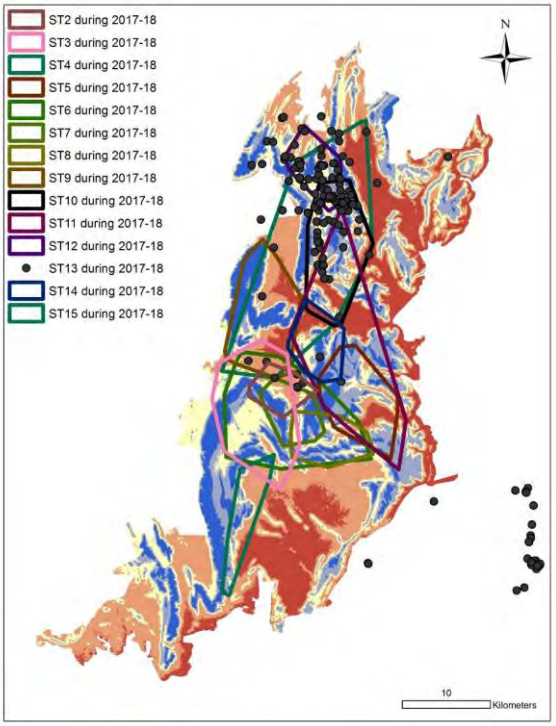


Fig. 3.4: Map showing the annual home range of tigers during 2017-18

3.3.5 Year wise comparison of the home range of tigers between 2014-18

Overall, a total of 1440, 1425, 1617, 1484, 1724, 1408, 1070, 1131, 1452, 425, 303, 509, 367 and 304 locations were recorded for ST2, ST3, ST4, ST5, ST6, ST7, ST8, ST9, ST10, ST11, ST12, ST13, ST14 and ST15 respectively during 2014-18. The comparison of home ranges of tigers over the period of 2014-18 are shown in Fig. 3.1.

Table 3.1: Comparison of home ranges from 2014-18

Tigers	Home range (100% MCP) estimation in sq. km (2014-18)			
	2014-15	2015-16	2016-17	2017-18
ST2 (Female)	53.51	47.24	20.3	24.08
ST3 (Female)	125.44	103.07	128	103.5
ST4 (Male)	367.16	322.75	470	236.92
ST5 (Female)	79.2	67.52	115.4	64.73
ST6 (Male)	196.57	213.7	274	138.55
ST7 (Female)	39.13	30.82	33	32.45
ST8 (Female)	49.32	40.15	53.4	39.39
ST9 (Female)	46.98	76.39	96.2	80.08
ST10 (Female)	111	80.29	123.23	79.14
ST11 (Male)	NA	NA	521	163.31
ST12 (Female)	NA	NA	NA	31.8
ST13 (Male)	NA	NA	NA	976.12
ST14 (Female)	NA	NA	NA	35.79
ST15 (Male)	NA	NA	76.38	32.98

During the study period (2015-18), ST2 was observed to be occupying areas of Karnakawaas-Tarunda-Haripura beats along with her cubs. First litters of ST2 tigress, *i.e* ST7 and ST8 tigress which attained adulthood, were observed occupying areas of Slopka-Kalighati-Karnakawaas-Umri and Jahaz-Slopka-Kalighati-Bhesota-Deori-Pandupol beats respectively. ST3 tigress was observed occupying areas of Ghanka -Richunda-Kharika-Bhagani-Sadar-Kankwari-Garh-Rajor. The male ST4 was observed occupying areas of Lodge-Panidhal-Umri-Pandupol-Bhatela-Slopka-Sukola-Binak-Umri-Sadar-Ganeshpura-Indok-Haripura beats and another male ST6 was observed occupying areasof Karnakawas-Haripura-Tarunda-Kalighati-Sadar-Pandupol-Slopka-Kankwari-Jahaz-Bhagani beats. The female ST5 was observed occupying areas of Sukola-Umri-Pandupole-Rotkala-Bhatyala-Kiraska beats. The tigresses ST9 and ST10 occupied Northern areas of Sariska Tiger reserve falling in Akbarpur and Talvriksha Ranges. Tigress ST9 occupied North-western areas of Berawas-Indok beats whereas, ST10 tigress occupied the North-eastern areas of Panidhal-Lodge-Rampur II-Rampur III-Binak-Lekhri beats along with her cubs. ST11 was observed to be using Umri-Rotkyala-Sukola-Kiraska-Ghamodi-Lilunda-Deori beats. ST12 uses the area of ST10. ST13 was observed to use the natal area (Karnakawas) initially, and further moved out in the territorial division at Rajgarh. The animals were captured and shifted to the tiger enclosure (Naya Pani). The animal following released got established in Panidhal-Lodge-Rampur II- Rampur III-Binak-Lekhri beats. ST14 was observed to be using Sukola-Kiraska-Ghamodi-Lilunda beats. ST15, the male cub of ST9 tigress, initially used the natal are before it moved out to Ajabgarh range and occupied Rajor-Garh-Bhagani-Bhangarh-Dighota beats. Individual year-wise home range of tigers in Sariska TR is provided in Fig. 3.5 – 3.18.

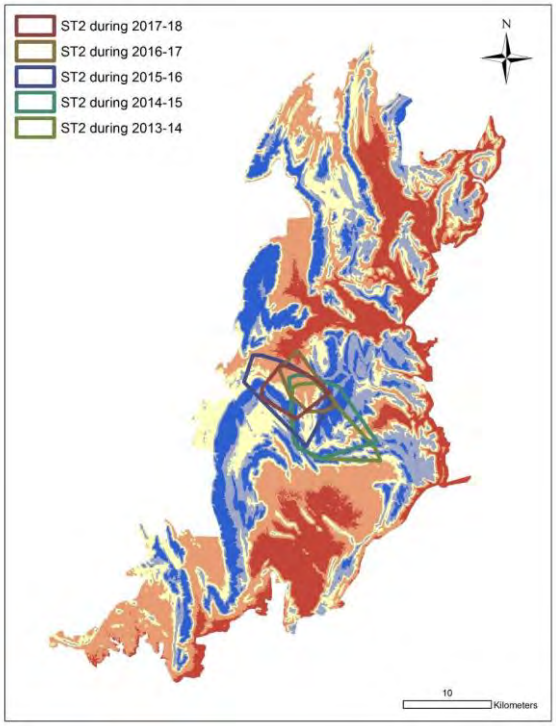


Fig. 3.5: Home range of ST2 during 2013-18

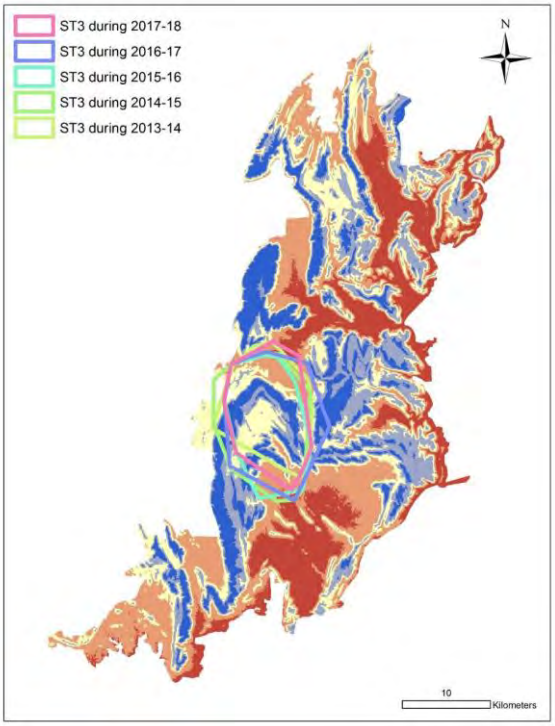


Fig. 3.6: Home range of ST3 during 2013-18

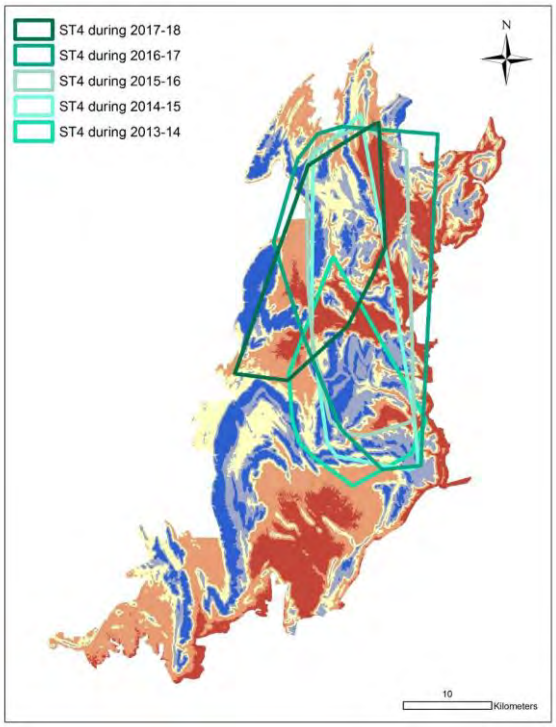


Fig. 3.7: Home range of ST4 during 2013-18

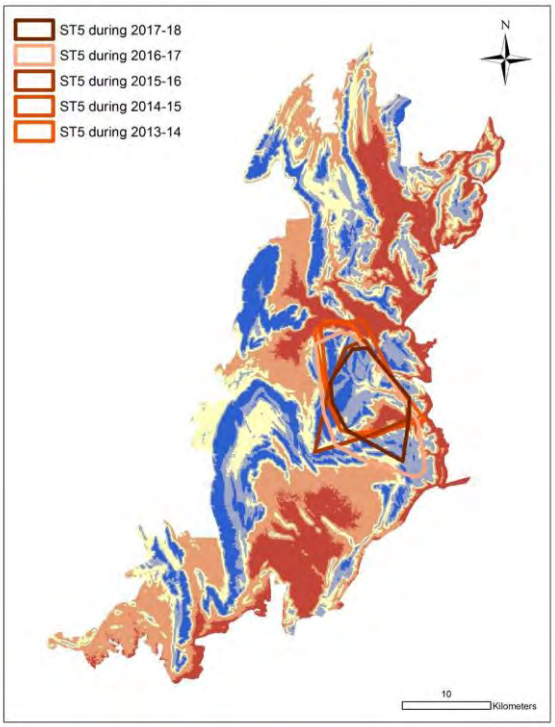


Fig. 3.8: Home range of ST5 during 2013-18

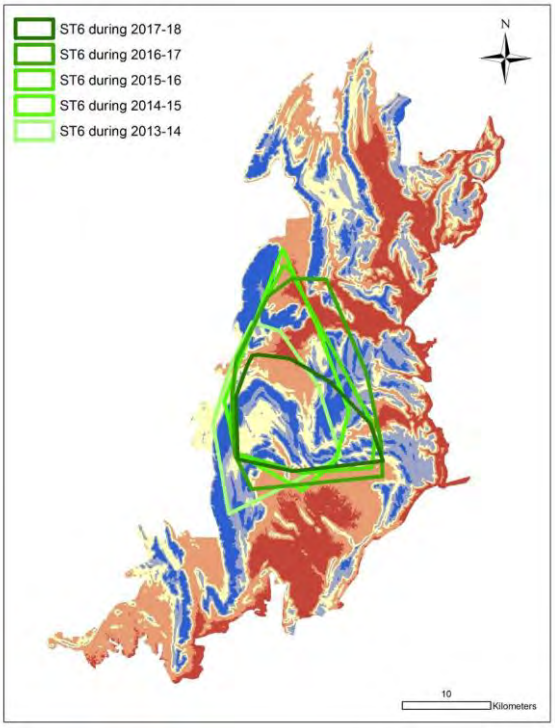


Fig. 3.9: Home range of ST6 during 2013-18

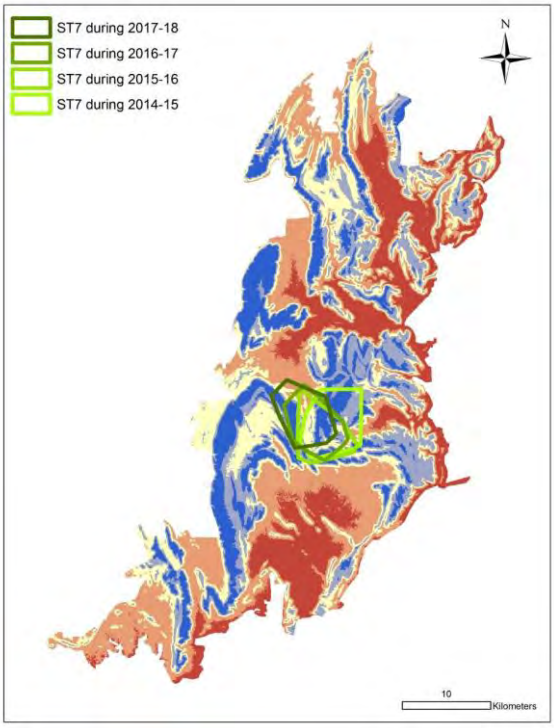


Fig. 3.10: Home range of ST7 during 2014-18

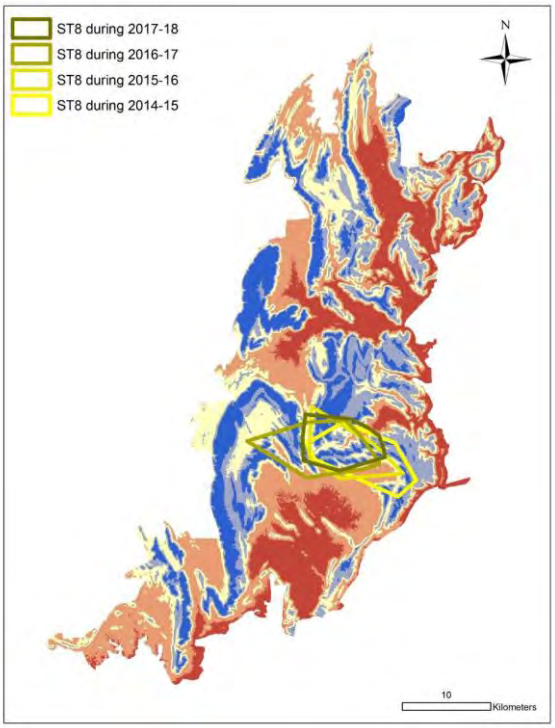


Fig. 3.11: Home range of ST8 during 2014-18

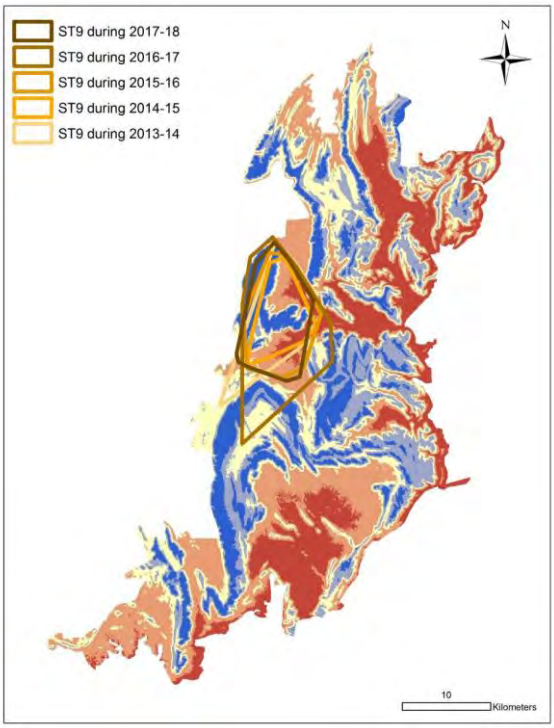


Fig. 3.12: Home range of ST9 during 2013-18

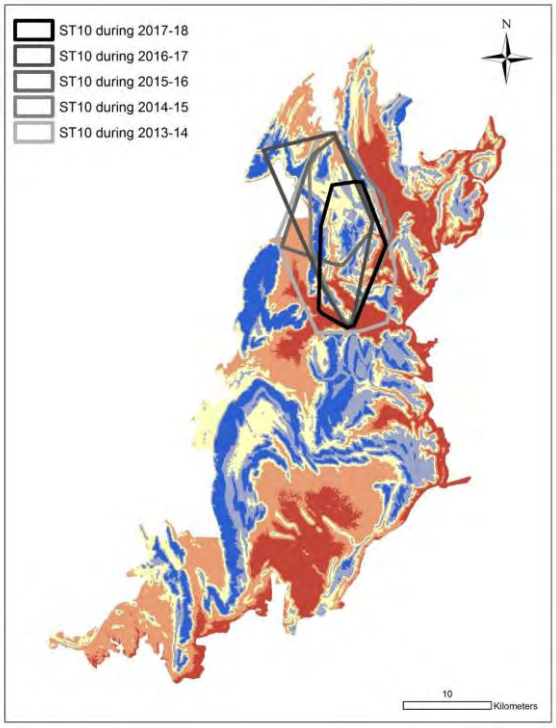


Fig. 3.13: Home range of ST10 during 2013-18

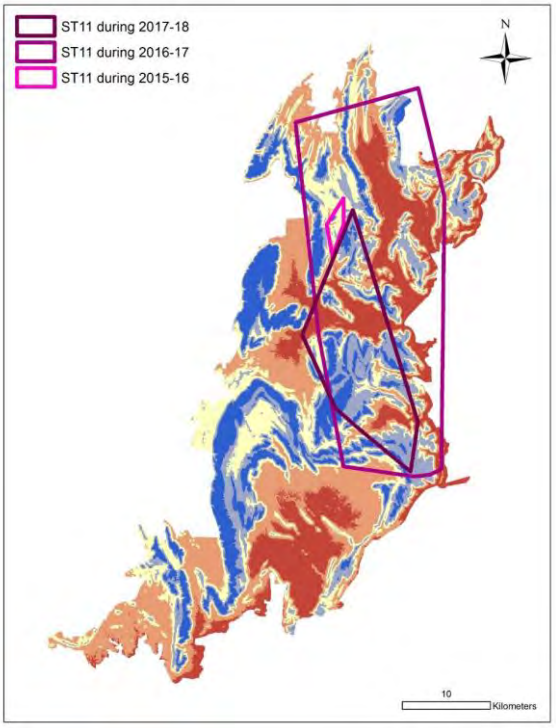


Fig. 3.14: Home range of ST11 during 2015-18

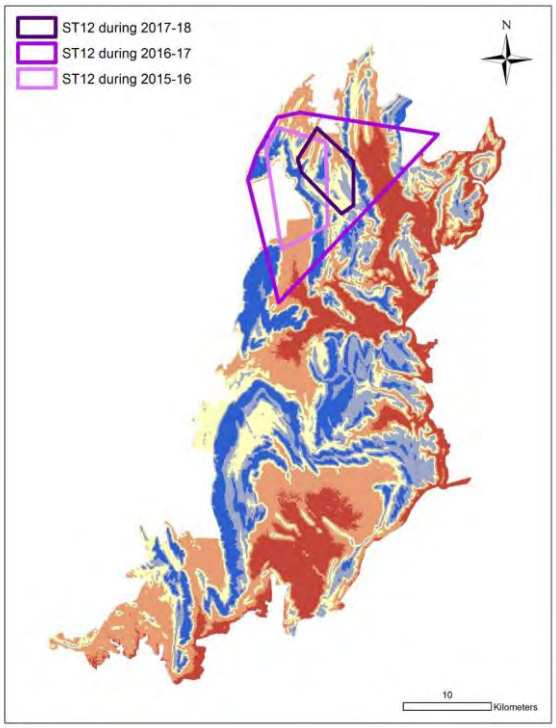


Fig. 3.15: Home range of ST12 during 2015-18

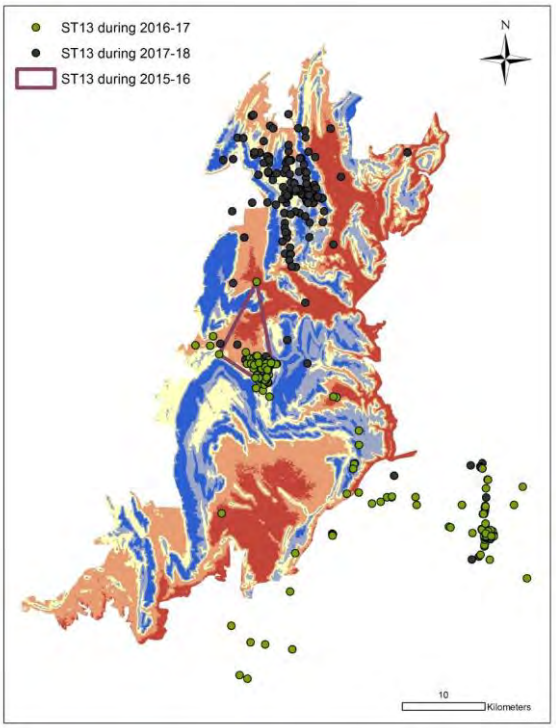


Fig. 3.16: Home range of ST13 during 2015-18

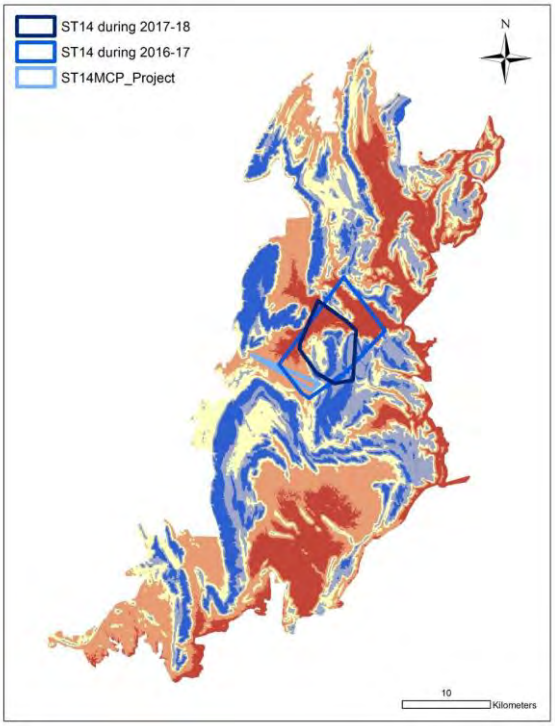


Fig. 3.17: Home range of ST14 during 2015-18

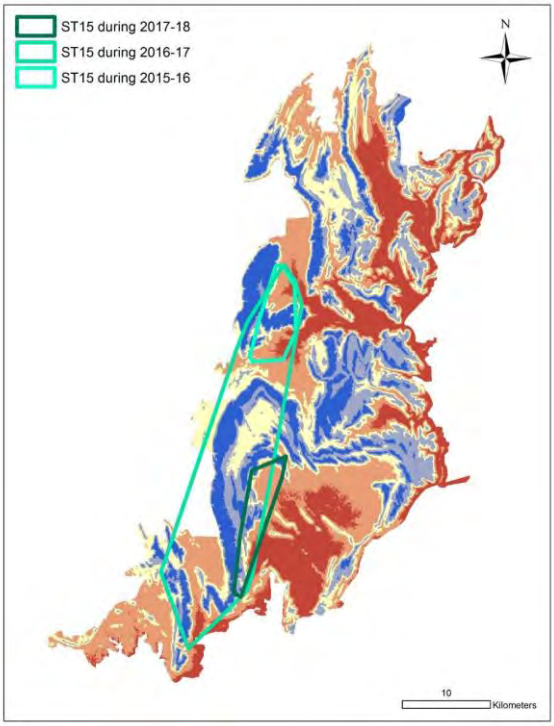


Fig. 3.18: Home range of ST15 during 2015-18

CHAPTER 4
PREY STATUS & DISTRIBUTION

4.1 Introduction

The primary reason for the unprecedented decline in tiger population are prey depletion, habitat loss and poaching is now a well-known fact (Sankar et al., 2009). Models based on tiger population dynamics have indicated that many of the fragmented tiger populations were unable to sustain poaching pressures despite high fecundity (Chapron et al., 2008) and large prey base. In fact, two tiger populations in India –Sariska TR and Panna TR, lost their tiger populations due to poaching despite having good prey base (Sankar et al., 2009, 2010).

After the reintroduction, high stress levels among the reintroduced tigers was observed due to the prevailing disturbance in Sariska. Reintroduced tigers didn't litter for first four years due to high stress levels and lack of inviolate space. However, village relocation process was also ongoing to create inviolate space for tiger breeding. 565 Gujjar pastoralist families have also been relocated from 6 villages till 2013. In this context, it was imperative to understand the response of prey population to village relocation and explore future population management scopes.

In this study, we estimated wild ungulate density and livestock density over three years (2013 – 2016) to understand the response of wild ungulates and change in livestock population following resettlement of 565 families.

4.2 Methods

4.2.1 Population estimation of principal prey species and livestock

Prey and livestock density were estimated through line transects under distance sampling framework using three years data collected from 2013 – 2016 (Buckland et al., 1993). A total of 38 line transects of 1.4 to 2 km each was laid randomly across 800 sq. km covering the tiger occupied area in Sariska which was representative of major terrain, habitat types. Each line transect was walked every dry and wet season thrice during the study period. Total effort was 1005.50 km during the study period. We recorded species, group size, age–sex composition, sighting angle measured using a hand held compass (KB 20, Suunto, Vantaa, Finland), and sighting distance measured by a laser range finder (Yardage Pro 400, Bushnell, Overland Park, Kansas, USA) on every walk. We recorded age and sex compositions when possible and classified animals as males, females, or fawns.

To model detection functions, we examined the data for each species/survey year for signs of evasive movement and peaking at a great distance from the line transect. Following this, the data was either truncated at great distances or reclassed so as to ensure a reliable fit of key functions and adjustment terms to the data. Akaike Information Criterion (AIC) and goodness-of-fit (GOF-p) tests were used to judge the fit of the model. We only considered models with values more than 0.70 in the goodness of fit (GOF-p) test. Using the selected model, estimates of group density (Dg), group size (GS), and individual density (Di) were derived. To test for significance between age and sex ratios across years, we computed 95% bootstrap confidence intervals (Hilborn and Mangel, 1997) as the data did not conform to the assumptions of normality.

4.3 Results

We estimated density of four principal prey species (Sambar, Chital, Nilgai and Wild Pig) out of total eight prey species detected on transects and livestock across three survey years. Total annual effort was 338.4 km. during the study period. Present study recorded a 40% increase in the wild ungulate density in Sariska over three years following relocation of 565 families from the reserve. Wild ungulate density increased from 46.8 ungulates/ km^2 in 2013 – 14 to 64.2 ungulates/ km^2 in 2015 – 16. Proportion of fawns increased over three years for both Sambar and Chital. Livestock density in the study area remained fairly stable across three years.

Table 4.1: Details of density estimates of principal prey species

Species	2013-14		2014-15		2015-16	
	Density	SE	Density	SE	Density	SE
Sambar	9.13	2.3	10.48	3.20	16.1	4.49
Chital	12.4	3.4	11.38	3.16	24.33	7.85
Wild Pig	9.1	2.5	4.15	1.76	8.12	3.18
Nilgai	16.2	2.6	15.59	2.59	13.69	2.00

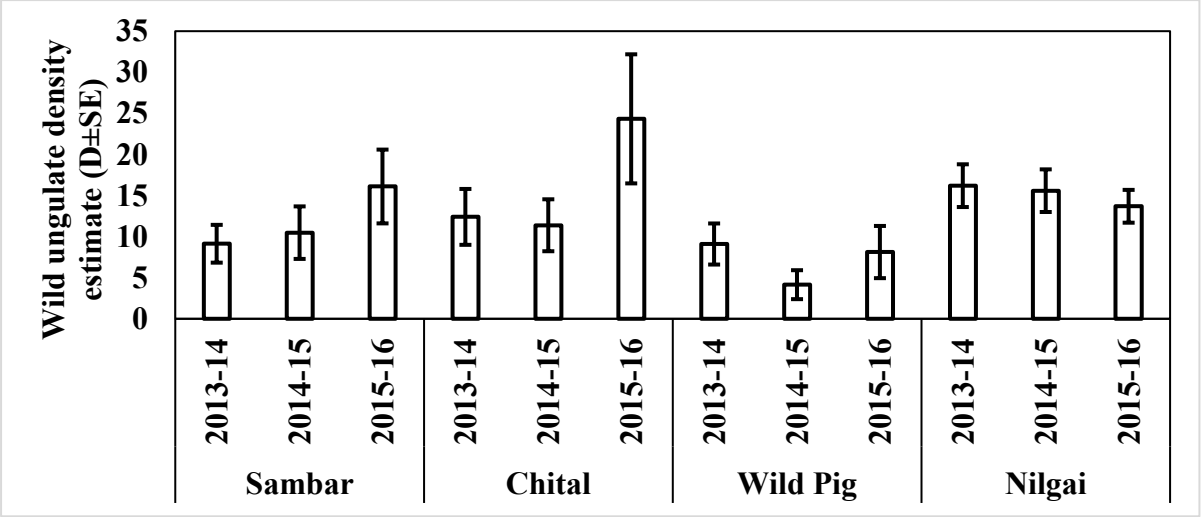


Figure 4.1: Details of density estimates of prey species during 2013 – 16 in Sariska

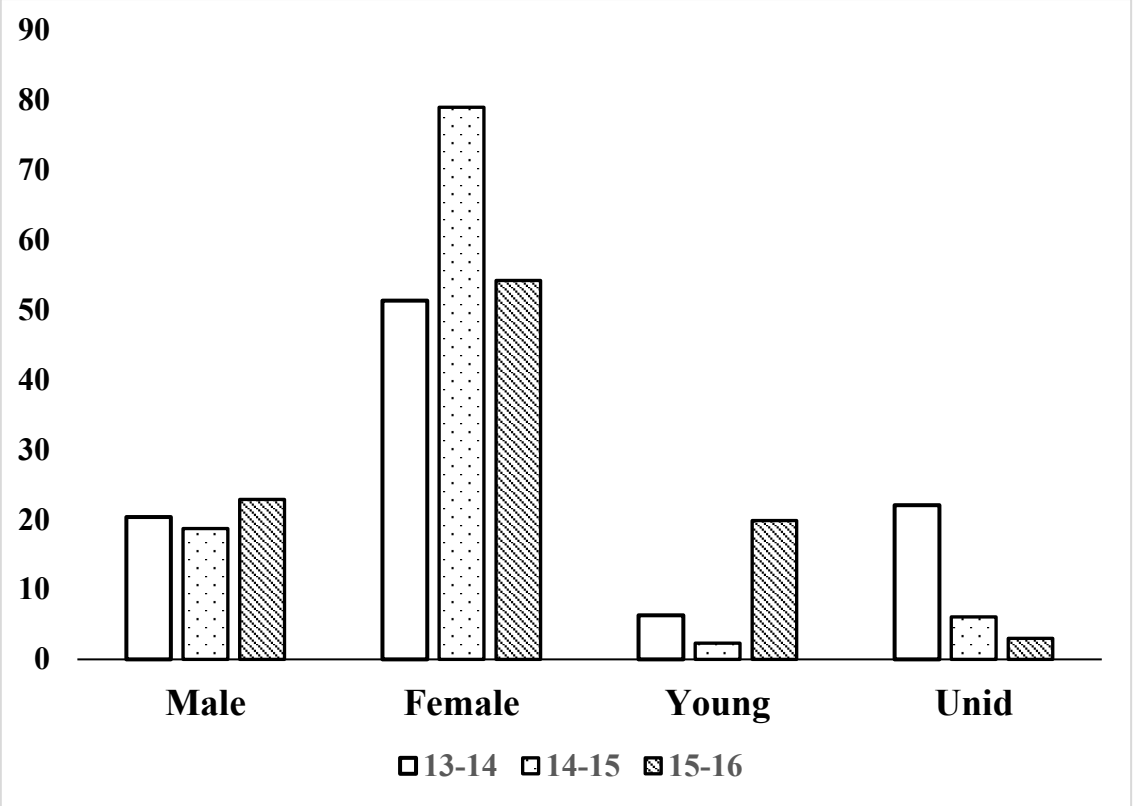


Figure 4.2: Composition (proportional) of adult males, adult females and young (up to yearling) for Sambar across three years

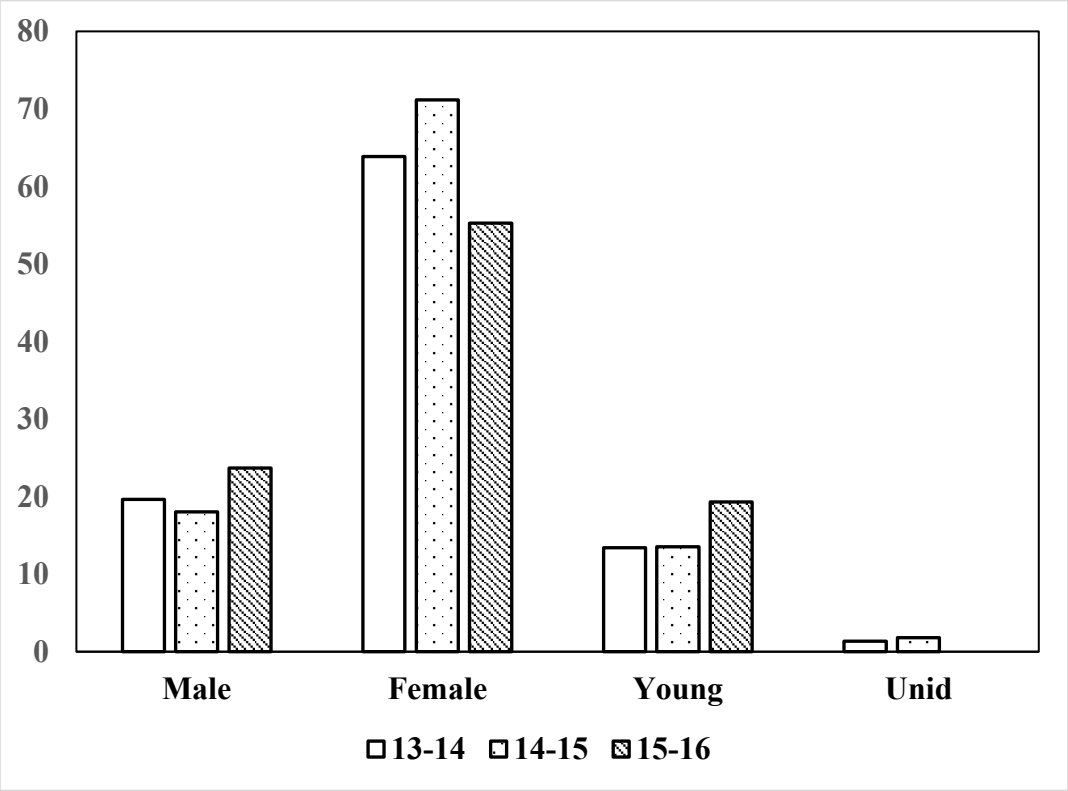


Figure 4.3: Composition (proportional) of adult males, adult females and young (up to yearling) for Chital across three years

Additionally, we also estimated prey and livestock population density of entire Sariska Tiger Reserve (1200 sq. km) during 2017 – 18 using the above-mentioned methods. However, the result of the same is presented separately as spatial coverage used to study response of wild ungulates and change in livestock population following resettlement of 565 families (800 sq. km) was different from the current study (2017 – 18, 1200 sq. km.).

Table 4.1. Details of density estimates of principal prey species & Livestock during 2017 - 18

Prey Species	Density of individuals	Standard Error
Sambar	9.07	3.81
Chital	17.1	9.09
Wild Pig	8.72	4.24
Nilgai	9.93	3.42
Livestock	69.41	25.07

4.4 Discussion

Our study presents evidence of the effectiveness of village relocation regarding prey population recovery following village relocation. Harihar (2009) documented tiger and prey population recovery in northern Indian protected area of Rajaji Tiger Reserve following Gujjar relocation. Madhusudan (2004) recorded recovery of ruminant grazers such as gaur and chital following 49% decline in livestock population. We observed approximately 25% increase in chital and sambar density following 44% decrease in livestock population, while nilgai and wild pig density decreased over three years. Proportion of fawns in the both the population increased also. Out of the various plant species collected by local people for fuel wood, *Anogeissus pendula* was most preferred (95%) followed by *Acasia leucophloea* and *Zizyphus mauritiana* forming the remaining smaller percentage. In addition, *Phoenix sylvestris* and *Butea monosperma* trees were heavily lopped and grass species such as *Apluda mutica, Heteropogon contortus* and *Chloris dolichostachya* are extracted for stall feeding of livestock. All these above mentioned vegetation forms food sources for wild ungulates (Sankar 1994). Resource extraction coupled with livestock grazing creates heavy competition for wild ungulates. Present livestock density (66.84±11.15 (SE)/ km^2) is much lower than the livestock density estimate (221.33/ km^2) assessed before tiger reintroduction in 2007 in STR, which is attributed to the fact that 565 families have been resettled outside STR. This remarkable decrease in livestock density reduced pressures for ruminant grazers like chital. Hence, the population is recovering. Sambar density increase is probably because of the reduction in resource extraction such as *Anogeissus, Apluda etc* coupled with reduced livestock grazing. Nilgai and wild pig prefer degraded habitat (Sankar, 1994). Reduction in their number is likely the indication of habitat quality improvement.

CHAPTER 5
PREY SELECTION AND FOOD HABITS

5.1 Introduction

Tigers (*Panthera tigris*) are obligate carnivores that occur sympatrically with leopards (*Panthera pardus*) in most of their range. These wide ranging congeneric mammalian carnivores differing in size (tiger: 120-270 kg, leopard: 30-90 kg) largely prey on ungulates such as Cervids, Bovids and Suids (Schaller, 1967; Seidensticker, 1976; Johnsingh, 1983; Karanth and Sunquist, 1995, 2000; Bagchi et. al., 2003; Andheria et. al., 2007). Previous studies on the food habits of sympatric leopards and tigers have shown that their diets are very similar when prey is abundant (Schaller, 1967; Johnsingh, 1983; Karanth and Sunquist, 1995; Bagchi et. al., 2003; Andheria et al., 2007). However, under deteriorating habitat conditions leopards may not be as adversely affected as tigers due to their ability to shift towards smaller prey (Ramakrishnan et al., 1999). Therefore, studies assessing the food habits of sympatric carnivores not only aid in our understanding of factors influencing their ecological segregation but may also serve as an indicator of change in habitat quality (Ramakrishnan et al., 1999).

5.2 Methodology

Diet and food preference of tiger were estimated from the scat analysis as well as from the kills (Reynolds and Aebischer, 1991; Mukherjee et al*.,* 1994; Biswas and Sankar; 2002, Sankar and Johnsingh 2002; Bagchi et al., 2003). Scats were collected from all the locations used by the tiger throughout the year. All the collected scats were sun dried and preserved for future analysis. The micro-histological structure of the hairs used to identify the prey species. A total of 78 scats were collected from Sariska Tiger Reserve during 2017-18.

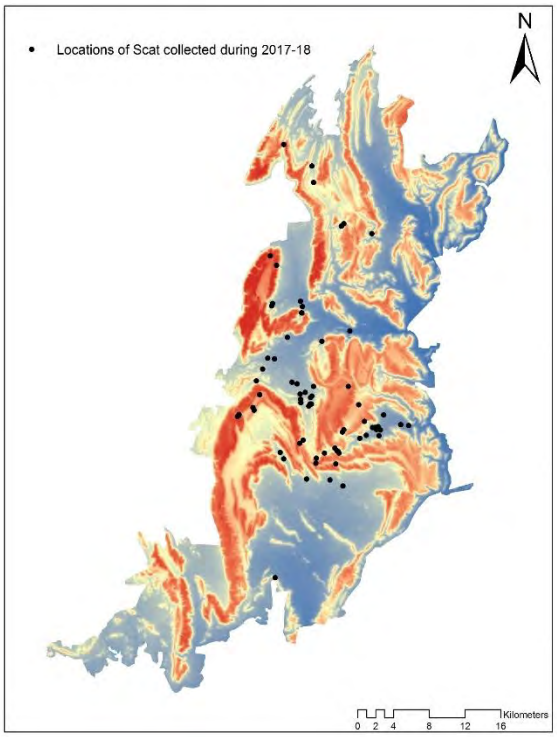


Figure 5.1: Map showing the locations of scat collected during April 2017- March 2018 in Sariska Tiger Reserve

5.3 Result

A total of eight species were identified in the collected tiger scats namely, Sambar, Chital, Nilgai, Wildpig, Buffalo, Cattle, Goat and Hare. Of these Sambar contributed the maximum in tiger's diet (33.63%) followed by Chital (30%), Cattle (17.27), Nilgai (7.27%), Buffalo (6.36%), Hare (2.72%), Goat (1.81%) and Wildpig (0.90%). Sambar as the main prey species for tiger in the study area has been re-established, as had been the trend throughout the study period 2008-13 (Sankar et al., 2013). The percentage of occurrence of prey species found in the scats of tigers during April 2017-March 2018 is shown in Fig 5.2.

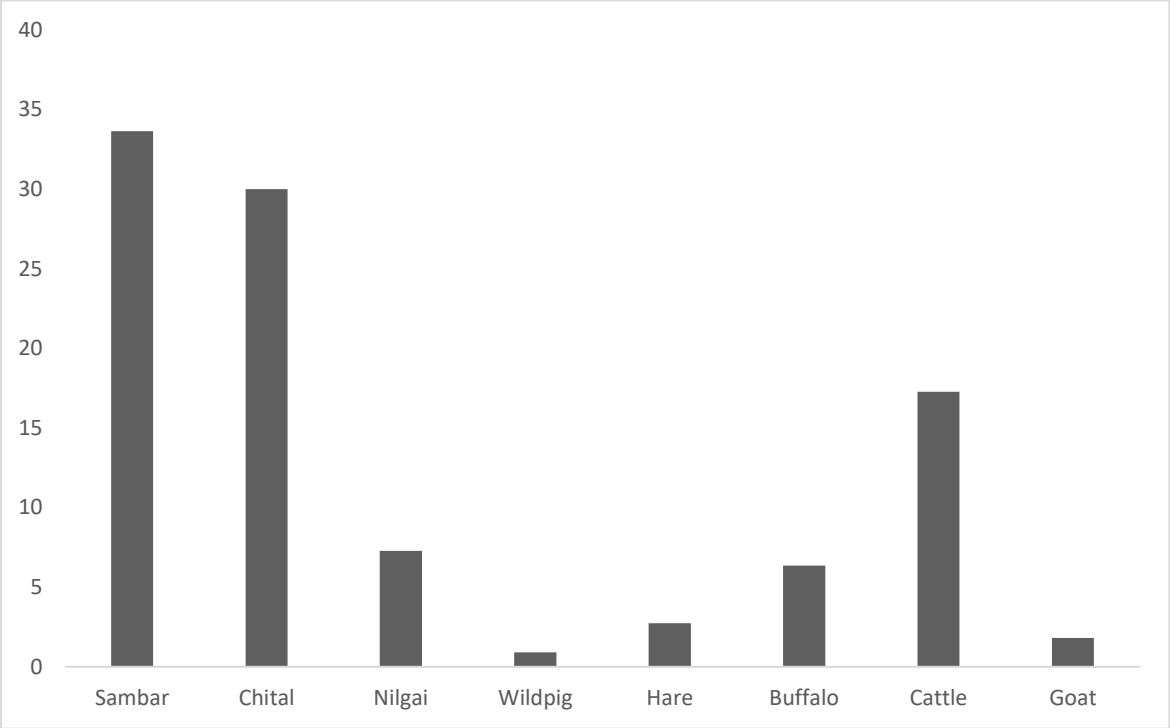


Figure 5.2: Percentage occurrence of prey species found in the scats of tigers during April 2017 to March 2018

5.4 Discussion

Sambar was observed to be the principle prey species for tigers followed by chital and cattle as inferred from the percentage occurrence of prey remains in tiger scats. Sambar's preference by tiger could be attributed to the larger body weight and wide distribution of sambar across the study area. Similar results were obtained by other studies in the country (Karanth and Sunquist 1995; Biswas and Sankar, 2002).

CHAPTER 6
POPULATION STATUS OF CO-PREDATORS

6.1 Introduction

Estimates of abundance of carnivores are necessary for conservation and management implications. However, abundance estimation of carnivores is difficult due to their elusive nature and nocturnal behaviour, large albeit patchy distribution. It is also important to understand the co-existence of different sympatric carnivores in a forested area for our better knowledge and management practices. Generally, coexistence in carnivores appears to be facilitated by differences in body size (Kiltie, 1984; Rosenzweig, 1966). Since predator body size is usually correlated with the size of prey utilized (Hespenheide, 1973; MacDonald, 1980; McNab, 1971; Rosenzweig, 1966), body size differences often result in the segregation of predators along a continuous prey size resource axis. As tertiary consumer, predator plays an important role in regulating prey species such as herbivores and omnivores (Carbone et al., 1999). Such predator-prey dynamics maintain the health and balance of ecosystems.

While, considerable conservation attention and investment is primarily focused towards the conservation of tiger population (Dinerstein et al., 2007) in Indian sub-continent, our understanding about the conservation status and ecology on the entire carnivore community remains poor. Leopard (*Panthera pardus*) and striped hyena (*Hyaena hyaena*) are largely coexisting with tiger in most of its distribution range in Indian sub-continent. Leopard population has also declined due to continual loss of habitat, poaching for illegal trade in body parts (Environmental Investigation Agency (EIA) and Wildlife Protection Society of India (WPSI), 2006) and human-leopard conflict. Data on Leopard abundance and ecology from India are also limited. Leopard populations have become heavily fragmented and isolated (Uphyrkina et al., 2001) and loss of habitat is the most serious long-term threat to leopard and their prey. Increasing human population, changing land use practices, soaring demands from our urban population and more recently fast expanding economic activity have started straining the delicate balance at which tiger and leopard survive (Wickramanayake et al., 1998). Mills and Hofer (1998) estimated the population of striped hyena to be over 1000 within India which was a gross under estimate and suggested that striped hyena population is declining as a result of global population decline of other sympatric carnivores due to decrease in natural sources of carnivores.
Here, we estimate the population status of leopard and striped hyena and compared our results with long term population monitoring data to understand the trend of population of these two co-predators.

6.2 Methods

6.2.1 Field data collection methods

We used a grid-based sampling approach to photograph leopard and striped hyenas within the study area and used Spatially explicit capture-recapture models (SECR, Efford 2004; Borchers and Efford, 2008). Sampling units consisting of grids of the square cell (2 km^2) was superimposed on the map of intensive study area of Sariska National Park. We deployed a pair of camera traps in each grid during December 2017 – January 2018. A total of 130 locations were selected for the placement of camera traps covering an area of 414.35 km^2 in the study area. One day was considered as a single occasion, resulting in 32 occasions and effort of 4160 trap nights.

6.2.2 Analysis

We identified all photographs of leopards and striped hyena obtained from camera traps using pelage markings on hind limbs, forelimbs and stripes on flanks (Singh, 2010; Gupta et al., 2010; Harihar, 2010). Following the identification, unique identification numbers were given to individual striped hyenas. We created two matrices that summaries spatio-temporal detection history of individuals and spatio-temporal layout of traps for SECR (Efford, 2015).

6.2.3 Abundance of leopard and striped hyena

Spatially explicit capture-recapture models (Efford, 2004; Borchers and Efford, 2008) estimate density directly from the spatial capture histories thereby avoiding the use of ad hoc estimation of ETA done in traditional capture-recapture studies. SECR uses spatial histories of individual animals to construct centre of activity from where its detection declines as we move away. This process is modelled by two parameters (1) g0, the detection probability at the activity centre and (2) sigma, the spatial movement parameter.

6.3 Results

In total, 65 and 309 photographs of 39 and 74 individual leopard and striped hyenas were obtained. The estimated population size of leopard and striped hyena in the study area were 64.55 (50.12 - 97.70, 95% CI) and 213.17 (145.59 - 344.56, 95% CI) respectively. Density estimates of leopard and striped hyena were 13.02±2.74 individuals/ 100 km^2 and 11.67±1.38 individuals/ 100 km^2 in the study area (Table 6.1.).

Table 6.1: Population density (D) estimates of leopard and striped hyena (/ 100 km^2), spatial movement parameter (σ), and detection probability at the activity centre (g0)

Species	g0 (SE)	Sigma (σ) in meters (SE)	Density [striped hyenas / 100 km^2 (95% CI)]
Leopard	0.003 (0.0009)	2219.44 (275.01)	13.02 (8.65 - 19.59)
Striped Hyena	0.013 (0.001)	2812.9 (117.05)	11.67 (9.27 - 14.69)

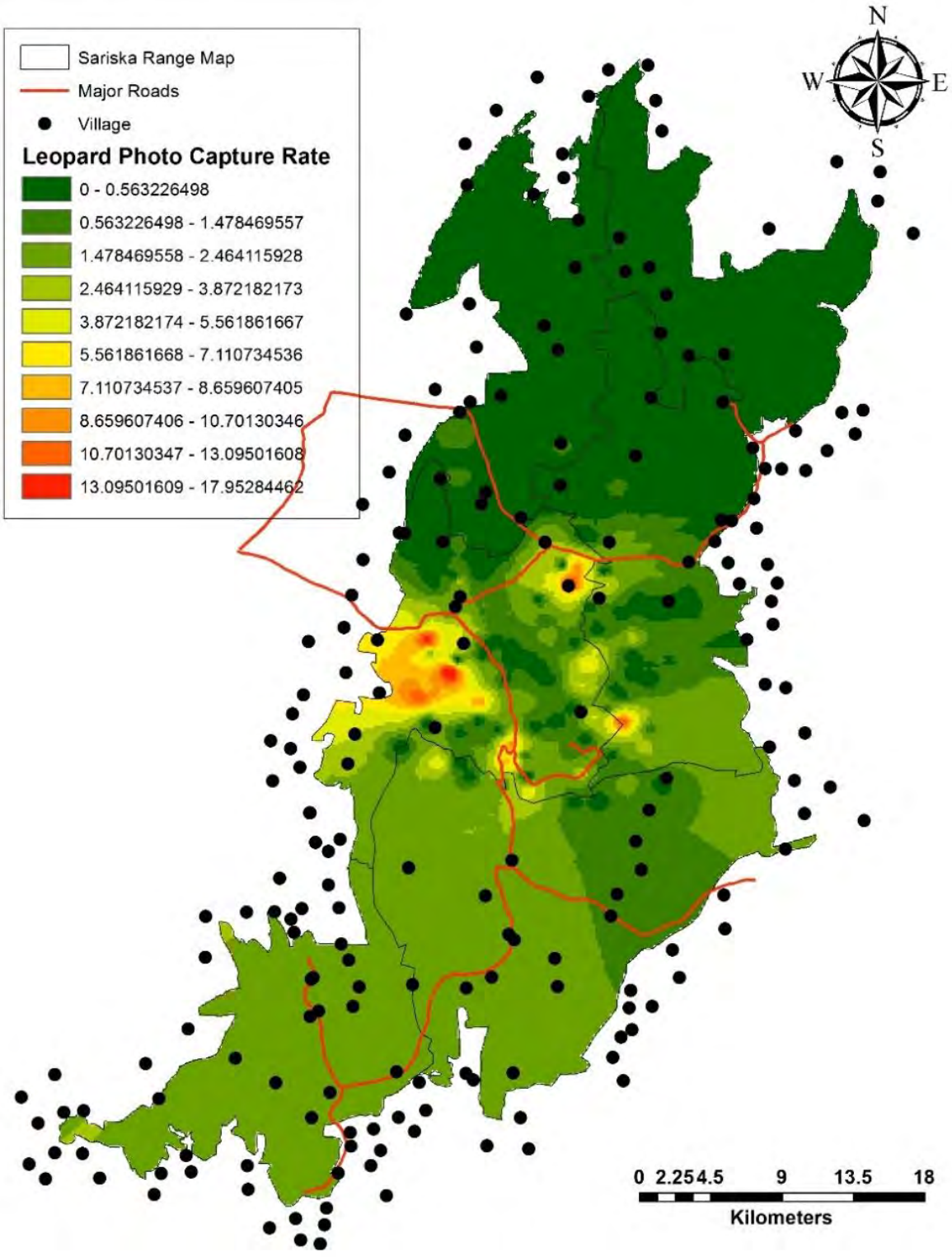


Figure 6.1: Spatial distribution of leopard in Sariska Tiger Reserve

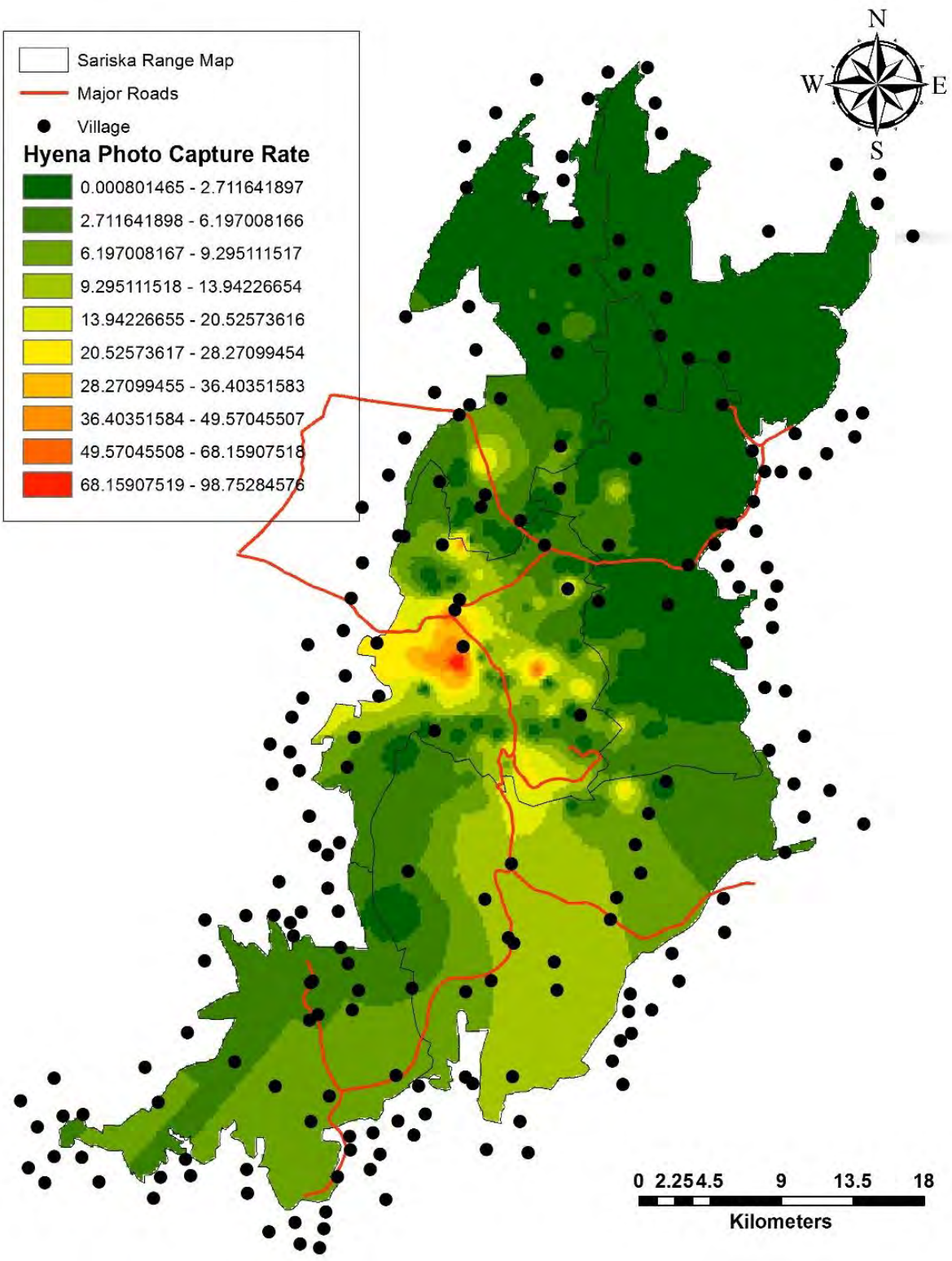


Figure 6.2: Spatial distribution of striped hyena in Sariska Tiger Reserve

6.4 Discussion

Our findings suggest density estimates of leopard and striped hyena were comparatively higher in the study area. Density estimates of both leopard and striped hyena are available only from Rajaji National Park in the Himalayan foothills (Harihar et al., 2009, 2010) and Achanakmar Tiger Reserve (Mandal et al., 2017). Both the above-mentioned areas have low tiger population density (Jhala et al., 2011, 2015). Striped hyena density estimate in the present study is comparatively higher to the estimates obtained from RNP, Kumbhalgrah WLS and Esrana Forest Range. STR probably sustains the reported highest density estimate of striped hyenas in the world (Kruuk, 1976; Wagner, 2006; Singh, 2010).

Table 6.2: Estimated leopard and striped hyena densities in different protected areas of India

Study Site	Leopard Density/ 100 Km^2	Reference	Striped hyena density/ 100 Km^2	Reference
Rajaji National Park	14.9	Harihar et al. 2009	3.91	Harihar 2009
Achanakmar Tiger Reserve	11.34		4.54	Mandal et al. 2017
Satpura National Park	7-10	Edgaonkar 2007	-	-
Mudumalai Tiger Reserve	14.9	Kale et al. 2011	-	-
Kumbhalgarh WLS	-	-	6.5	Singh 2010
Esrana Forest Range	-	-	3.67	Singh 2010
Pench Tiger Reserve	10.6±3.2	Majumder 2011		

Long-term research on leopard demography in Sariska suggests that leopards changed their spatio-temporal behaviour and occupied peripheral habitat to avoid the tigers following the tiger reintroduction in Sariska in 2008 (Mondal et al., 2010). Consequently, leopard density decreased in the best available habitat (Mondal et al., 2012). Although leopard population initially declined, and their diet shifted towards smaller prey, however, the population bounced back during 2012 – 13 probably due to compensatory immigration from peripheral areas (Chatterjee et al., 2016).

Table 6.3: Population density (D) estimates of leopard (/100 km^2) [Source: Leopard Ecology Project final Report]

Year	Density [leopards / 100 km^2 (SE)]
2007	9.3 (2.2)
2008	7.7 (1.9)
2009	5.3 (1.4)
2010	3.3 (1.2)
2011	7.1 (2.0)
2012	16.8 (2.2)
2013	14.16 (2.7)
2014	14.9 (3.6)
2015	16.9 (3.7)

However, the population of striped hyena remained roughly comparable over nine years. Density estimates of striped hyena slightly increased from 12.52±2.17 individuals/ 100 km^2 to 15.44±2.48 individuals/ 100 km^2 over the years (Mandal, 2018).

Table 6.4: Population density (D) estimates of striped hyena (/ 100 km^2) [Source: Mandal, 2018]

Year	Density [striped hyenas / 100 km^2 (SE)]
2007 - 08	12.52 (2.17)
2011 - 12	13.19 (1.67)
2012 - 13	13.90 (1.43)
2013 - 14	14.65 (1.72)
2014 - 15	15.44 (2.48)

SPATIO-TEMPORAL ACTIVITY

7.1 Introduction

Carnivore coexistence is a complex process driven by a plethora of ecological processes such as portioning of diet, space and time (Caro and Stonner, 2003; Chesson and Kuwang, 2008). Carnivore spatio-temporal activity is governed by the activity of their principal/ preferred prey. Species existence is dependent on limiting factors such as food and habitat (Grinnel, 1922). However, niche partitioning such as utilization of food, space and time in a particular however unique and different way than others, other than the limiting resource enables coexistence (MacAurther, 1958). Carnivores with significant diet overlap will try to avoid competition either by partitioning themselves on prey weight class and consequently spatio-temporal activity to exploit those resources in a different manner other than the competitor. Sustenance of specialist carnivores will depend more on the specialized niche. Whereas, subordinate species will broaden their niche to avoid competition with apex predators.

Here, we have used camera trapping to understand the spatio-temporal behavior of the carnivore guild (tiger, leopard and striped hyena), meso-carnivores and their prey with respect to anthropogenic pressure.

7.2 Methods

In total, 130 locations were surveyed using camera traps to understand spatio-temporal activity pattern of large and small carnivores, their prey and human activity. Time evidences obtained from camera traps was then recorded systematically and was analysed using circular statistics (Andersen et al. 2000) in program Oriana and package camtrapR (Niedballa et al., 2016). Peak activity period (95% CI), peak activity time; and overlap among tiger, their prey, other carnivores and human were also analyzed in program ORIANA (Andersen et al., 2000) and package camtrapR (Niedballa et al. 2016). Spatial overlap was calculated using Pianka's Index based on camera trap data.

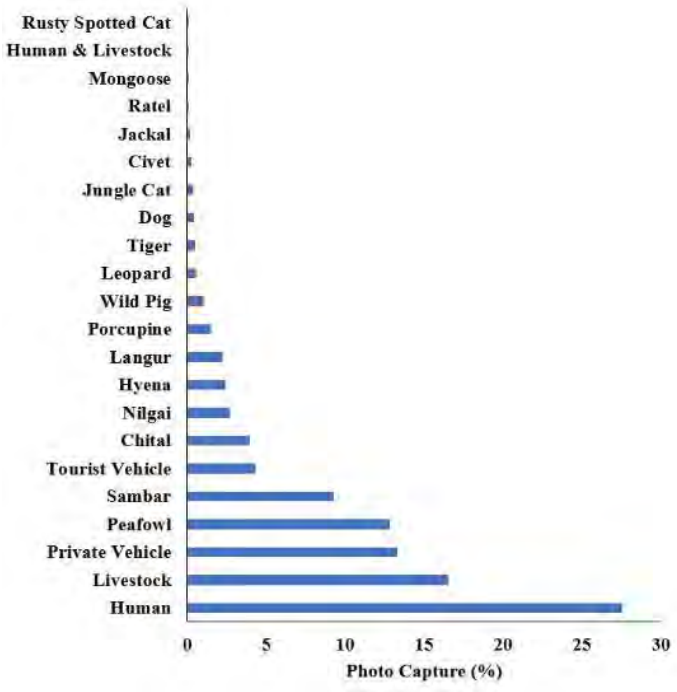


Figure 7.1: Percentage of photographs category wise

7.3 Results

In total, 44,596 photographs were obtained through the camera trapping exercise.

7.3.1 Spatio-temporal activity of carnivores

Tigers exhibited crepuscular activity and were primarily active during twilight hours with a peak at early night (Table 7.1.). Striped hyenas were observed to be completely nocturnal. However, temporal activity of leopard was observed to be bimodal with a peak at early morning [6:18 (03:30 – 09:07)]. Leopard showed a broader span in major activity peak from midnight to early morning.

Table 7.1: Temporal activity of tiger, leopard and striped hyena

Species	Tiger	Leopard	Hyena
Number of Observations	210	254	1058
Activity Peak (95% CI)	23:01 (22:16 - 23:47)	06:18 (03:30 - 09:07)	23:24 (23:07 - 23:41)

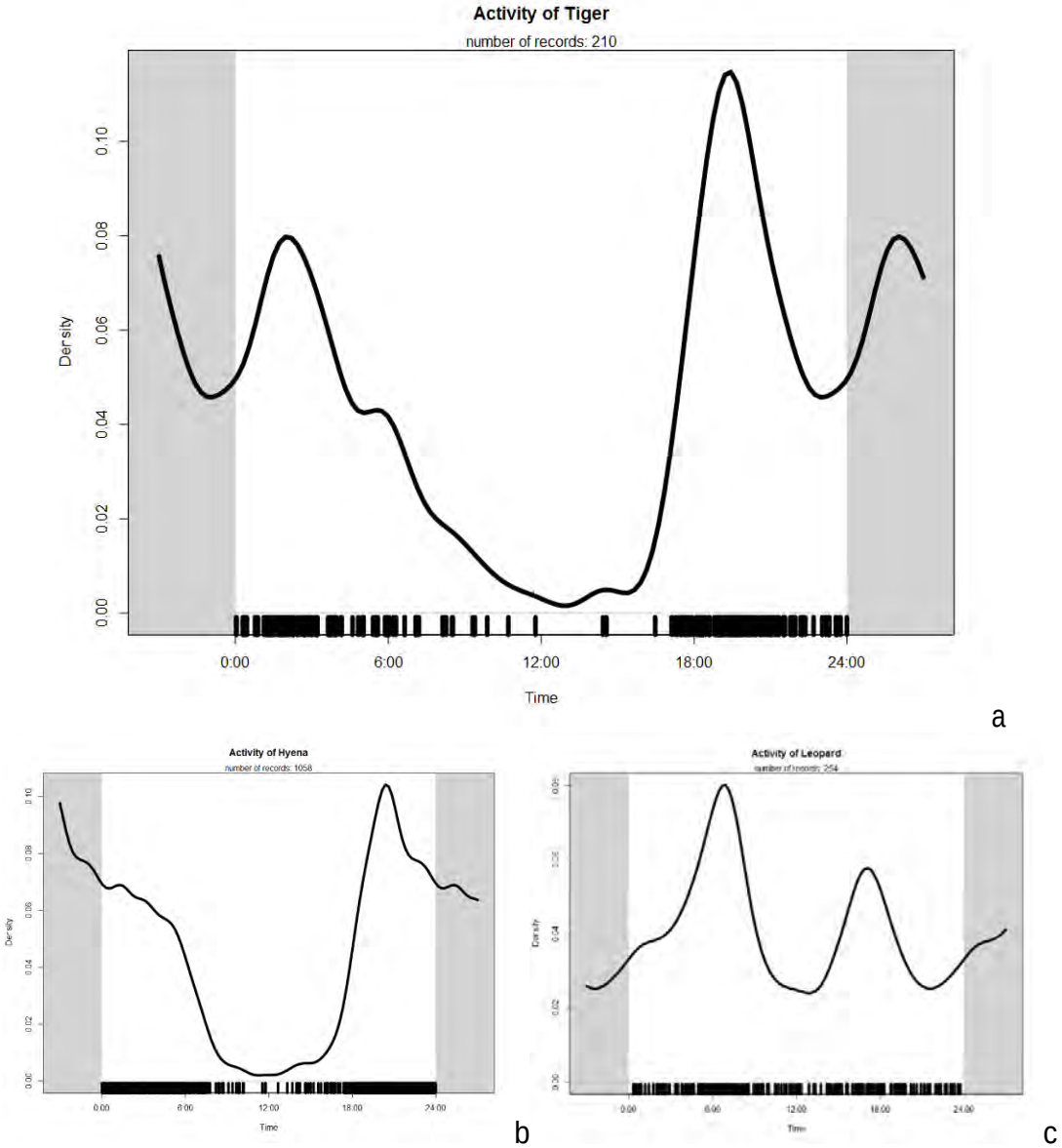


Figure 7.2: Temporal activity pattern of (a) tiger, (b) striped hyena and (c) leopard

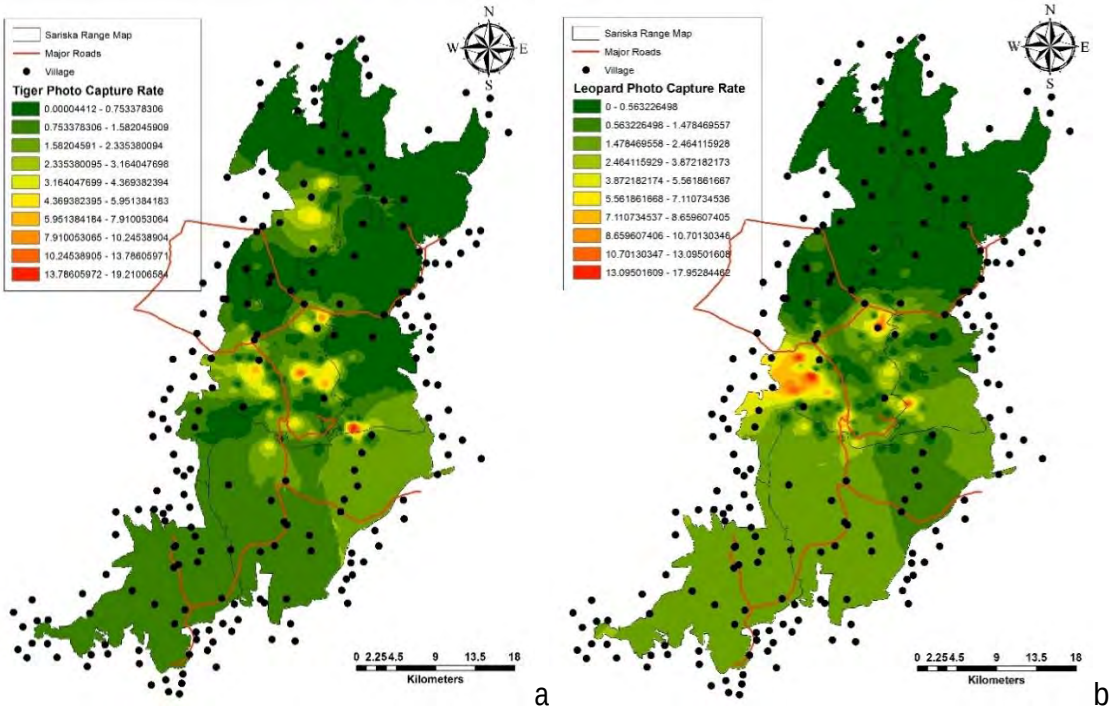


Figure 7.3: Spatial distribution of (a) tiger and (b) leopard in Sariska Tiger Reserve

7.3.2 Spatio-temporal activity of ungulate prey

Chital, nilgai and wild pig's activity were observed to be diurnal and spread out throughout the day, whereas, sambar was overserved to be crepuscular with a peak activity time during 17:58 – 18:32 h (Figure 7.2.).

Table 7.2: Temporal activity of ungulate prey

Species	Number of Observations	Activity Peak (95% CI)
Chital	1754	13:37 (13:24 - 13:50)
Nilgai	1212	12:29 (12:10 - 12:47)
Sambar	4136	18:15 (17:58 - 18:32)
Wild Pig	463	12:18 (11:48 - 12:47)

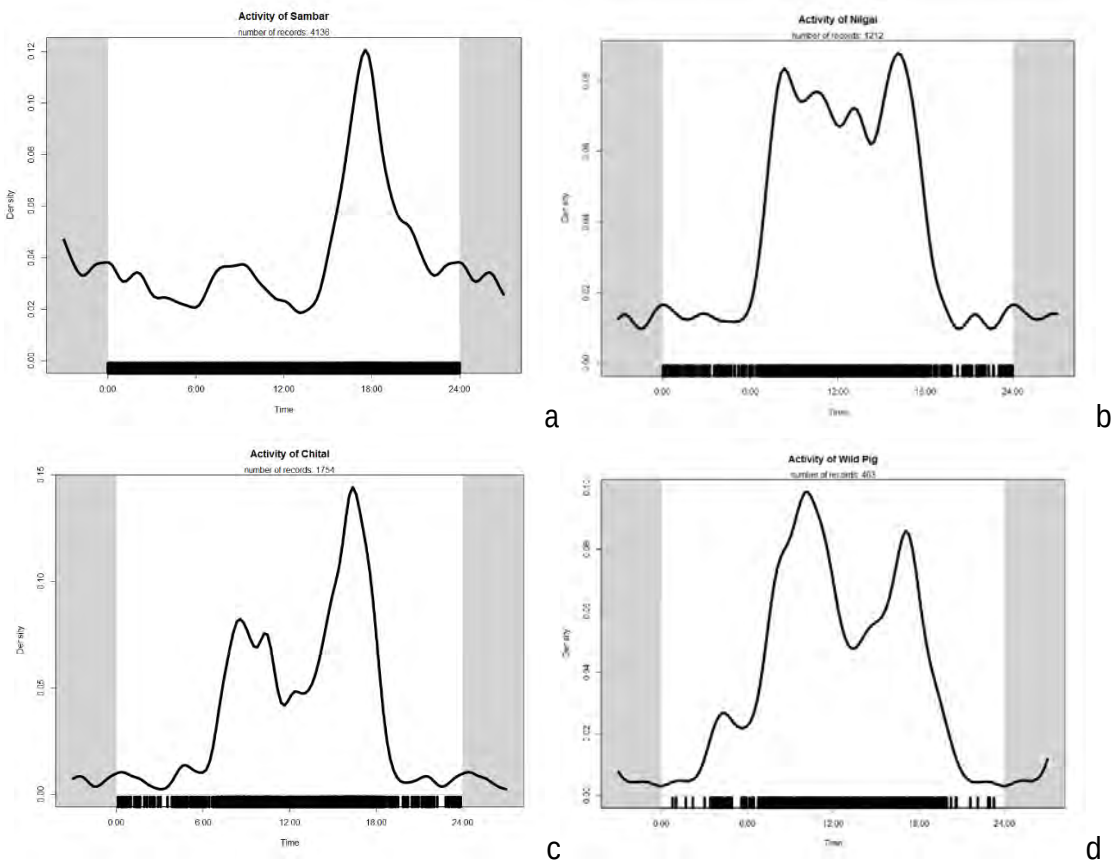
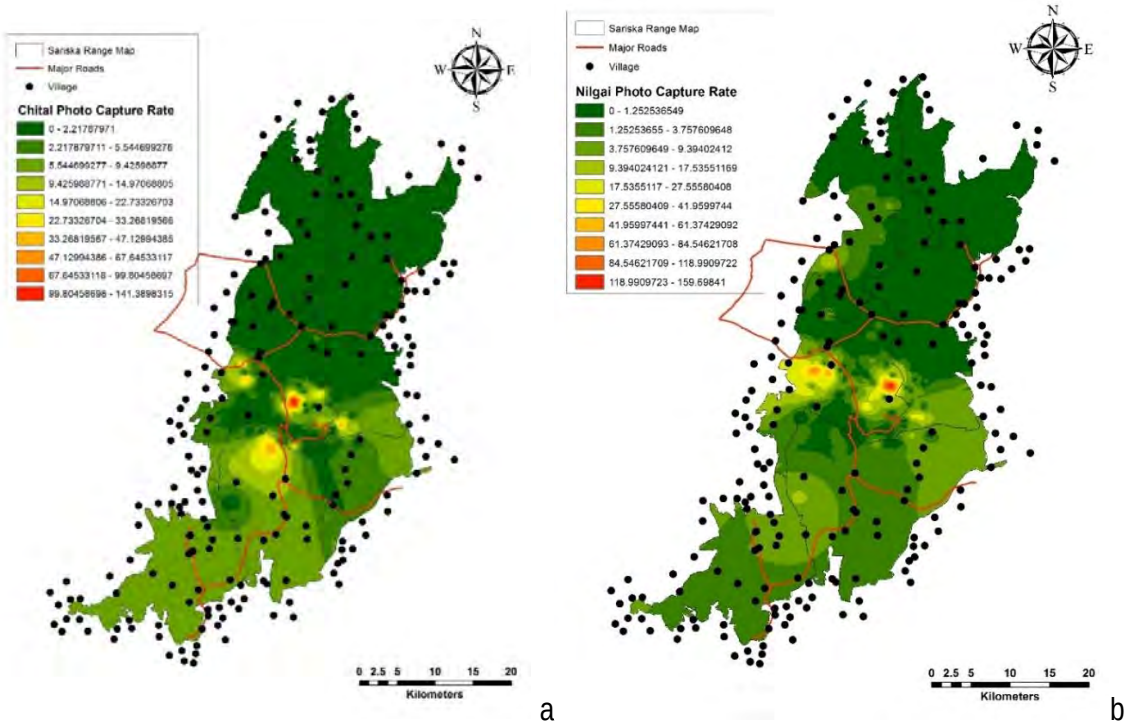


Figure 7.4: Temporal activity pattern of (a) sambar, (b) nilgai, (c) chital and (d) wild pig



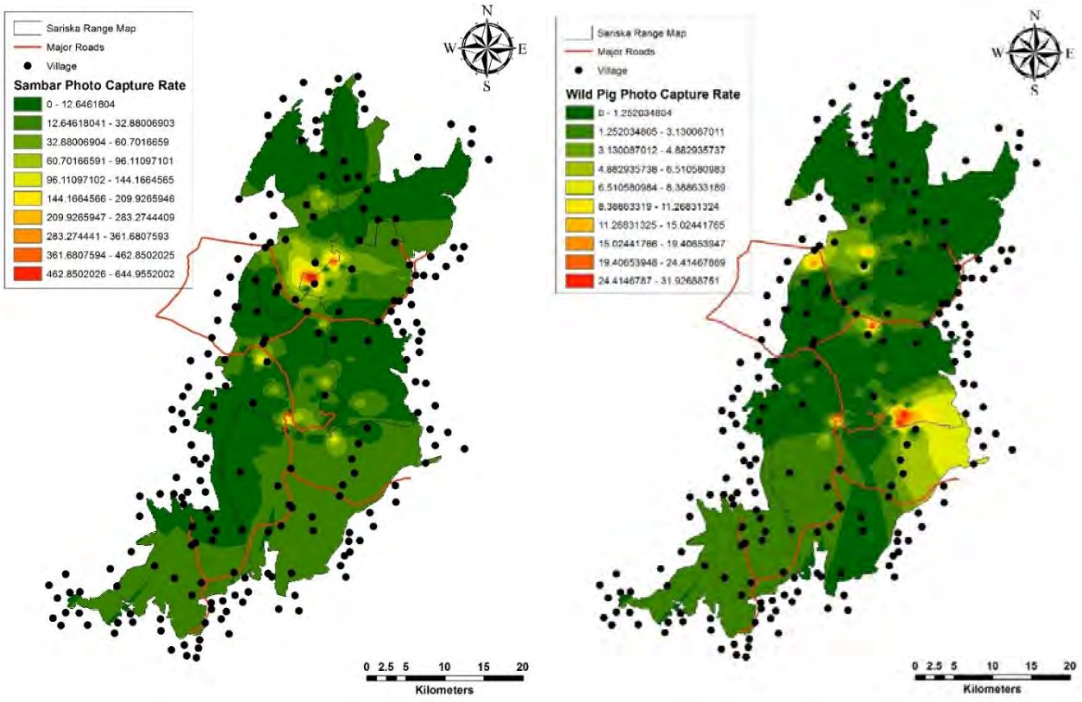


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Figure 7.5: Spatial distribution of ungulates [(a)Chital, (b)Nilgai, (c)Sambar and (d)Wild Pig] in Sariska Tiger Reserve

7.3.3 Anthropogenic pressure

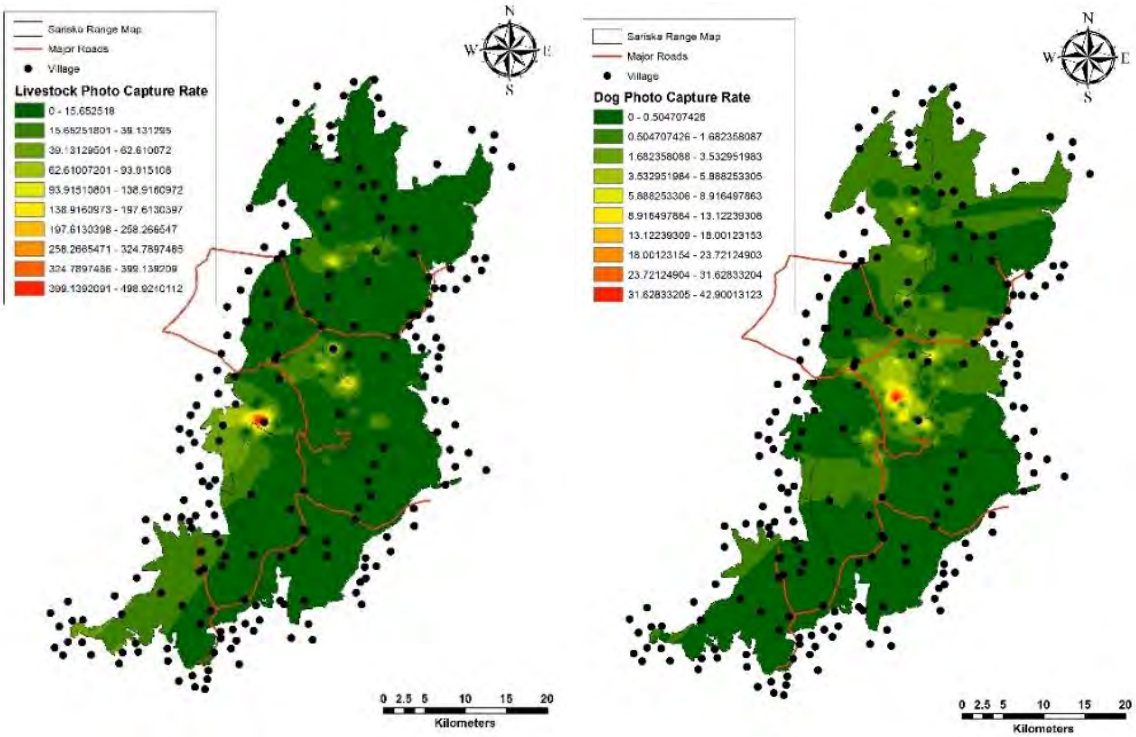


Figure 7.6: Spatial distribution of livestock and dogs in Sariska Tiger Reserve

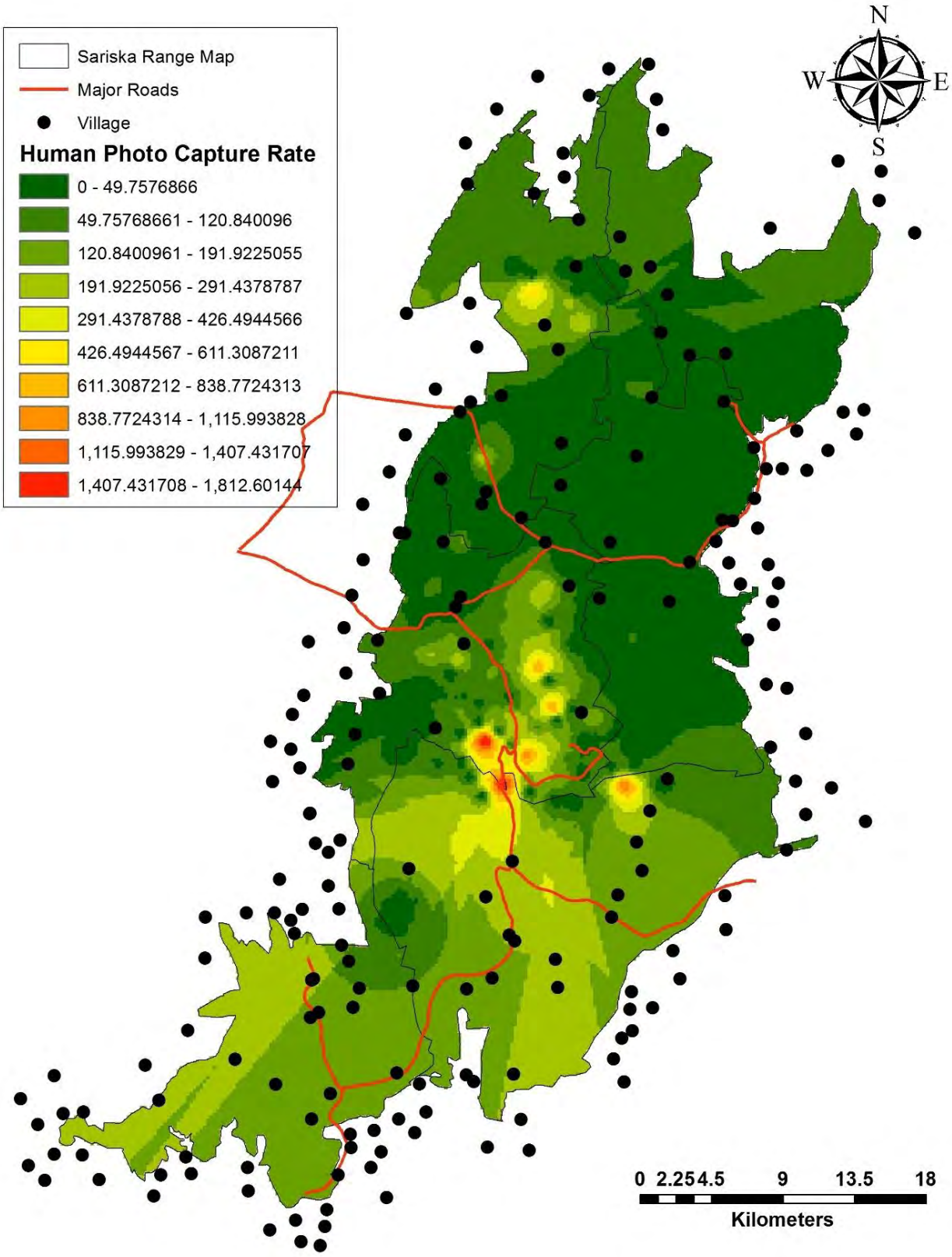


Figure 7.7: Human photo capture rate in Sariska Tiger Reserve

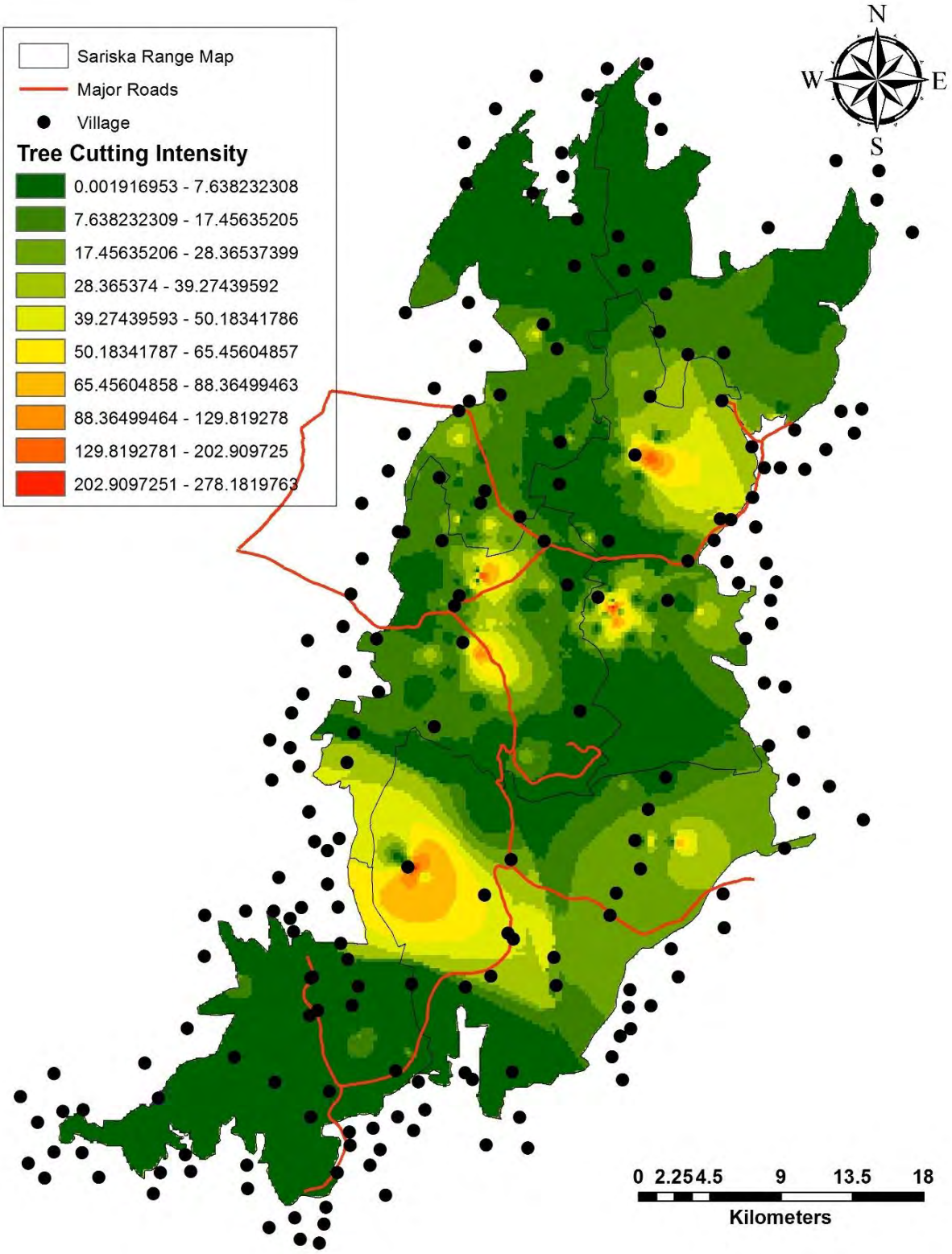


Figure 7.8: Intensity of tree cutting in Sariska Tiger Reserve based on 200 surveyed points

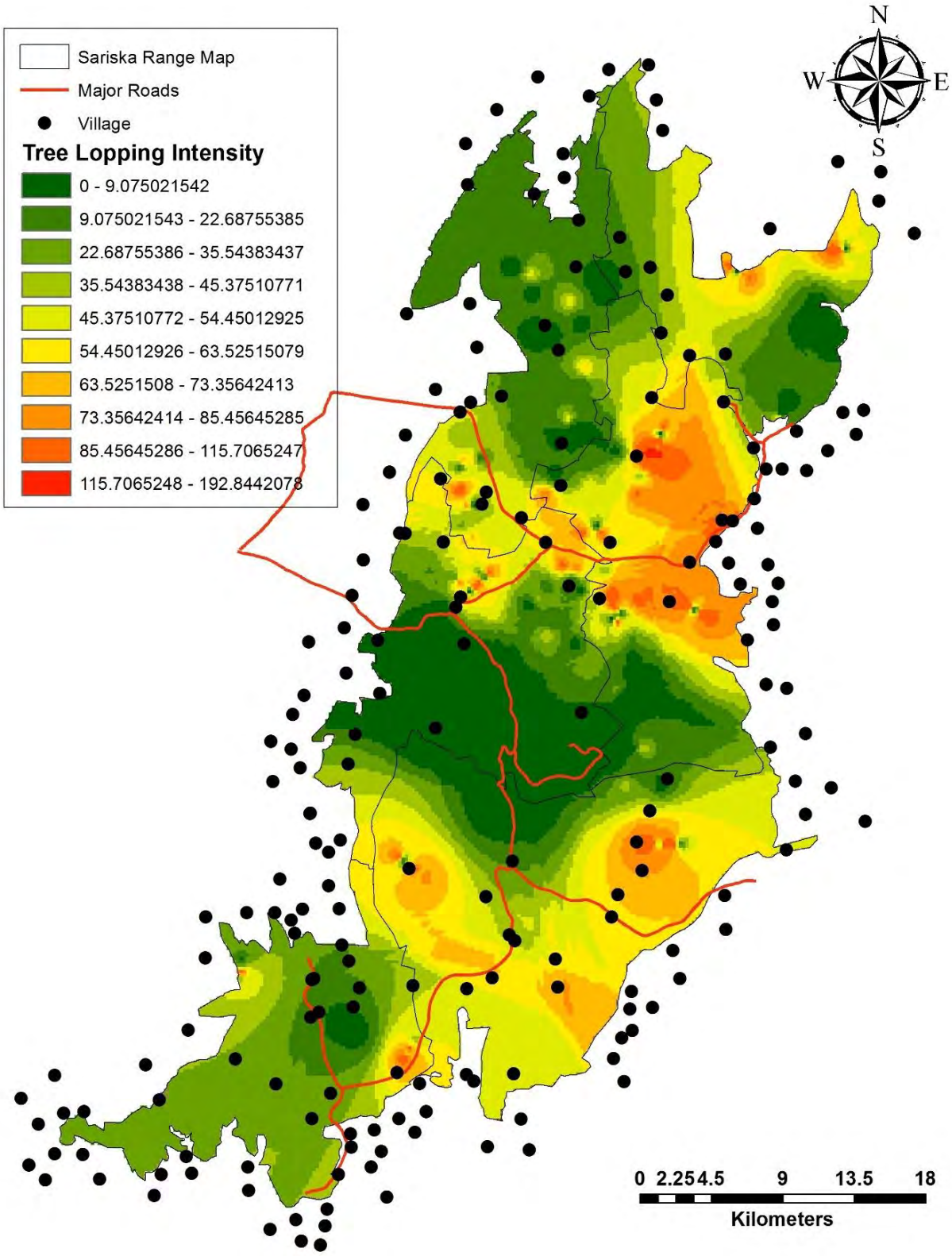


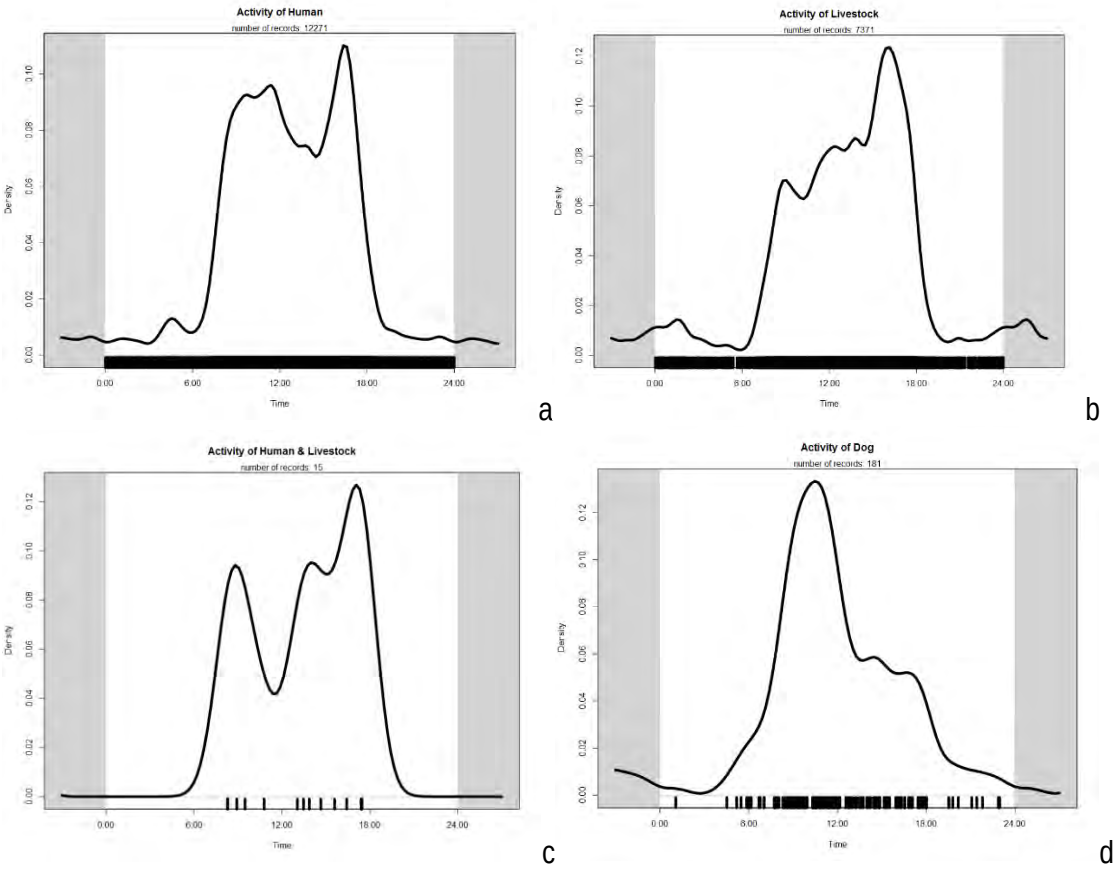
Figure 7.9: Intensity of tree lopping in Sariska Tiger Reserve based on 200 surveyed points

7.3.4 Temporal activity of human, livestock, dog and vehicles

Due to the presence of 29 villages inside the reserve, human activity inside the reserve is high. However, human activity is limited to the day time. Livestock grazing is spread throughout the day with a peak during 13:36 – 13:47 h.

Table 7.3: Temporal Activity of anthropogenic pressure

Species	Number of Observations	Activity Peak (95% CI)
Dog	181	11:41 (11:08 - 12:15)
Human	12271	12:45 (12:41 - 12:49)
Human & Livestock	15	13:42 (11:48 - 15:36)
Livestock	7371	13:41 (13:36 - 13:47)
Tourist Vehicle	1926	13:43 (13:31 - 13:56)
Vehicle	5927	13:38 (13:33 - 13:43)



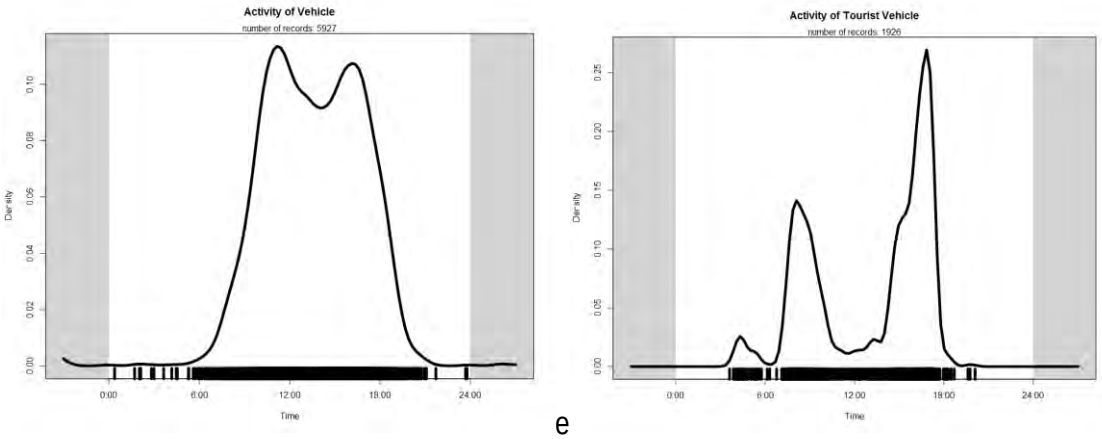


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Figure 7.10: Temporal activity of anthropogenic pressure

7.3.5 Spatio-temporal activity of small carnivores

Table 7.4: Temporal Activity of small carnivores

Species	Number of Observations	Activity Peak (95% CI)
Civet	114	23:37 (22:49 - 00:26)
Jackal	75	01:21 (00:10 - 02:33)
Jungle Cat	157	23:35 (22:42 - 00:28)
Mongoose	22	12:33 (11:18 - 13:47)
Ratel	41	00:00 (22:56 - 01:03)
Rusty Spotted Cat	6	23:49 (21:34 - 02:05)

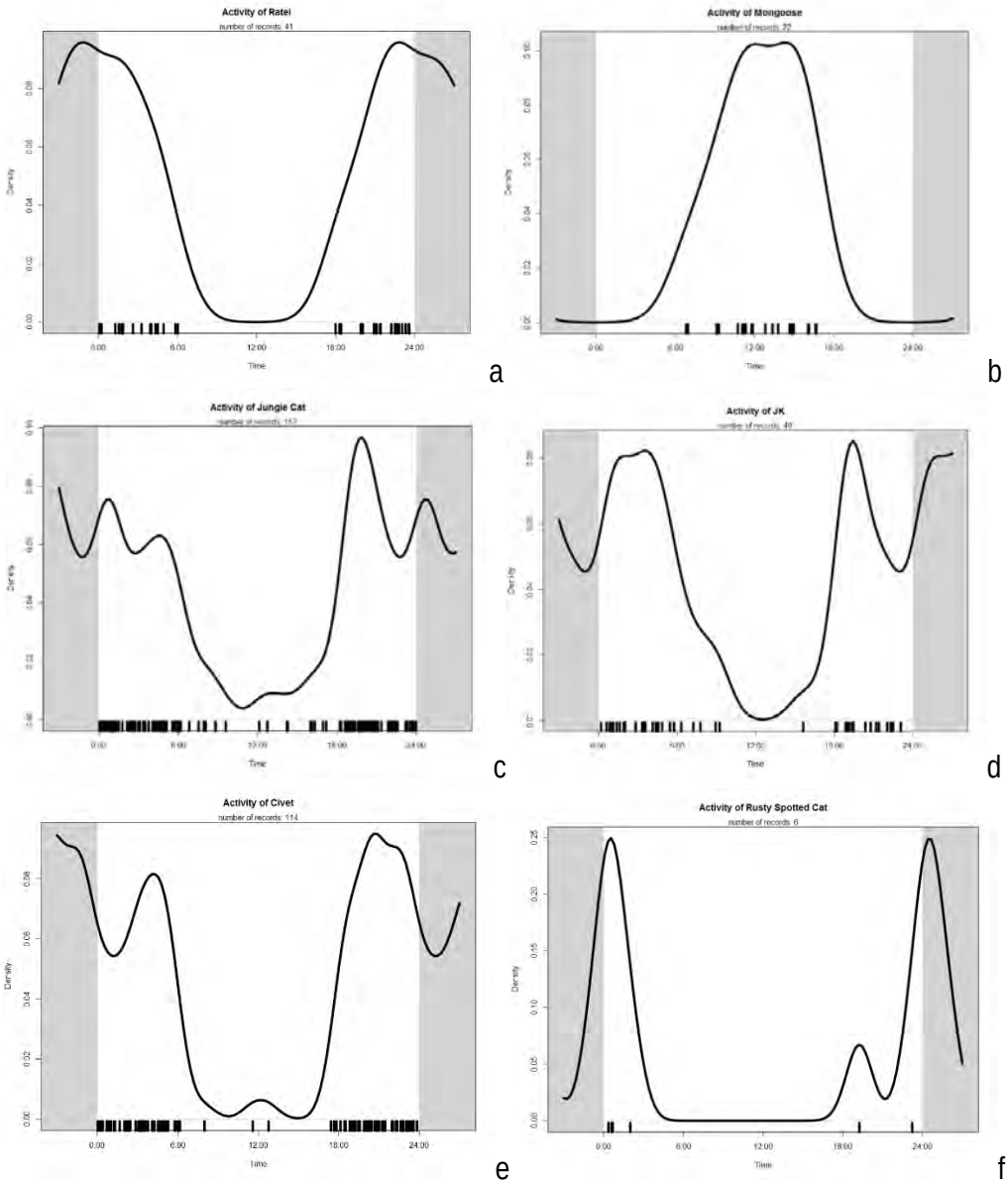


Figure 7.11: Temporal activity of (a) ratel, (b) mongoose, (c) jungle cat, (d) jackal, (e) civet, and (f) rusty spotted cat

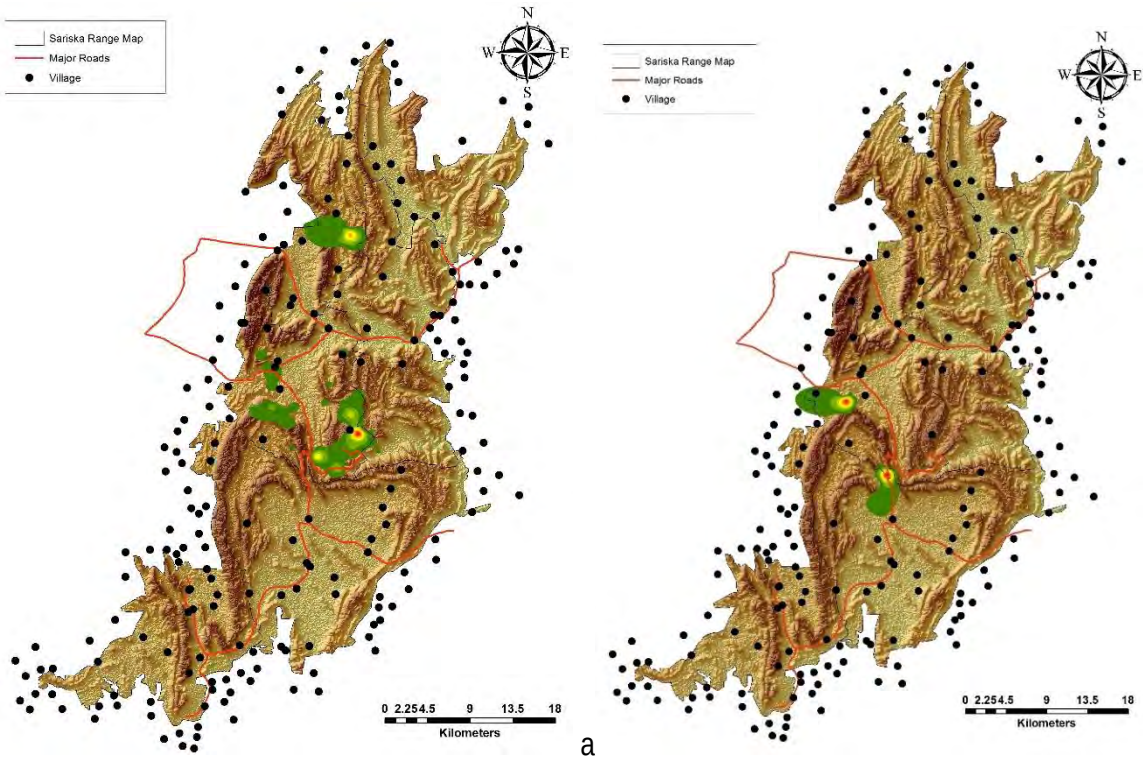


Figure 7.11: Spatial distribution of (a) jungle cat and, (b) rusty spotted cat

7.3.6 Temporal overlap of tiger with prey

Tiger's temporal activity overlapped highest with their principal prey, Sambar followed by chital. Temporal activity overlaps with nilgai and wild pig was minimal.

Table 7.5: Temporal Overlap between tiger and ungulate prey

	Chital	Nilgai	Sambar	Tiger	Wild Pig
Chital	-	< 0.001	< 0.001	< 0.001	< 0.001
Nilgai	1.207	-	< 0.001	< 0.001	< 0.05
Sambar	21.118	15.9	-	< 0.001	< 0.001
Tiger	10.487	8.413	2.776	-	< 0.001
Wild Pig	1.042	0.214	6.483	7.213	-

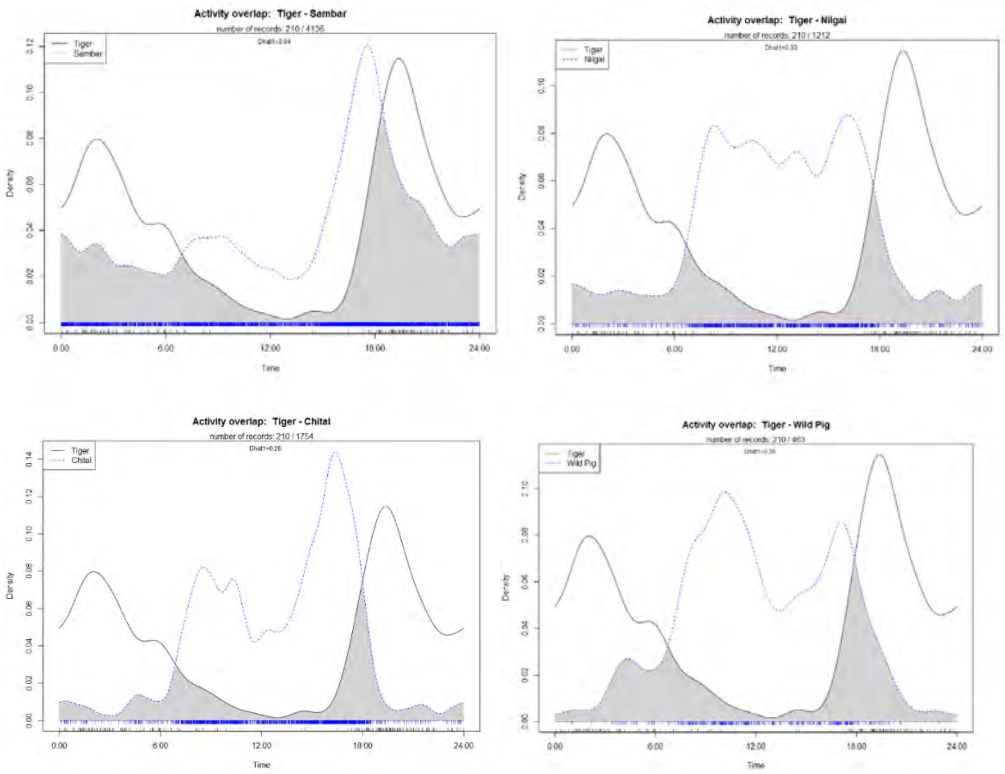


Figure 7.12: Temporal overlap between tiger and its prey

7.3.7 Temporal overlap of tiger with co-predators

Tiger had significant overlap in temporal activity with striped hyena (87%). However, tiger's temporal activity overlap with leopard (61%) was comparatively lower.

Table 7.6: Temporal overlap between tiger, leopard and striped hyena

	Hyena	Leopard	Tiger
Hyena	-	< 0.001	< 0.01
Leopard	4.349	-	< 0.001
Tiger	0.301	2.037	-

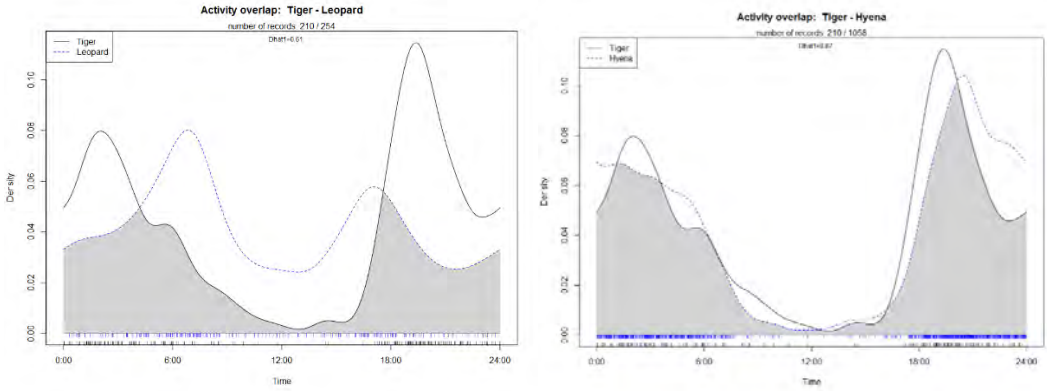


Figure 7.13: Temporal overlap between tiger, leopard and striped hyena

7.3.8 Temporal overlap of tiger with human, livestock and dog

Carnivores, in general were observed to avoid anthropogenic pressure on temporal scale. This has probably permitted them to survive in the human dominated landscape in high density by segregating themselves on temporal scale.

Table 7.7: Temporal overlap between tiger and anthropogenic pressure

	Dog	Human	Human & Livestock	Livestock	Tiger	Tourist Vehicle	Vehicle
Dog	-	< 0.001	0.2 > p > 0.1	< 0.001	< 0.001	< 0.001	< 0.001
Human	0.509	-	> 0.5	< 0.001	< 0.001	< 0.001	< 0.001
Human & Livestock	0.148	0.063	-	> 0.5	< 0.001	0.2 > p > 0.1	0.5 > p > 0.2
Livestock	1.312	5.105	0.047	-	< 0.001	< 0.001	< 0.001
Tiger	5.688	12.27	1.01	11.602		< 0.001	< 0.001
Tourist Vehicle	2.802	15.468	0.119	10.706	12.763	-	< 0.001
Vehicle	1.279	7.641	0.097	4.135	13.729	19.914	-

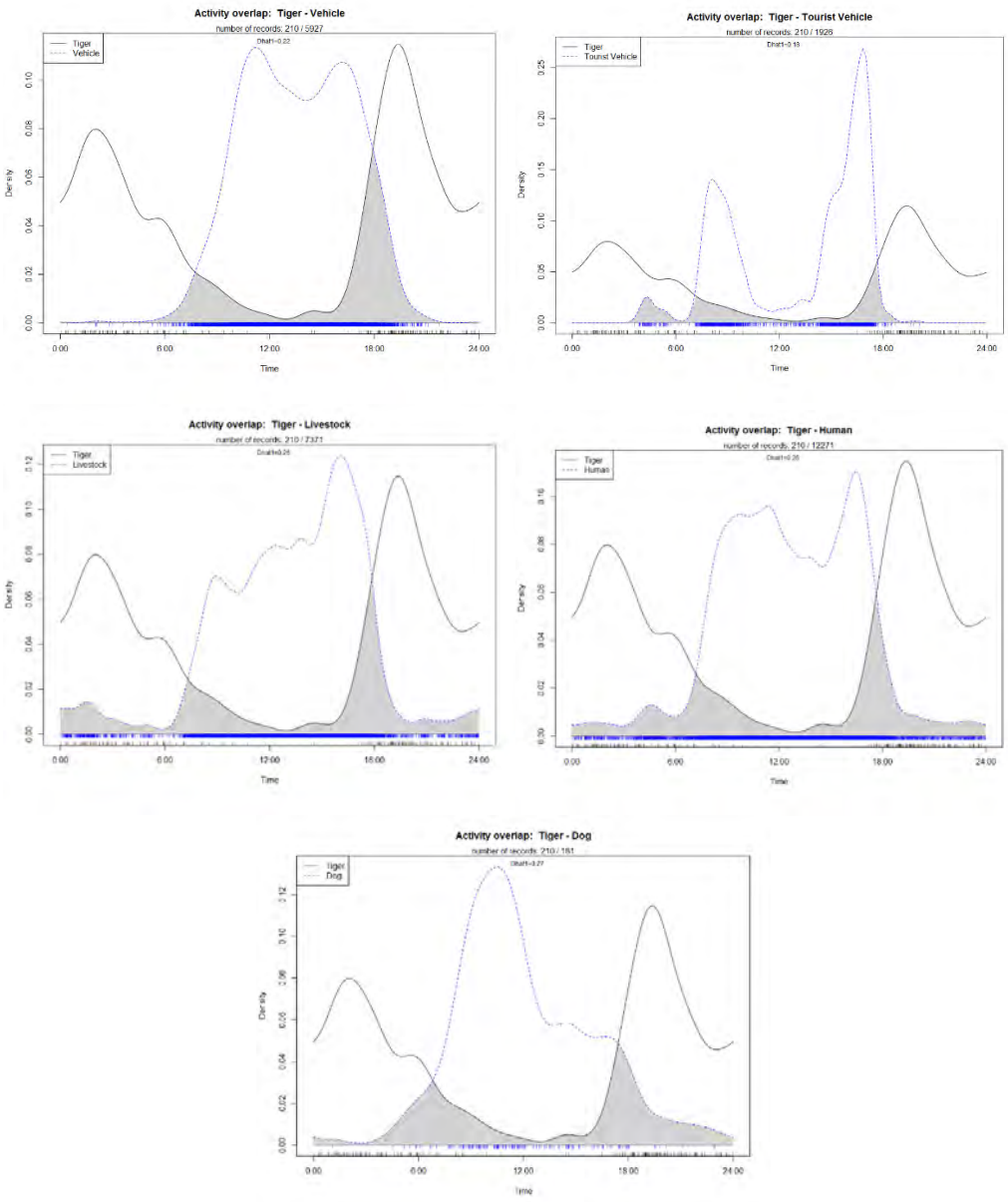


Figure 7.14: Temporal overlap between tiger and anthropogenic activity

7.3.9 Temporal overlap of livestock with herbivores

Livestock had a considerable temporal overlap with ungulate prey of tigers indicating huge grazing pressure and competition for ungulates in Sariska.

Table 7.8: Temporal overlap between livestock and ungulate prey

	Chital	Livestock	Nilgai	Sambar	Wild Pig
Chital	-	< 0.001	< 0.001	< 0.001	< 0.001
Livestock	2.38	-	< 0.001	< 0.001	< 0.001
Nilgai	1.207	2.64	-	< 0.001	< 0.05
Sambar	21.118	57.614	15.9	-	< 0.001
Wild Pig	1.042	2.189	0.214	6.483	-

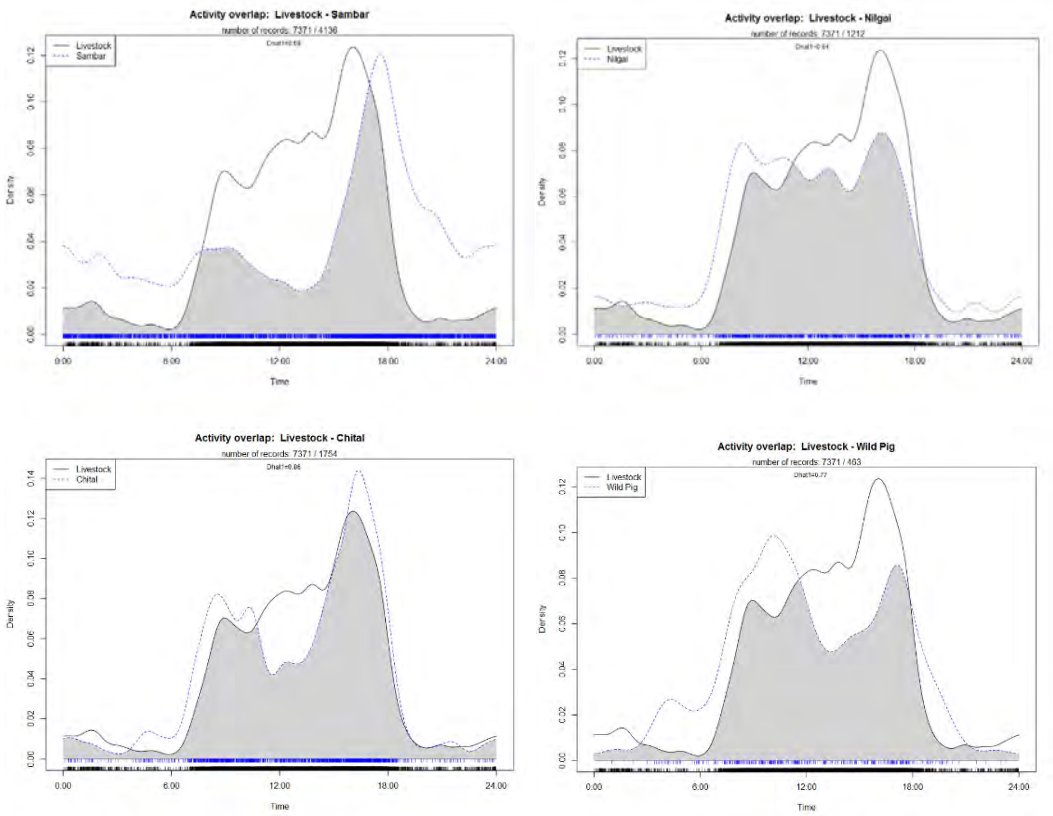


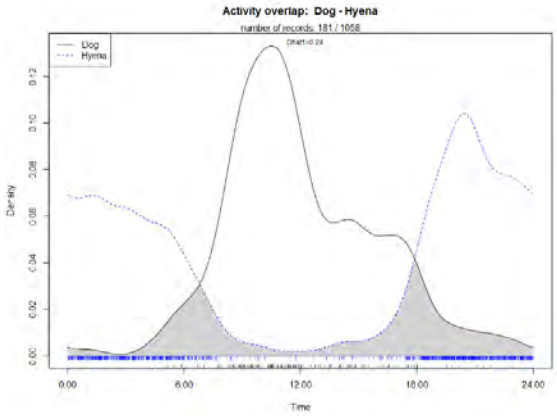
Figure 7.15: Temporal overlap between livestock and wild ungulates

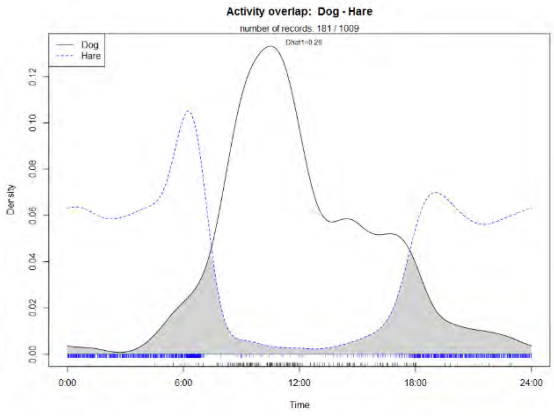
7.3.10 Temporal overlap between dog and wild animals

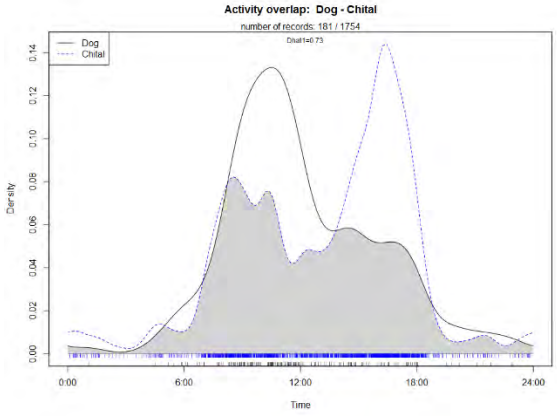
Recent studies are showing dogs have huge effect on wildlife. Dogs had significant temporal overlap with wild animals. Management should focus on eradication of dogs following relocation efforts from the tiger reserve.

Table 7.9: Temporal overlap between dog and wild animals

	Chital	Dog	Hyena	Jungle Cat	Nilgai	Peafowl	Porcupine	Sambar	Wild Pig	Hare
Chital	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Dog	1.374	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Hyena	38.98	9.69	-	0.2 > p > 0.1	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Jungle Cat	7.572	4.806	0.121	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.02
Nilgai	1.207	0.67	28.483	6.15	-	< 0.001	< 0.001	< 0.001	< 0.05	< 0.001
Peafowl	2.944	0.559	60.923	9.238	0.978	-	< 0.001	< 0.001	< 0.001	< 0.001
Porcupine	31.246	9.535	0.487	0.469	23.841	43.213	-	< 0.001	< 0.001	< 0.001
Sambar	21.118	4.79	15.757	2.315	15.9	62.424	14.396	-	< 0.001	< 0.001
Wild Pig	1.042	0.42	17.583	5.612	0.214	0.701	16.852	6.483	-	< 0.001
Hare	37.197	9.297	1.701	0.25	26.862	59.654	3.017	14.148	15.845	-


Activity overlap: Dog - Hyena
number of records: 181 / 1658
Dhat1=0.24
Dog
Hyena
Density
Time
0:00
6:00
12:00
18:00
24:00


Activity overlap: Dog - Hare
number of records: 181 / 1009
Dhat1=0.26
Dog
Hare
Density
Time
0:00
6:00
12:00
18:00
24:00


Activity overlap: Dog - Chital
number of records: 181 / 1754
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Dog
Chital
Density
Time
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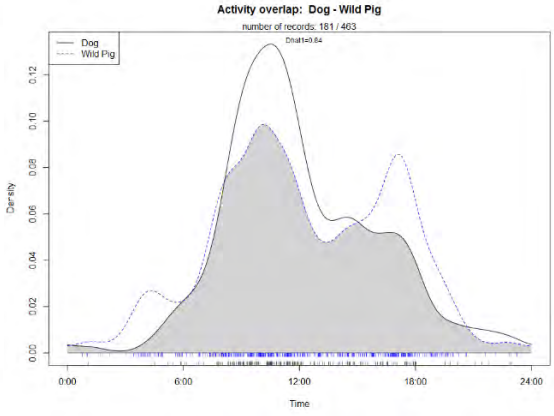
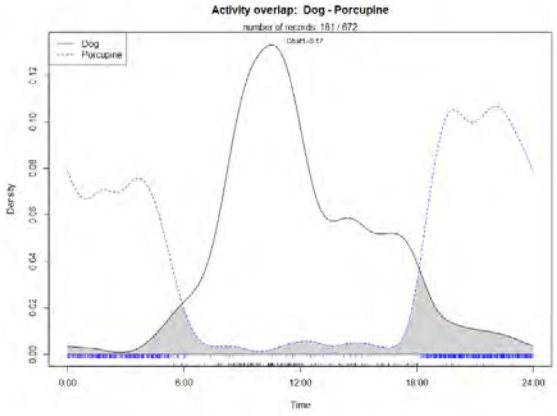
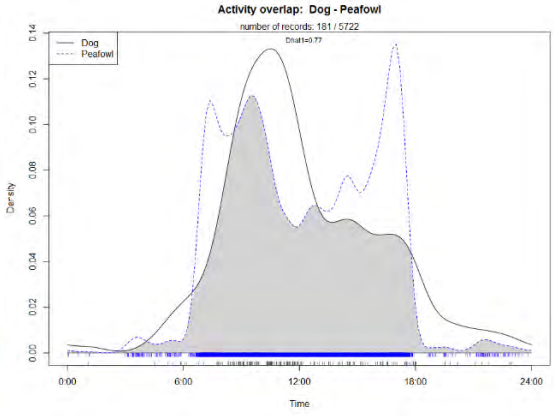
6:00
12:00
18:00
24:00


Activity overlap: Dog - Wild Pig
number of records: 181 / 463
Dhat1=0.84
Dog
Wild Pig
Density
Time
0:00
6:00
12:00
18:00
24:00


Activity overlap: Dog - Porcupine
number of records: 181 / 672
Dhat1=0.67
Dog
Porcupine
Density
Time
0:00
6:00
12:00
18:00
24:00


Activity overlap: Dog - Peafowl
number of records: 181 / 5722
Dhat1=0.77
Dog
Peafowl
Density
Time
0:00
6:00
12:00
18:00
24:00

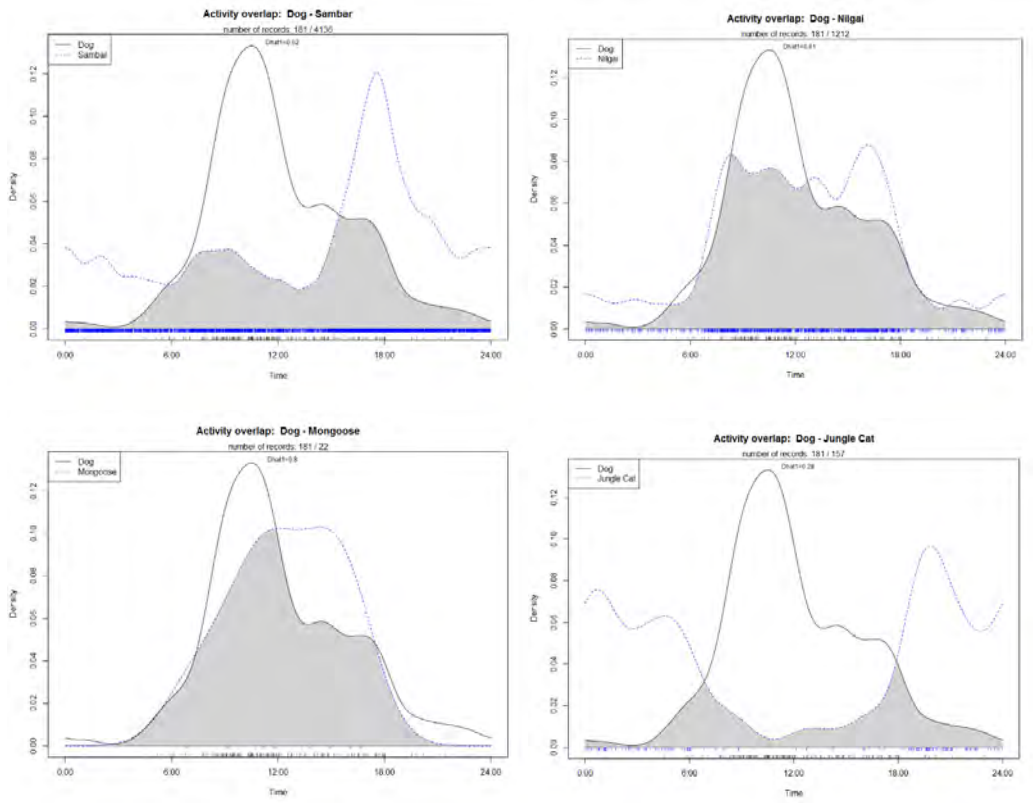


Figure 7.16: Temporal overlap between dogs and wild animals

7.4 Discussion

Tigers had high spatial overlap with co-predators, their prey (sambar and chital) and also with human and livestock. However, tigers temporally segregated themselves from anthropogenic activity (human and livestock) which probably enabled them to persist in this landscape without major human-tiger conflict. Although, leopards had higher spatial overlap with tigers, they avoided tigers on a temporal scale. Tigers had highest spatio-temporal overlap with their principal prey sambar. Sambar approximately contributes to 40-50% in tiger diet (Sankar et al., 2013). Thus, sambar population management will be crucial for tiger population in future.

Table 7.10: Spatial overlap between tiger, co-predators, their prey and anthropogenic pressure

Category	Variables	Pianka Index
Tiger & Co-predators	Tiger & Leopard	3.25
	Tiger & Hyena	2.86
Tiger & Prey	Tiger & Sambar	4.53
	Tiger & Chital	0.11
	Tiger & Wild Pig	0.17
	Tiger & Nilgai	2.60
Tiger, Human & Livestock	Tiger & Livestock	3.63
	Tiger & Human	2.57

Figure 7.17: Spatio-temporal overlap between tigers, co-predators, prey, livetsock and human

	SPACE	TIME	SPACE-TIME OVERLAP
CHITAL			LOW SO & LOW TO
WILD PIG			LOW SO & MEDIUM TO
HUMAN			MEDIUM SO & LOW TO
NILGAI			MEDIUM SO & HIGH TO
HYENA			MEDIUM SO & HIGH TO
LEOPARD			HIGH SO & LOW TO
LIVESTOCK			HIGH SO & LOW TO
SAMBAR			HIGH SO & HIGH TO

CHAPTER 8
FIRST PARTURITION OF REINTRODUCED TIGERS

8.1 Introduction

Management of wildlife, especially carnivores with low reproductive rates requires knowledge of reproductive parameters such as the age at first reproduction, reproductive rate, litter size, and inter-birth interval (Carter et al., 1999). Reproductive parameters are important indicators also to detect the lineage persistence in a population (i.e., lineage loss, individual fitness, population viability; Kelly, 2001). Gompper et al., (1997) suggested that lineage persistence is inversely related to age at first reproduction of a species and can be used to calculate rate of lineage loss per generation and generation timings (i.e., the average span between the birth of individuals and the birth of their offspring) which is crucial for conservation when considering risks. Small and isolated populations (<50 individuals) are vulnerable to such losses (i.e., genetic viability) if matriline losses are excessive; genetic diversity may be lost at a much more rapid rate in small and isolated populations than expected (Berger and Cunningham, 1995). Here, we study the first parturition of tigers in Sariska Tiger Reserve which is an isolated reserve with small tiger population.

8.2 *Methods*

Each individual reintroduced females were monitored since their reintroduction (Table: 8.1) by a team of two trained persons from 2008 onwards. All the reintroduced tigers were collared and monitored through ground tracking. In case, collars stopped working, tigers were tracked based on direct sighting, camera trapping and pugmark tracking every day.

8.3 *Results*

All the reintroduced females were monitored since their reintroduction (Table: 8.1). No female littered before reintroduction. The mean age of all females at first parturition was 59.8±08.16 months. The maximum age at which a female tiger starts breeding in semi-arid habitat of STR was 93 months. Approximate mean age of first reproduction of reintroduced tigers (ST2, ST09 & ST10) in Sariska was 68.33±11.11 months. Mean time of first reproduction of females since they were reintroduced was 31.33± 6.87 months. Two females (ST3 and ST5) did not reproduce till date. ST2 had littered two cubs [ST13 (M), ST14 (F)] again after a gap of 24 months in April 2014 at the age of 116 months.

In total, 12 cubs (four females, three males and three unknown) were born to three females. Mean litter size of reintroduced tigers in Sariska TR was 2±0.23 cubs.

Table 8.1: Age of first reproduction of reintroduced tigers in Sariska Tiger Reserve

Individual Id.	Approximate date of birth	Date of Reintroduction/ photographed	Age at the time of reintroduction/ photographed	Approximate age at first breeding	First time photographed with cubs	Id. Of Cubs
ST2	Oct-04	8/7/2008	48	May-12 (93 months)	8/7/2012	ST7 (F), ST8 (F)
ST3	Oct-06	27/02/2009	30	-	-	-
ST5	Oct-07	1/8/2010	36	-	-	-
ST9	Dec-11	22/01/2013	30	Dec-15 (66 months)	29/08/2014	ST15 (M)
ST10	Dec-11	22/01/2013	30	Jun-14 (46 months)	7/2/2016	ST11 (M), ST12 (F)
ST14	Mar-14	12/7/2014	04 months	Jan-18 (45 months)	6/4/2018	ST16 ST17
ST12	Jun-14	29/08/2014	03 months	18-Jun (49 months)	31/08/2018	ST18, ST19, ST20

Mean age of female cubs at which they separated from their mother was 22.5±0.95 months and males were 22±1.24 months. There was no significant difference in age of separation between sexes. However, all the four females established their territory adjacent to their natal area, while all the males have dispersed from the natal area.

Individual Id.	First time photographed (age at that time)	Established own home range
ST7 (F)	08/07/2012 (4 months)	Feb 2014 (21 months)
ST8 (F)	08/07/2012 (4 months)	Feb 2014 (21 months)
ST12 (F)	29/08/2014 (3 months)	April 2016 (21 months)
ST14 (F)	12/07/2014 (4 months)	May 2016 (25 months)
Mean age of separation: 22.5 ± 0.95 (SE) months		
ST11 (M)	29/08/2014 (3 months)	May 2016 (24 months)
ST13 (M)	12/07/2014 (4 months)	Feb 2016 (19 months)
ST15 (M)	07/02/2016 (3 months)	Oct 2017 (23 months)
Mean age of separation: 22 ± 1.24 (SE) months		

8.4 Discussion

Mean age of first reproduction in Central Indian landscape was reported be 31 – 39.8 months [Chundawat et al., 2002 (n=5), Majumder et al., 2012 (n=1)]. Smith and MacDougal (1991) reported mean age of first reproduction in Nepal to be 40.8 months (n=5). However, mean age of first reproduction in Ranthambore TR, the founder population was reported to be comparatively higher [51.3±4.5 months (Singh et al., 2013)].

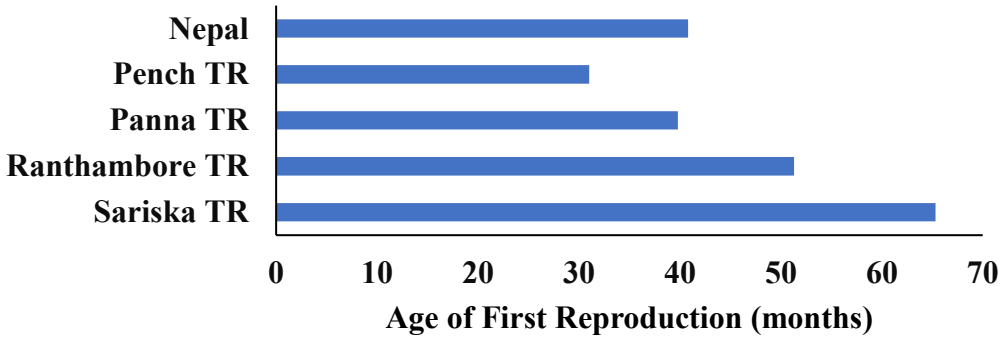


Figure 8.1: Age of first reproduction of tigers in Indian sub-continent

Mean time of littering after reintroduction in Panna TR was comparatively lower [16.20±9.07 months (Sarkar pers. comm)] than Sariska TR.

This is probably due to scarce availability of suitable breeding patches in Sariska TR. Our findings suggest reintroduced tigers may have been exploring the area to identify suitable breeding patches for comparatively higher time.

CHAPTER 9
FACTORS GOVERNING BREEDING OF TIGERS

9.1 Introduction

Tiger population decline is driven by large-scale habitat and prey loss caused by complex socio-cultural, political and economic reasons. The smaller, porous, and isolated areas together with linear development and human habitations across landscape further pose a challenge to conservation. The present study aims to understand the factors influencing the spatial dynamics and breeding ecology of reintroduced tigers of Sariska Tiger Reserve, Rajasthan and explore future conservation implications.

Sariska Tiger Reserve (1200 km^2) is an isolated reserve that shares sharp boundary with human habitation with 29 villages within the reserve. The reserve situated in the semi-arid landscape of western India represents the westernmost distribution limit of the tiger.

9.2 Methods

Radio-telemetry (n=04), direct sighting, camera trapping and pugmark tracking were used to monitor individual tigers during the study period (2013 – 16). Seven annual home range polygons of seven adult females were considered to study the factors governing breeding and spatial dynamics of tigers. The polygons were further classified as breeding/ non-breeding. Home range polygon was classified as 'breeding,' if the female was accompanied by cub(s). Rate of photo capture of human and livestock, distance to village, road and waterholes, prey availability and ruggedness were used as variables to understand the influence of different variables on breeding of tigers using multiple linear regression. Multiple linear regression was used to predict suitable areas using ArcGIS for tiger breeding in Sariska. We used Jenks natural breaks to categories suitable areas for breeding (i.e. High, medium and low) to prioritise villages for relocation at the site level.

9.3 Results

The present study showed that ruggedness and human disturbance significantly influenced breeding and spatial dynamics of tigers in Sariska (Adjusted R^2: 0.9953, P Value: 0.047). While ruggedness positively, human disturbance negatively influenced tiger breeding. Terrain complexity appeared to have masked human disturbance at some breeding sites. For example, tigresses have littered and used areas despite being very close (>1 km) to the highway and surrounded by villages owing to terrain complexity.

Table 9.1: Result of Multiple Linear Regression to explain factors influencing breeding of tigers in Sariska Tiger Reserve

	β Estimate	Standard Error	t value	P Value	
(Intercept)	-1.1434	0.2473	-4.623	0.1356	
age	0.3064	0.1027	2.982	0.206	
hum	-1.0787	0.1096	-9.839	0.0645	.
road	-0.8454	0.1628	-5.192	0.1211	
vill	-1.4123	0.2107	-6.704	0.0943	.
rugg	4.1764	0.231	18.081	0.0352	*

Dependant Variable: Breeding or Non-breeding [(0/1), bred]
Model: Intercept, age, hum (Human Disturbance), road_dist (Distance to Road), vill_dist (Distance to Village), rugg (Ruggedness)
Residual standard error: 0.0368 on 1 degrees of freedom
Multiple R-squared: 0.9992, Adjusted R-squared: 0.9953
F-statistic: 253 on 5 and 1 DF, P-value: 0.04769

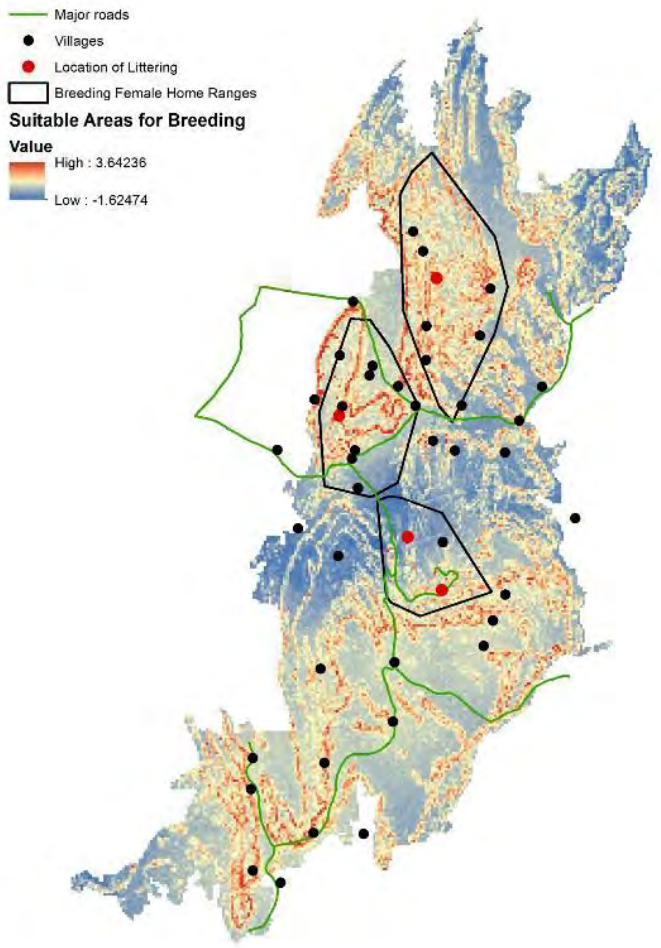


Figure 9.1: Map showing suitable patches for tiger breeding in Sariska with home ranges of breeding tiger overlaid on the map

9.4 Discussion and Management Implications

Based on the suitable areas for breeding, we prioritize two separate blocks consisting of 6 villages for relocation to achieve optimum conservation success in creating inviolate space for tiger breeding and population recovery.
Block I: Sukola, Dabli, Kiraska and Lilunda;
Block II: Haripura and Kankwadi

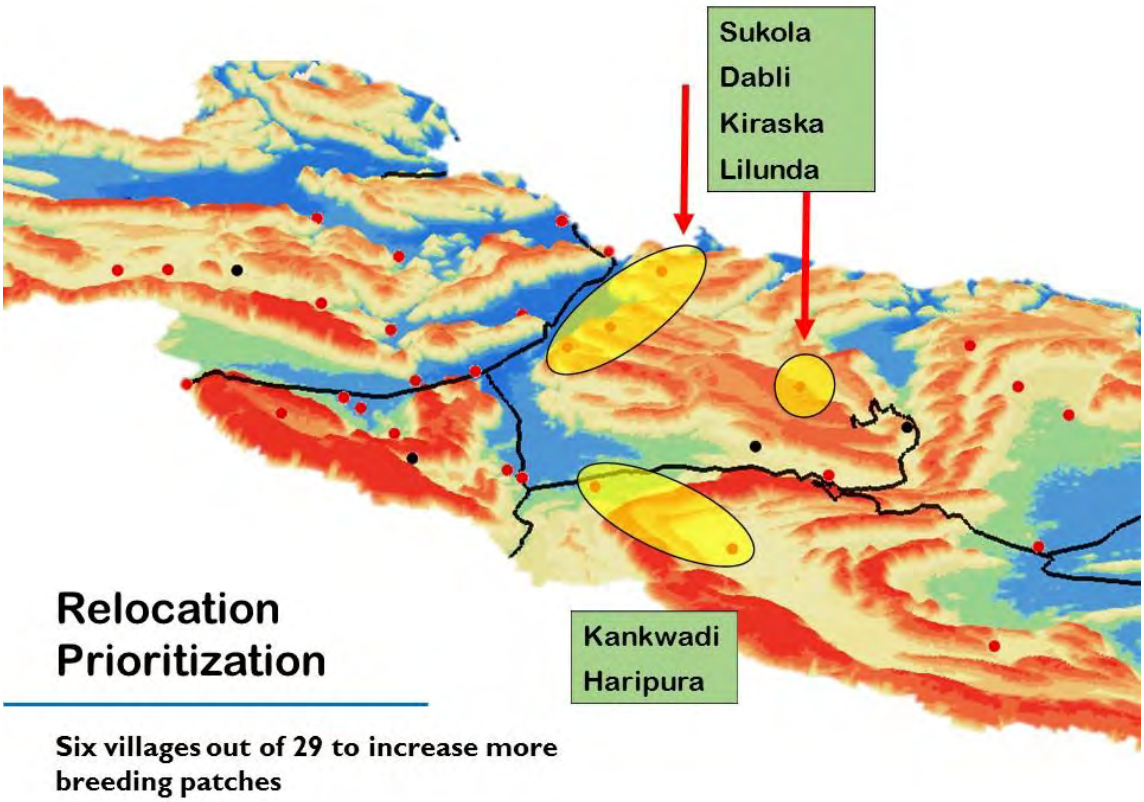


Figure 9.2. Prioritized villages for relocation

Our site level analysis showed that optimum conservation success can be achieved by relocating 6 villages out of a total of 29 villages using 26% of the required budget. Relocation of these villages are crucial to create more inviolate space for tiger breeding in Sariska. Although, potential tiger carrying capacity of Sariska based on prey availability is 44 tigers, our findings suggest it is gross over estimate as suitable breeding area are less to accommodate these many tigers in Sariska. The study also highlighted the importance of terrain complexity in concealment and producing apparent inviolate areas, crucial for tiger breeding. Our results also indicate the importance of site prioritization for village relocation, imperative in determining reintroduction success.

9.5 Future population Management Scope

Population Viability Analysis (PVA) was used to predict viability of the tiger population (100 years) under different management scenarios for active management of reintroduced tiger population in Sariska. In total, we have created five scenarios using Vortex v10 program.
These five scenarios were modelled to create realistic scenarios with the population exhibiting demographic parameters reported from Sariska, demographic parameters reported from wild tiger population with or without supplementation in a highly managed scenario (no prey base depletion and village relocation).

Simulations show that without supplementation and village relocation working in tandem to create more inviolate space to accelerate recruitment rate in Sariska, the population is vulnerable to extinction in approximately 50 years.

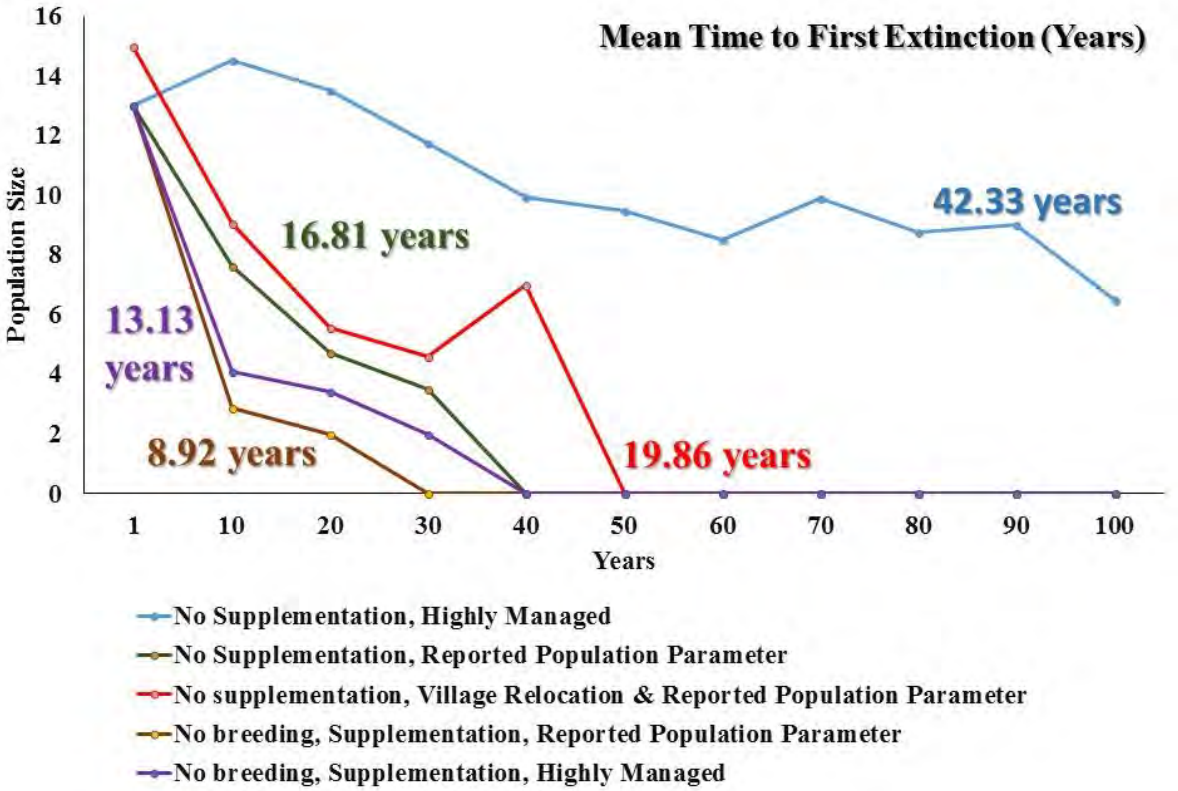


Figure 9.3: Various scenarios for tiger population management in Sariska

It is highly recommended that the population should be supplemented in a regular interval following the recommendation proposed in Annual Report of 2015 – 16. However, age-sex dynamics of Sariska's tiger population should be considered with great importance in consultation with experts before any further supplementation to the population and identification of potential individual tigers.

Recommended Scenario during Annual Report 2015 - 16
Natural Mortality with supplementation
Population Viability Analysis revealed further supplementation of at least two individuals (one male and one female) every 3-5 years for next 15-20 years to rule out extinction.

9.6 Sariska, A Reintroduction Success?

Reintroduction success for a small population of large carnivores is defined by a 3-year breeding population with natural recruitment exceeding mortality (> 10 years) or breeding by wild born generations (10 years post-reintroduction) (Hayward et al., 2007). Although, population proliferation in Sariska was not like that of the reintroduced population of Panna Tiger Reserve, the tiger reintroduction in Sariska has been a successful effort by both the definitions.

Initial stocking and supplementation of the population has been undertaken during 2008 – 13. During the last 10 years, recruitment rate (five litters resulting in birth of nine cubs in Sariska) was higher than the mortality.

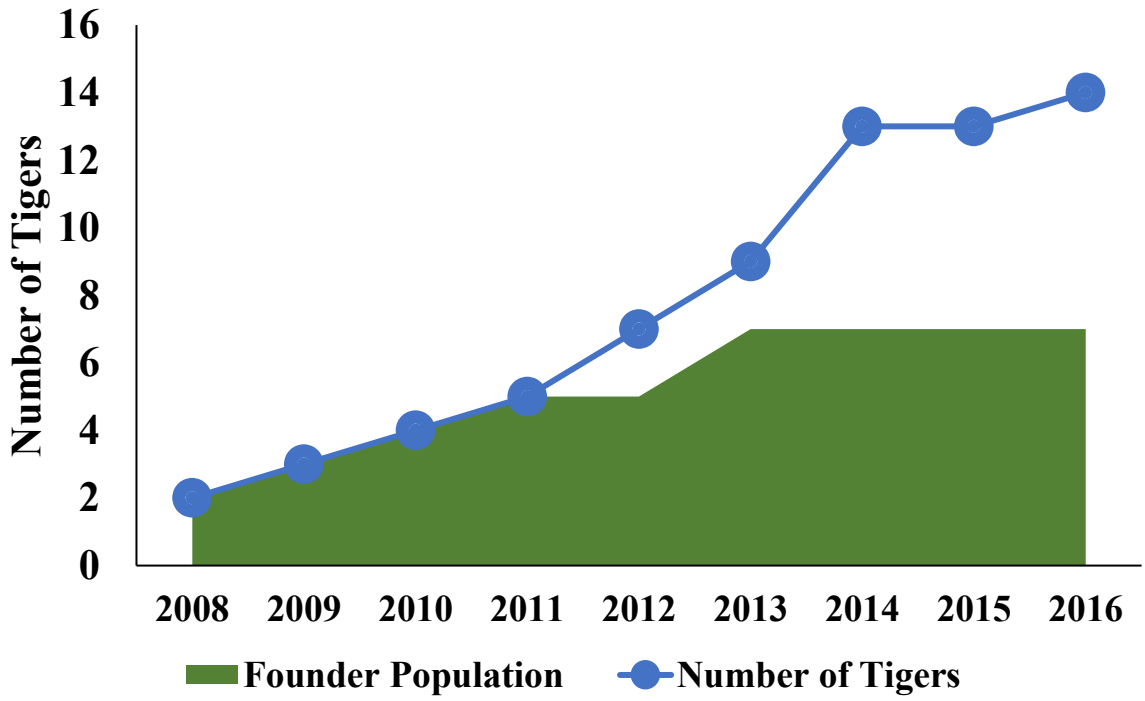


Figure 9.4: Population growth of tigers in Sariska

ST14 (F2 Generation), wild born litter of ST2 has given birth at an approximate age of 45 months. She along with her cub was photographed during April 2018.

Thus, tiger reintroduction in Sariska is a success [a 3-year breeding population with natural recruitment exceeding mortality (> 10 years) or breeding by wild born generations (10 years post-reintroduction) (Hayward et al. 2007)] by both the definitions.

CHAPTER 10
EFFECT OF VILLAGE RELOCATION ON GROUND BIRDS AND SMALL MAMMALS

10.1 Introduction

Human conversion of natural habitat is the largest primary cause of loss of biological diversity. Studies have reported that the protected areas that are interspersed with human settlement result in variable negative effects due to anthropogenic dependency and pressures. Due the rise of the unsustainable demand of natural resources by the local communities as well as the stress due to various developmental activities, the natural system are subjected to great strain. The balance between natural habitat and human-dominated landscapes will determine the future of biological diversity conservation over large areas of the planet. The expansion of the land use that accompanies human population growth also results in the fragmentation of natural habitat. Fragmentation causes the reduction, isolation, and removal of native vegetation from the natural landscape which is detrimental for the biodiversity (Fahrig, 1997).

Long-term studies are needed to understand biotic sustainability in regenerating and degraded forests. These studies should include habitat use, dispersal, and population viability. The amount of forests (i.e. thresholds) required to retain forest species richness in human-dominated areas is needed to for better knowledge. Information is required for understanding the mechanisms of species losses in isolated forests. Specifically, the evidence is necessitated on the synergistic or additive effects of biodiversity loss drivers such as forest degradation, invasive species, drought, wildfires and climate change on forest biodiversity in human-dominated landscapes (Brook et al., 2008; Cleary, 2003; Silk et al., 2002)

In India voluntary relocation of villages has been one of the principles in the management of protected areas. The aim of voluntary relocation from wildlife sanctuaries and national parks is to create inviolate space for biodiversity conservation where minimal human use is allowed (Shahabuddin 2005). Such inviolate spaces are essential for sustaining natural biodiversity in large continuous forest habitats. However, most village relocations in the country have historically taken place in the absence of information related socio-economic status or forest dependency or identification of key needs that are required in new sites. For example, Bhadra tiger reserve, relocation programmes have been ineffective in successfully rehabilitating people, leading to severe impoverishment and social dislocation of marginalised groups (Karanth 2007). For those reasons village relocation has always been a controversial issue in conservation circles. Yet little is known about the socio-economic impacts of such displacements or their effectiveness in restoring biodiversity.

Sariska Tiger Reserve is one such Indian protected area where village relocation has been prioritised as one of the key programmes to be undertaken for saving biodiversity. Sariska was one of the important conservation areas for the Tiger (*Panthera tigris*) in its north-western limit in India until it got locally extinctions in 2004-2005. It represents the last few remnants of native tropical dry forest and scrub still to be found in the Aravalli Range.

Sariska already has a long history of village relocations. Relocation of villages located within the Sanctuary area was undertaken in1960's. One village, Karnakawas was moved from the Core area between 1975-77, and unsuccessful attempts have been made to move two other villages, Kirska and Kanakwari. Since then 7 villages have successfully been relocated from the reserve till date. Some villages are still remaining inside the park and need to be relocated. The relocation of villages was successfully carried out in the year 1966-67, 1976-77, 2008-09 and 2011-12. Some of the villages were partially relocated and still the relocation programme is ongoing. These different phases

of relocation produced heterogeneous mosaic of different successional stages of secondary forest, interspersed with cleared areas dominated by shrubs and bushes, and pockets of primary forest.

Table 10.1*:* Name of villages with their status of relocation

Name of Villages	Year of Relocation
Kalighati, Slopka	1966-67
Kanyawas	1976-77
Deori, Rotkyla	2008-09
Bhagini, Umri	2007-10
Kankawadi-Karat-	2011 (Partially relocated)
Pilapani	
Haripura, Dabli &	2013 (relocation ongoing)
Kiraska, Sukola	
Lilunda, Kundalka &	Not relocated
Rekamala	

10.2 Methods

10.2.1 Population estimation of ground birds

For most species, estimation of abundance is a fundamental too for conservation. Line transect method was used to estimate the population of target species of galliformes in the study area. For estimating biological population line transect sampling is practical, efficient and relatively inexpensive (Anderson et. al., 1979). Few researches suggest that line transects method found to be more accurate than point counts for estimating birds (Raman, 2003).

From the centre of each village a 1.5 km radius circular area was chosen for intensive sampling. The size of the area was 7.07 sq. km. The area was divided into 500x500 m grid and 15 transect was laid in chequerboard design to cover all types of habitat in the study area. Length of the transects varied from 500 m to 680 m. Total 60 transect were laid in all four village sites and total effort was 36.17 Km. All the transects were walked once in the morning between 07:00 AM to 09:30 AM from the month of December to April. In total 60 transect in all four village sites (study site), five species of ground birds were detected on line transect. These were peafowl (*Pavo cristatus*), jungle bush quail (*Perdicula asiatica*), grey francolin (*Francolinus pondicerianus*), painted spur fowl (*Galloperdix lunulata*) and red spur fowl (*Galloperdix spadicea*).

Data was analysed using the program DISTANCE 6.2 (Thomas et. al., 2009). Four key functions (uniform, half-normal hazard rate and negative exponential all with cosine series adjustment) were considered for analysis. Minimum Akaike Information Criterion (AIC) and Chi-square was used for the selection of the best fit models. The encounter rates were obtained using the formula by Rodgers (1991). Encounter rate (ER) = n / l (Whereas 'n' is the number of individual and '1' is the total length of the transect). The value derived from the above calculation was used for obtaining the index of abundance.

10.2.2. Population estimation of rodents

Rodent density was estimated using trapping web design at four different village sites of the intensive study area. Two trap points were selected for rodent trapping from the 500x500 m grid of each village site. One trap point was selected within 200 m from the centre of the village site and other one is far from 1 km. The standard Sherman live traps (5 x 6.5 x 16.5 cm) were used for rodent trapping at eight different sites in all four study area (village site). Each trap was run for 15 consecutive trap nights with total sampling period amounted to 120 trap nights in all four study area. The traps were operated in 0.28 hector area (60 m x 60 m) concentric rings of 30 m radius. The traps were kept near bushes, trees, rocks, fallen logs or any other possible run way of rodents in sampling area. All the traps were baited with peanut butter between evening 05:30 PM to morning 07:00 AM and checked for animals between 07:00 AM to 08:30 AM in the morning. Trapped rodents were identified, weighed and measured for the tail length and body to head length (HBL). Rodents were identified up to species level using field guides (Prater, 1980; Menon, 2014). Animal sex was identified based on their genitalia. Each of the rodents were marked by paint colour at the base of the tail or either on the hind limb. Four colours were used for marking rodent viz red, blue, green and pink. The capture animal was marked and released at the spot where they were trapped. Program Mark was used for data analysis. Huggins p and c models were selected for closed capture data type. Minimum Akaike Information Criterion (AIC) was used to select the best fitted models.

10.2.3. Quantification of Vegetation

Most of the study shows that changes in bird community happen because of habitat alteration by changes in forest vegetation structure such as in the density of trees, density of bamboo understory, tree size class variation, densities of old trees and snags, amount of woody litter and tree species composition (Raman et al., 1998; Lohr et al., 2002). Vegetation structure (e.g. – Canopy cover, shrub cover, ground layer cover and invasive species) were recorded in each transects at an interval of 200 m. Three plots were selected in each transect. The first plot was laid at the beginning of the transect and rest of the two plot laid at 200 m and 400 m. Three types of circular area were laid for sampling vegetation in each plot. For trees, a 15m radius circular plot, 5m radius plot for shrub and two 0.5m radius plot for ground layer cover were laid for sampling vegetation. Total 180 plots were laid for vegetation sampling in all four village sites. Percentage of canopy cover, shrub cover and abundance of invasive species was calculated and compare between four village sites. The lopping score for each tree was additionally measured on a scale of 0–4 as follows: 0, no lopping; 1, rudimentary signs of lopping; 2, up to half of the main branches lopped; 3, more than half of the main branches lopped; 4, the tree reduced to a stump. The scale of lopping was calculated as the total lopping score divided by the total number of trees present. To obtain the Human disturbance factors such as wood cutting, lopping, grazing, human trails, and livestock dung was quantified in each plot. These were quantified at each plot in a scale of 0 to 4 (0–none, 1–low, 2–medium, 3–high and 4–very high). 1 = Low (Less than 25%) 2, = Medium (25%–50%) 3, = High (50%–75%) 4 = Very high (Above 75%).

10.2.4. Camera trapping for Small carnivores

A reconnaissance survey was carried out in each village sites before placing camera traps. Indirect signs such as spoor, scats and track signs of carnivores were identified and marked using a hand held Global Positioning System (Garmin etrex vista). The camera trapping was carried out within 1.5 Km radius circular area. A single camera was deployed in a 500x500 m grid on the basis of any evidence (spoor, scats and track sign). A total of 24 to 30 locations were selected for deploying cuddeback (Model-Attack, Ambush and C1) camera traps in each 7.07 sq. Km. intensive study area. Each camera traps ran for a minimum of 7 days to maximum of 25 days. CamtrapR software was used for analysing the data.

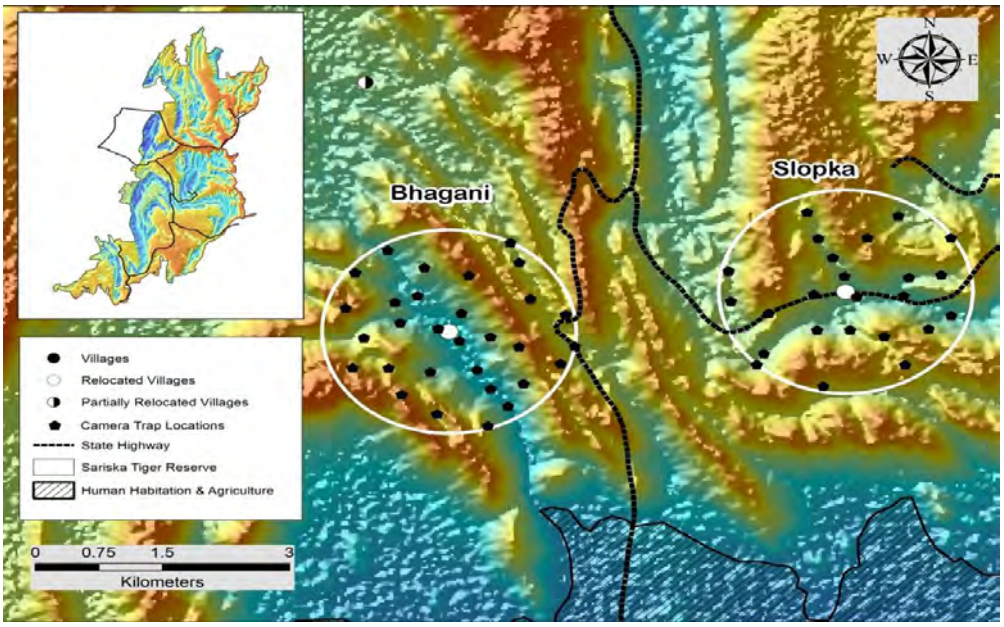


Figure 10.1: Camera trap locations of the village Slopka and Bhagani.

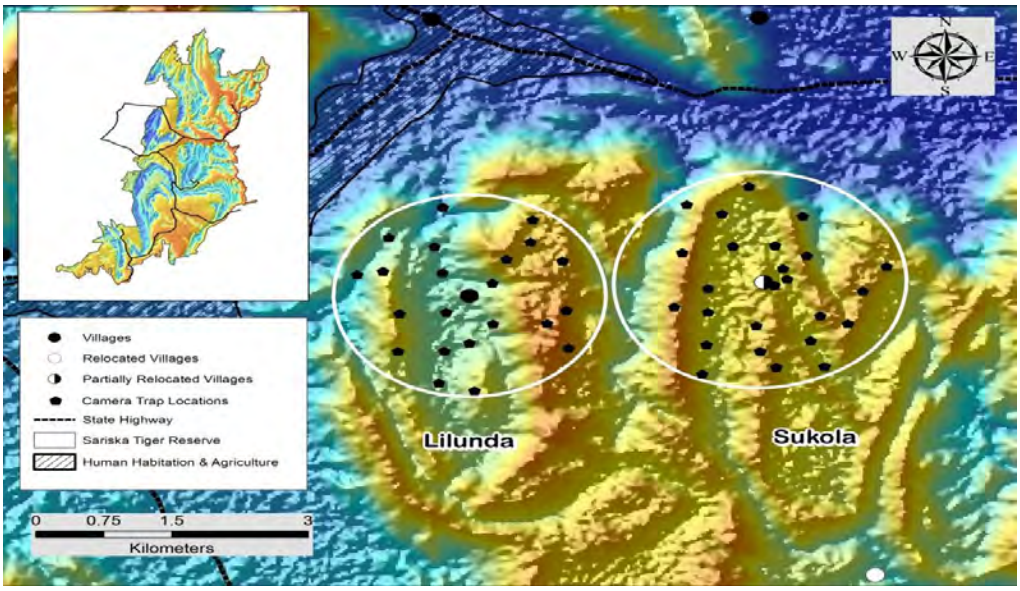


Figure 10.2: Camera trap locations of the village Sukola and Lilunda

10.3. Results

10.3.1. Density estimates of ground birds

In total 5 species of galliformes (ground birds) were detected on line transect. These involve peafowl (*Pavo cristatus*), jungle bush quail (*Perdicula asiatica*), grey francolin (*Francolinus pondicerianus*), painted spur fowl (*Galloperdix lunulata*) and red spur fowl (*Galloperdix spadicea).* Density estimates of galliformes was estimated for each village sites of Sariska. There were only few sightings of grey francolin (n=23, 20, 12 & 6), painted Spurfowl (n=6,4, &2), Red Spurfowl (n=3,1) and jungle bush quail (n=3,1) so we could not estimate their density separately. Estimated density of galliformes was highest for Bhagani (331/Km²) followed by Slopka (240/Km²), Lilunda (181/Km²) and Sukola (180/Km²) respectively. (Table 10.2 & Figure 10.2)

Table 10.2: List of tables with ground bird density in four different villages of Sariska Tiger reserve.

Name of villages	Species	Model	AIC	Chi square P value	Effective strip width (SE)	Mean Group size	Detection probability	Encounter rate (SE) per km	Group density (SE) per sq.km.	Individual density (SE) per sq.km.
Slopka	Galliformes	Half-normal-cosine	119.17	0.90	38.08 (±6.77)	2.75 (±0.26)	0.82	0.006 (±0.0009)	87.13 (±18.7)	240.42 (±56.5)
Bhagani	Galliformes	Half-normal-cosine	102.08	0.87	24.66 (±3.30)	3.07 (±0.32)	0.58	0.005 (±0.0007)	107.87 (±21.7)	331.40 (±75.53)
Sukola	Galliformes	Half-normal-cosine	71.20	0.96	27.46 (±4.41)	2.91 (±0.35)	0.54	0.003 (±0.0005)	61.97 (±14.8)	180.79 (±48.79)
Lilunda	Galliformes	Half-normal-cosine	67.78	0.99	21.78 (±3.46)	2.09 (±0.21)	0.64	0.003 (±0.0004)	86.43 (±18.9)	181.32 (±43.9)

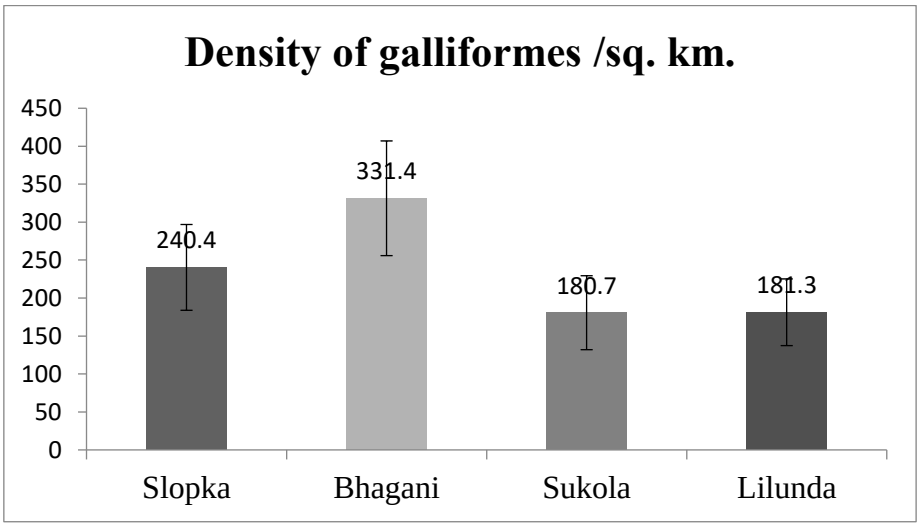


Figure 10.2: Density of galliformes in the all four villages of Sariska Tiger reserve.

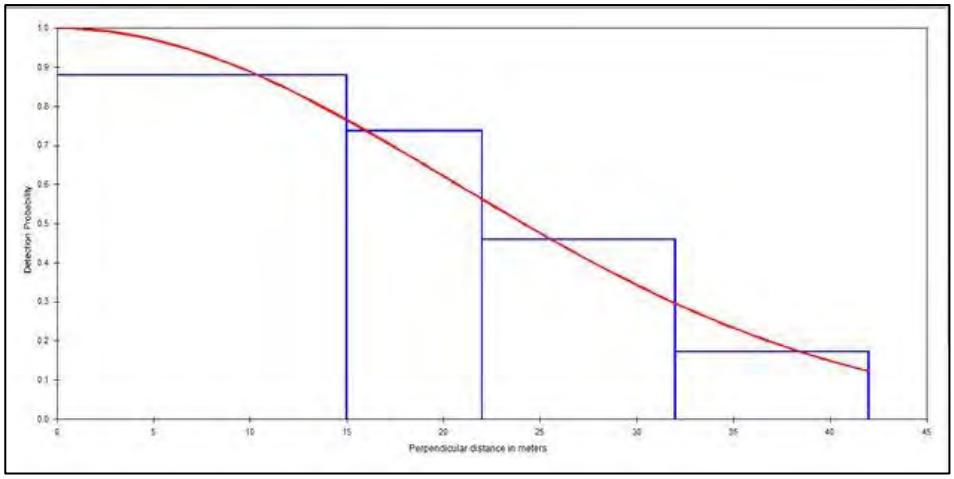


Figure 10.3: Detection function of best selected model for galliformes in Bhagani, Sariska.

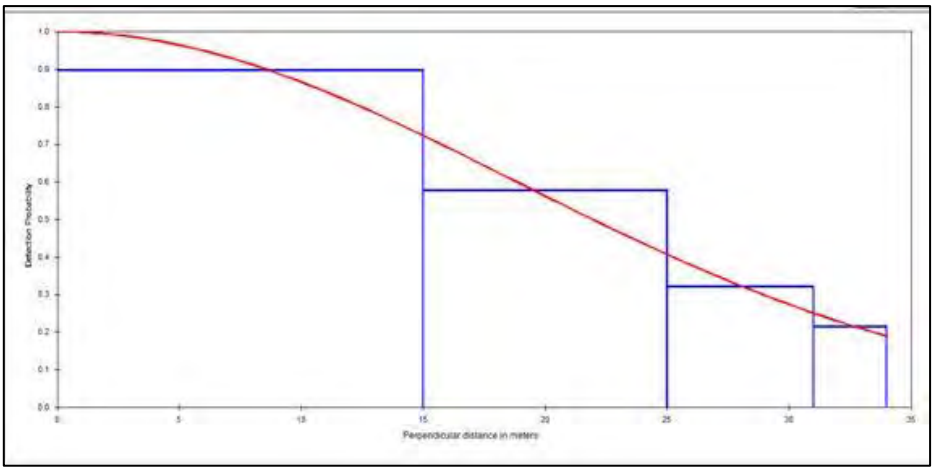


Figure 10.4: Detection function of best selected model for galliformes in Lilunda, Sariska

10.3.2. Density of Peafowl

Among all galliformes species peafowl was found most abundant in all study sites. Detection of peafowl was best explained by half normal detection function with cosine adjustment. Estimated density of peafowl was highest in Bhagani (158/ Km^2) followed by Lilunda (124/Km^2), Sukola (115/Km^2) and Slopka (108/Km^2) respectively. (Table 10.3 & Figure 10.5)

Table 10.3: List of tables with Peafowl density in four different villages of Sariska Tiger Reserve.

Name of village	Species	Model	AIC	Chi square P value	Effective strip width (SE)	Mean Group size	Detection probability	Encounter rate (SE) per km	Group density (SE) per sq.km.	Individual density (SE) per sq.km.
Slopka	Peafowl	Half-normal-cosine	56.65	0.99	33.08 (±6.77)	2.24 (±0.34)	0.73	0.003 (±0.0004)	48.61 (±12.2)	108.89 (±32.17)
Bhagani	Peafowl	Half-normal-cosine	42.30	0.98	18.49 (±3.59)	2.16 (±0.36)	0.54	0.002 (±0.0002)	73.16 (±17)	158.72 (±45.69)
Sukola	Peafowl	Half-normal-cosine	32.31	0.91	17.19 (±2.60)	1.70 (±0.2)	0.66	0.0023 (±	67.4(±13.8)	115.05 (±27.4)
Lilunda	Peafowl	Half-normal-cosine	36.09	0.97	17.69c (±4.10)	1.79 (±0.21)	0.65	0.002 (±0.0003)	69.63 (±19.7)	124.7 (±38.28)

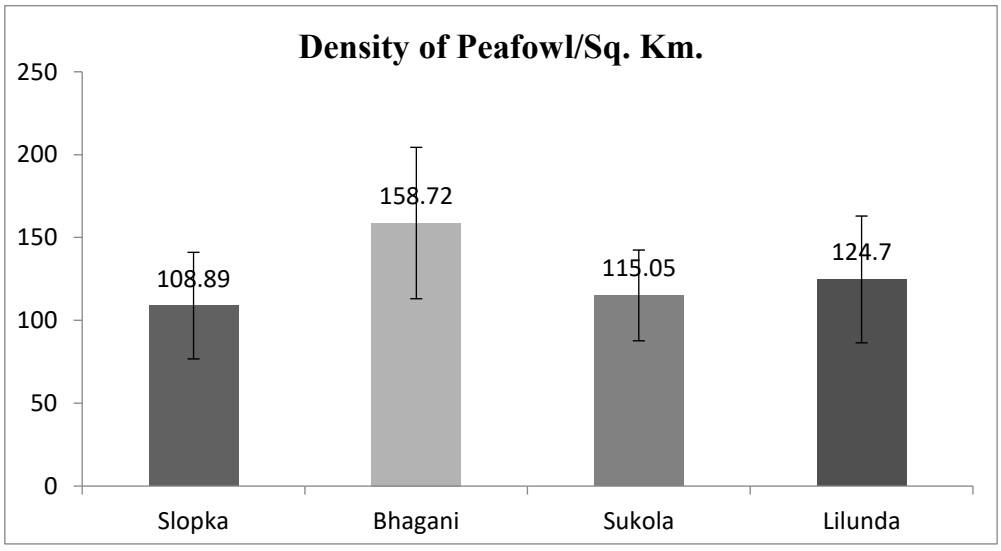


Figure 10.5: Peafowl density in four different villages of Sariska Tiger Reserve.

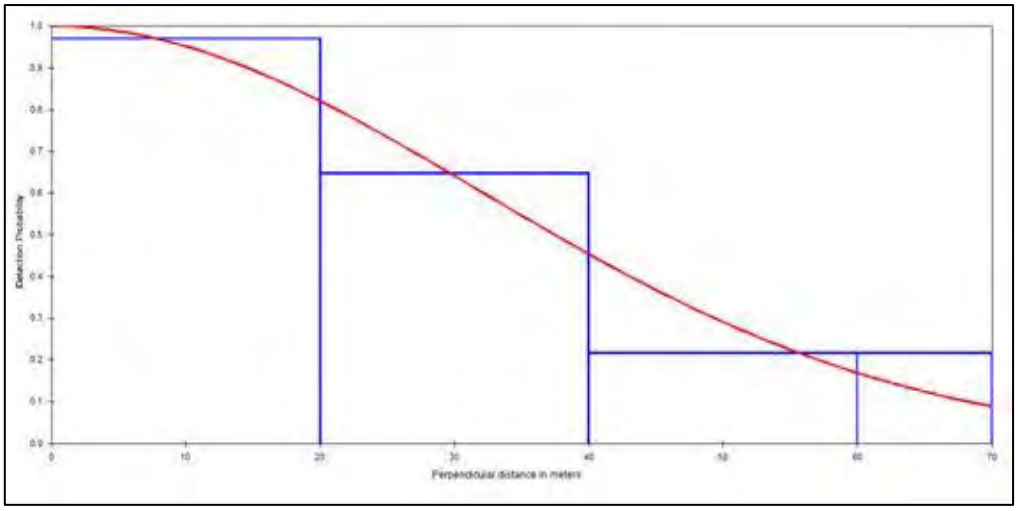


Figure 10.6: Detection function of best selected model for peafowl in Sukola

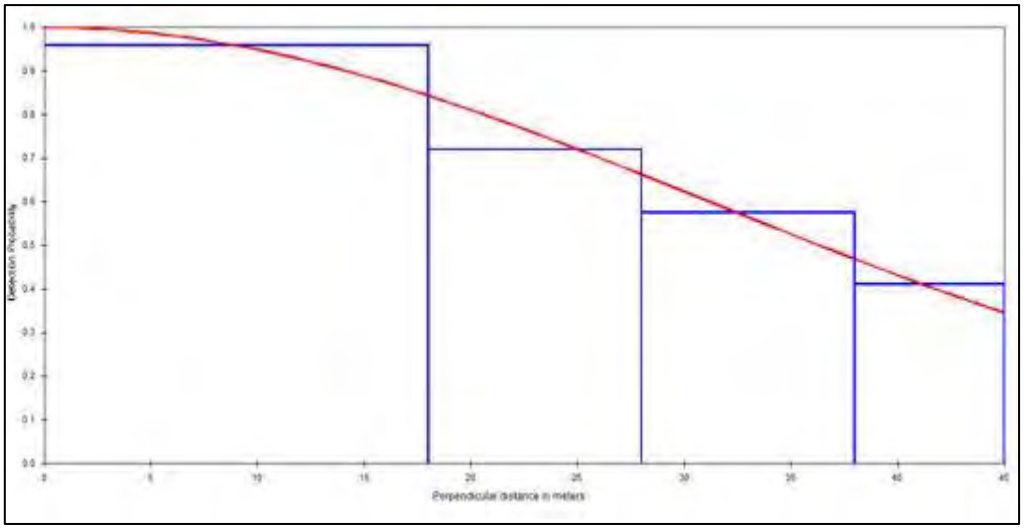


Figure 10.7: Detection function of best selected model for peafowl in Slopka, Sariska

10.3.3. Encounter rate of Galliformes

In total, 117 individuals of five species were detected on the line transect during the study period. The encounter rate was recorded highest for peafowl (2.13±0.11 per Km.) followed by grey francolin (1.26 ±0.11 per km), painted Spurfowl (0.33 ±0.112 per km), red Spurfowl (0.03 ±0.11 per km) and jungle bush quail (0.11 ±0.11)(Figure 10.8). We also calculate the encounter rate of all galliformes species in different habitat types as most of the galliformes species are very specific in terms habitat use.

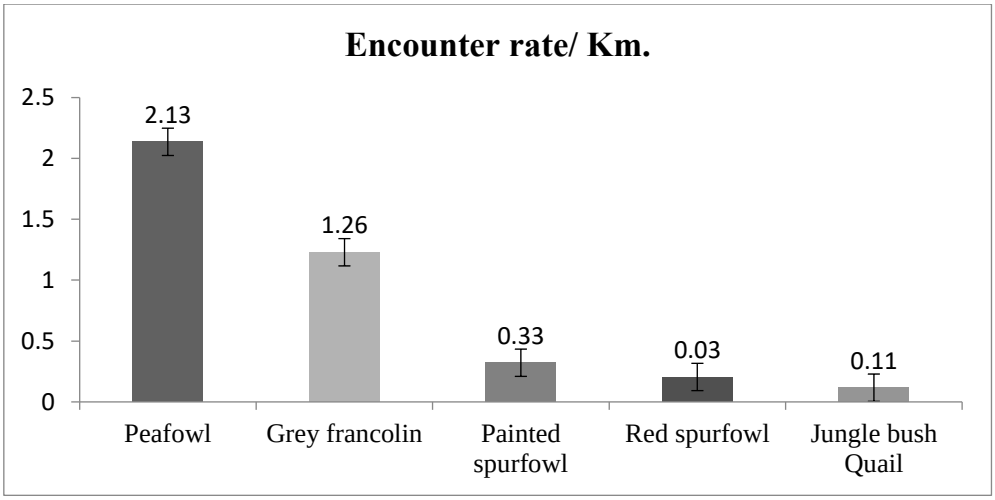


Figure 10.8: Encounter rate of all galliformes species in Sariska Tiger Reserve.

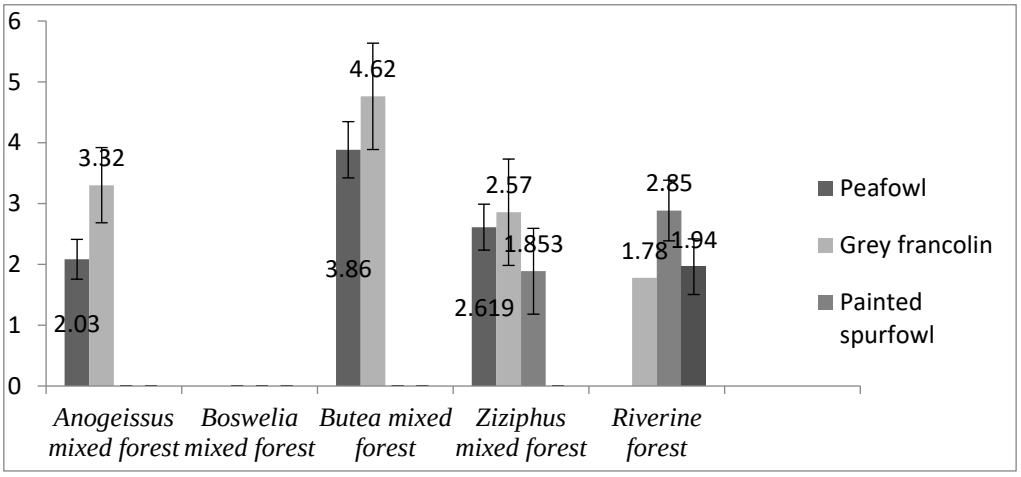


Figure10.9: Encounter rate of galliformes/ km in different habitat types of village Slopka.

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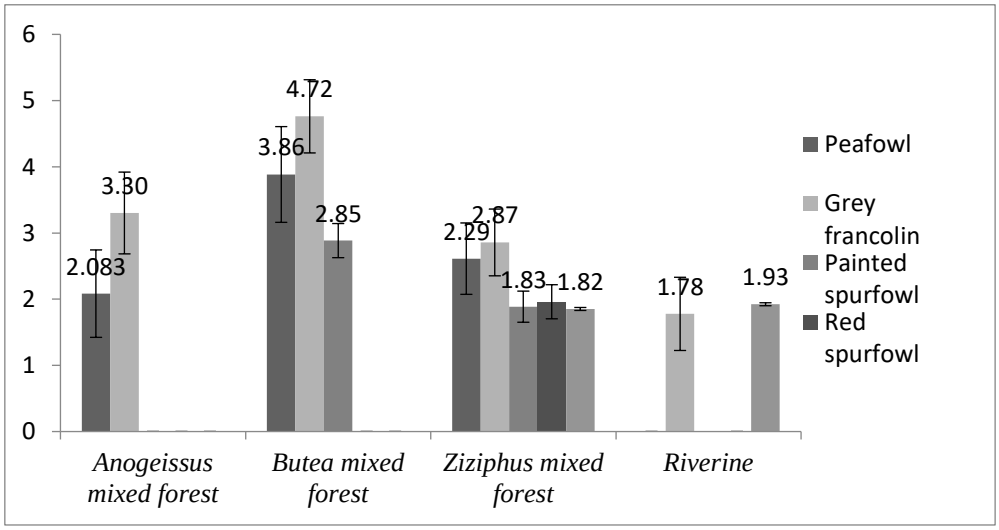

Figure 10.10: Encounter rate of galliformes / km in different habitat types of village Bhagani.

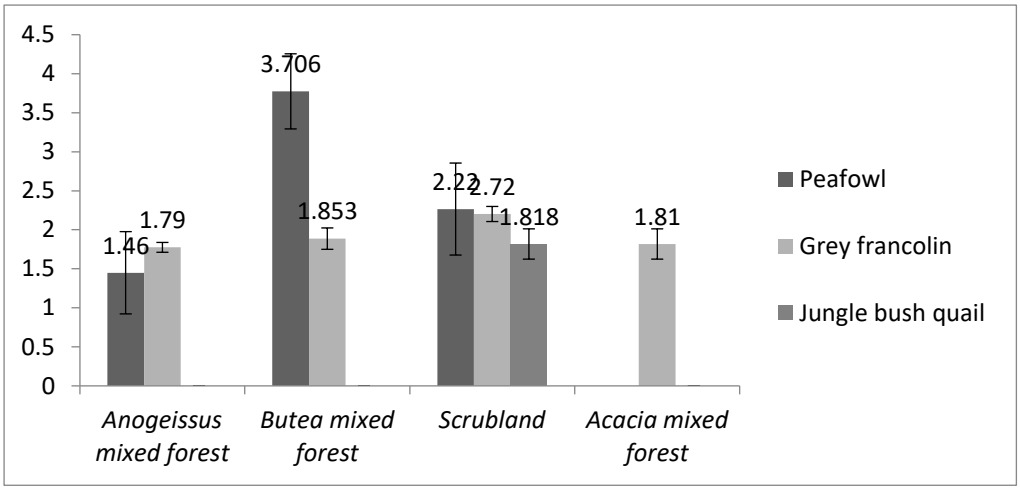

Figure10.11: Encounter rate of galliformes/ km in different habitat types of village Sukola

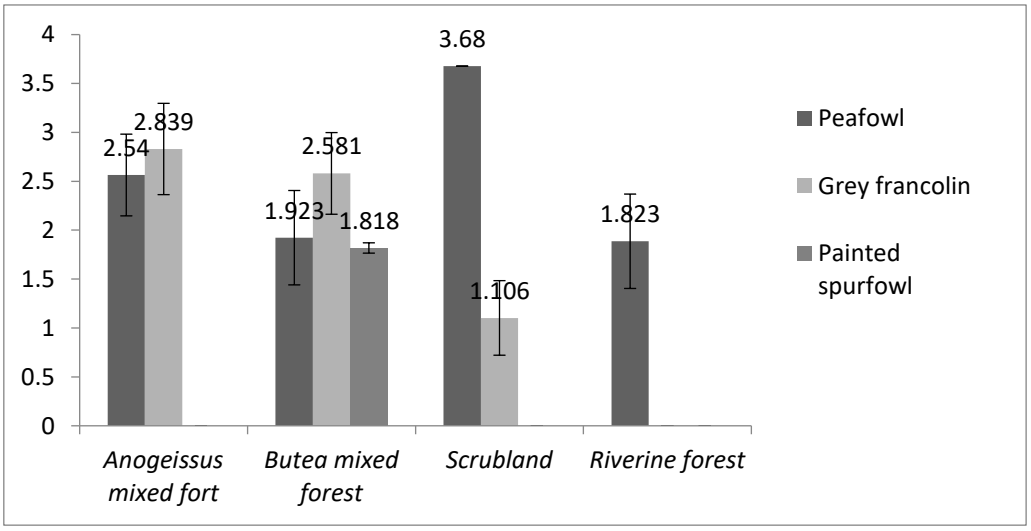

Figure 10.12: Encounter rate of galliformes in different habitat types of village Lilunda.

Encounter rates of galliformes species show marked difference in the different habitat types of different village sites of Sariska tiger reserve. The encounter rate of peafowl was highest in Butea mixed forest ((3.86/km, 3.86/km,3.70/km & 1.92/km) followed by Ziziphus mixed forest (2.61/km, 2.29/km) and Scrubland (2.22/km,3.68/km). Grey francolin was also observed in Butea mixed forest (4.62/Km, 4.72/Km) as well as Ziziphus mixed forest (2.57/Km, 2.87/Km). Encounter rate of Painted Spurfowl and red Spurfowl shows mark preference in riverine (1.78 & 1.82/Km) areas as well as Ziziphus mixed forest (2.57/km,1.83/km & 1.82/km)

10.3.4. Density estimates of Rodents

In total 34 individuals of six species were captured in four study sites of Sariska. Among all species Indian bush rat (*Gollunda ellioti*) was abundant (n=14) across all study sites followed by Little Indian field mouse *(Mus boduga*) (n=10) and Indian gerbil (*Tatera indica*) (n=3). The other species were Soft furred rat (*Millardia meltada*) (n=1), House mouse (*Mus musculus*)(n=3), and Brown rat (*Rattus norvegicus*) (n=3). Sampling of rodent was carried out in all four village sites. Program Mark was used to estimate rodent density for each site. Huggins' p and c model was selected in program Mark for density estimation and minimum AIC value was taken for model selection (Table 10.4). Highest density of rodents was estimated from Slopka (13.08 ± 0.31/ha) followed by Bhagani (9.72 ±1.38/ha), Sukola (9.12 ± 0.42/ha) and Lilunda (3.21± 0.71/ha) (Table 10.4).

Table 10.4. Density of rodents at four different villge of Sariska.

	Model selection	AIC	Density /ha	Standard error
Slopka	Huggins' p and c	226.09	13.08	0.31
Bhagani	Huggins' p and c	130.92	9.72	1.38
Sukola	Huggins' p and c	155.38	9.12	0.42
Lilunda	Huggins' p and c	71.23	3.21	0.71

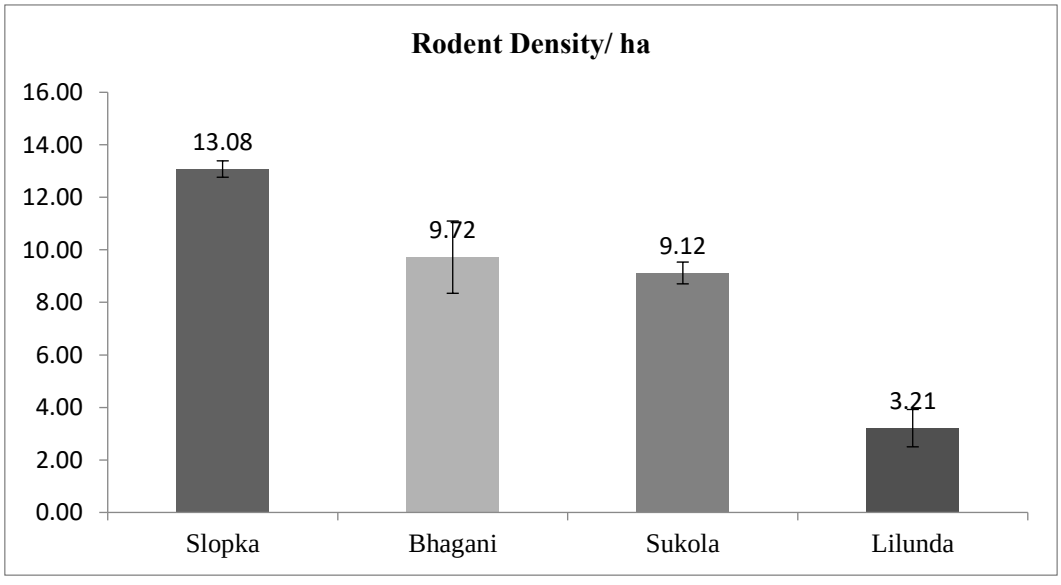

Figure 10.13 Density of rodents at four different villages of Sariska.

Table 10.5: Average body length ,tail length and weight of all rodent species captured during the study period

S. No.	Species	*HBL (mm)	Tail length	Weight (gm)
1	Indian Bush Rat	73.06	78.12	63.15
2	Little Indian Field Mouse	76.83	79.72	65.28
3	Indian Gerbil	77.83	113.00	54.67
4	House Mouse	51.25	60.00	49.38
5	Soft Furred Fat	42.00	50.00	46.00
6	House Mouse	150.00	135.33	164.33

*HBL= Head body length

10.3.5. Vegetation quantification

A total of 45 circular plots of 15m radius circular area were laid in each village. Different Parameters of human disturbance were recorded in each plot. Sign of cutting, lopping and grazing was recorded from each plot. Densities of trees along with canopy cover, shrub cover and presence of invasive species were compared with disturbed and undisturbed site. Abundance of different tree species was computed for all study sites. *Anogeissus pendula* was found to be most abundant tree species (1266 ± 1.43) followed by *Ziziphus mauritiana* (495 ± 0.94), *Butea monosperma* (408 ± 0.73), Boswelia *serrata* (452 ± 0.55) and Acacia catechu (369 ±0.59) (Figure 10.14).

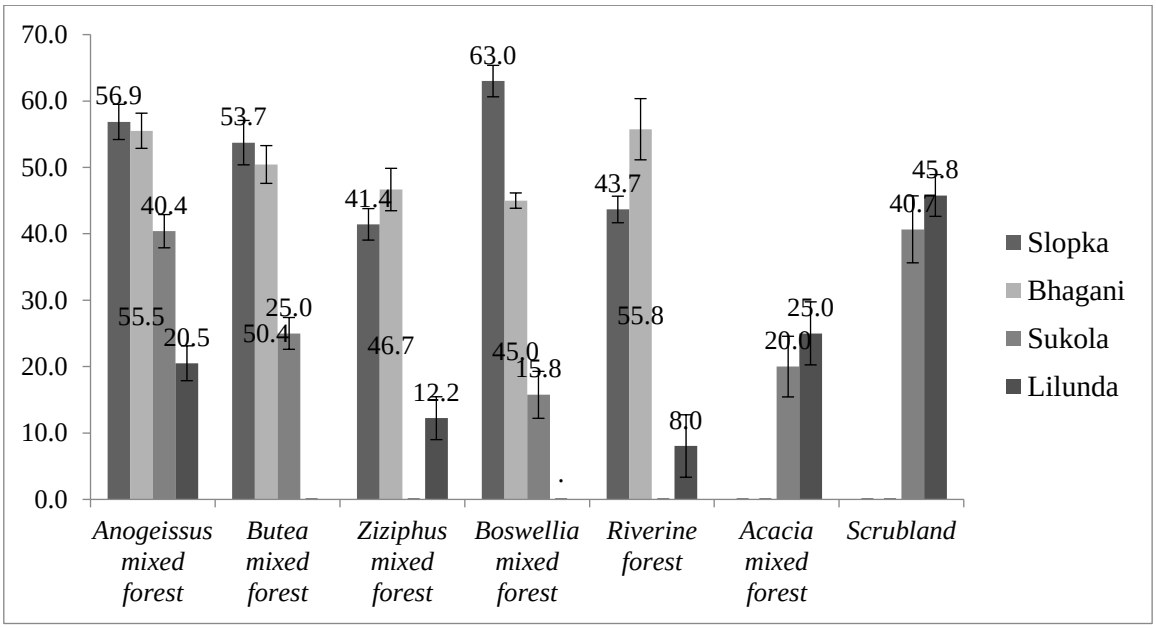

Figure 10.14: Different types of habitat at four village sites in Sariska tiger Reserve.

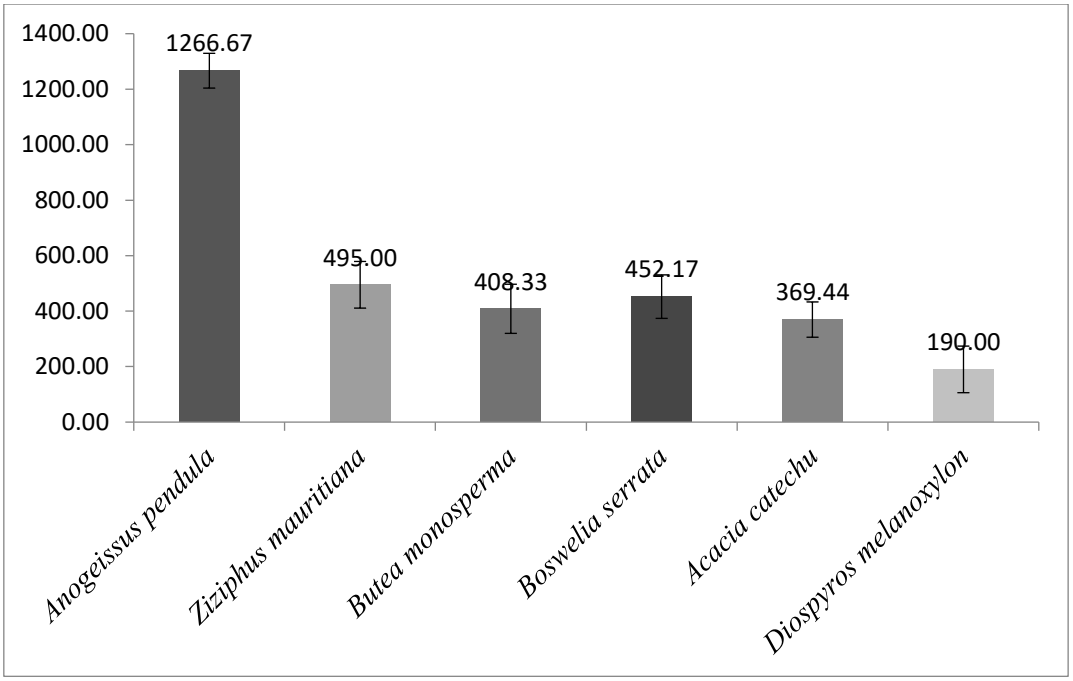

Figure 10.15: Abundance of different tree species in all four village sites of Sariska Tiger reserve.

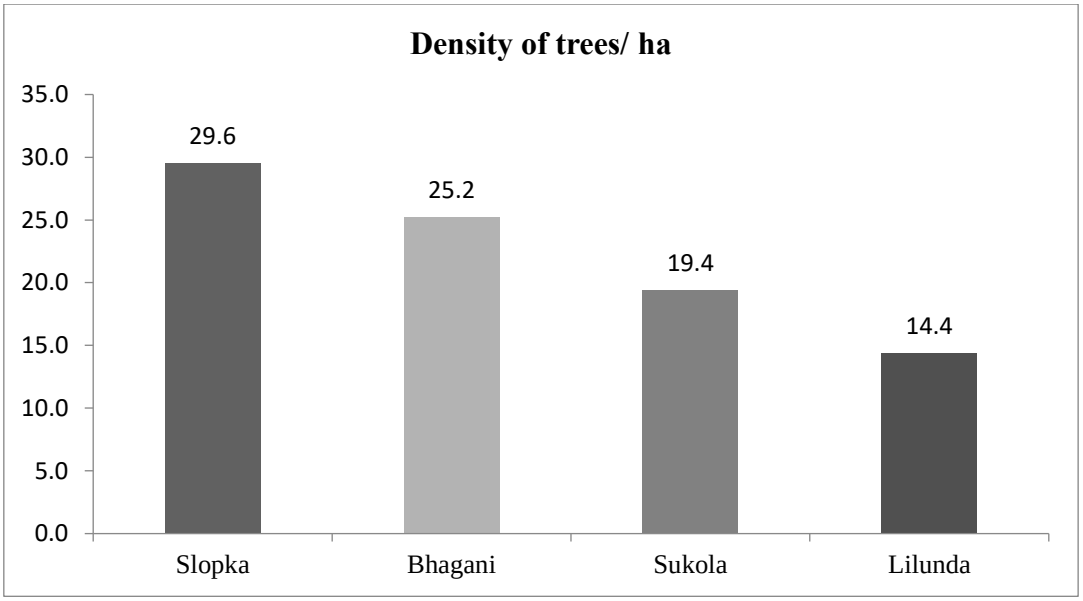

Figure 10.16: Density of tree was computed in different village sites of Sariska tiger reserve.

Densities of trees were assessed for each village site. Estimated density of tree was highest in Slopka (29.6/ha), followed by Bhagani (25.2/ha), Sukola (19.4/ha) and Lilunda (14.4/ha) (Figure 10.16).

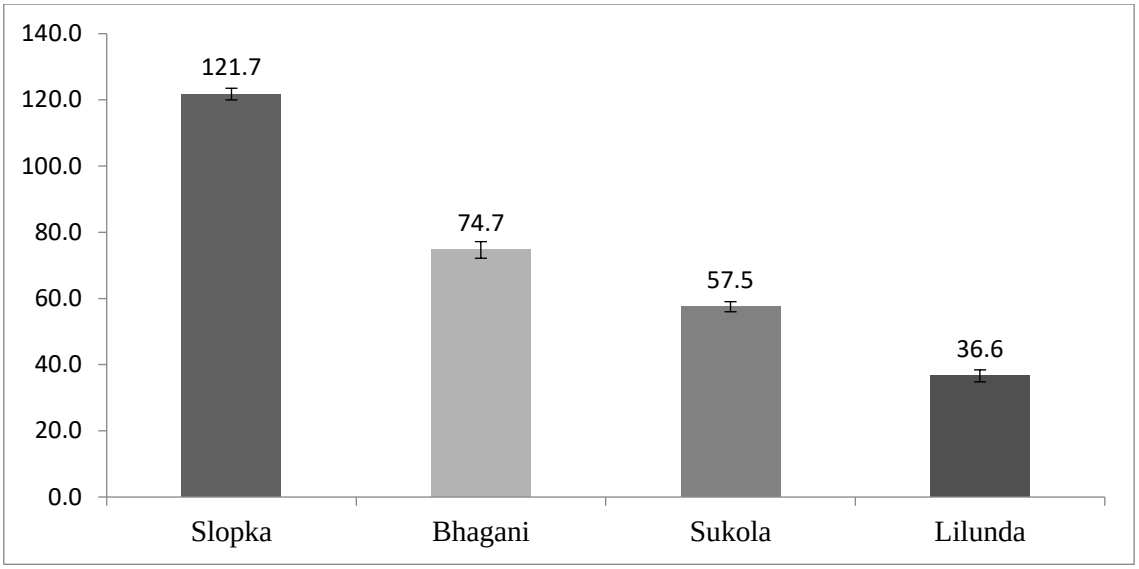

Figure 10.17: Percentages of shrub cover at different village sites of Sariska.

Shrub cover for each was assessed for each village site. Highest shrub cover was recorded from village Slopka (121.7±1.77/ha), followed by Bhagani (74.7±2.50/ha), Sukola (57.5±1.52/ha) and Lilunda (36.6±1.80/ha). (Figure 10.17)

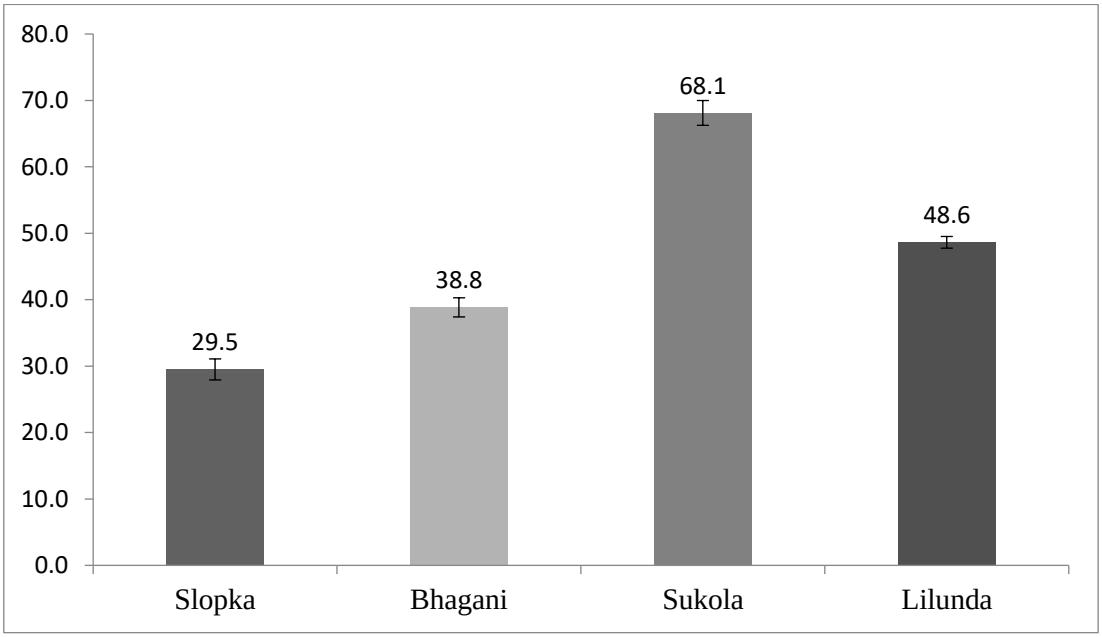

Figure 10.18: Abundance of invasive species at four different sites of Sariska tiger reserve.

Abundance of invasive species was quantified for each village site. Highest abundance of invasive species was found in Sukola (68.1±1.58/ha), followed by Lilunda (48.6±1.44/ha) and Bhagani (38.8±1.87/ha). Among all villages Slopka has the low abundance of invasive species (29.5±0.85/ha). (Figure 10.18)

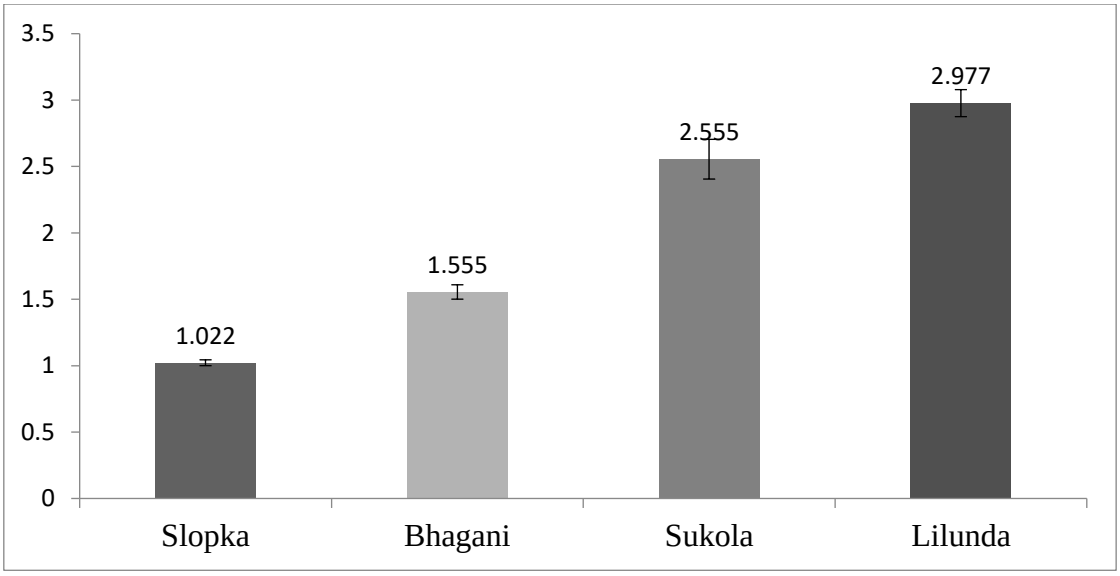

Figure 10.19: Human disturbance in four different sites of Sariska tiger reserve.

Human disturbance for each village site was quantified by scaling 0 to 4 in each plot. Average value was calculated for each village site. Lilunda had the highest score (2.977±0.2/ha), followed by Sukola (2.555±0.05/ha), Bhagani (1.55±0.14/ha) and Slopka (1.022±0.10/ha) (Figure 10.19)

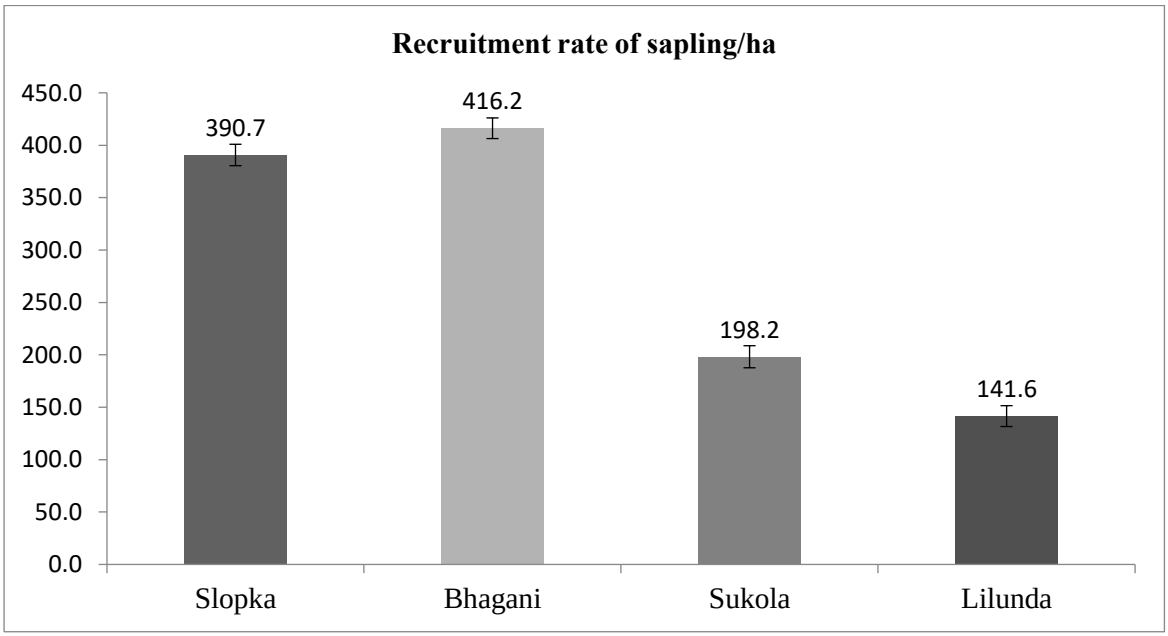

Figure 10.20: Recruitment rate of sapling in four different sites of Sariska tiger reserve.

Number of saplings was counted in each plot for all village sites. Highest recruitment rate was estimated in Bhagani (416.2±10.2/ha), followed by Slopka (390.7±9.83/ha), Sukola (198.2±10.5/ha) and Lilunda (141.6±9.95/ha). (Figure 10.20)

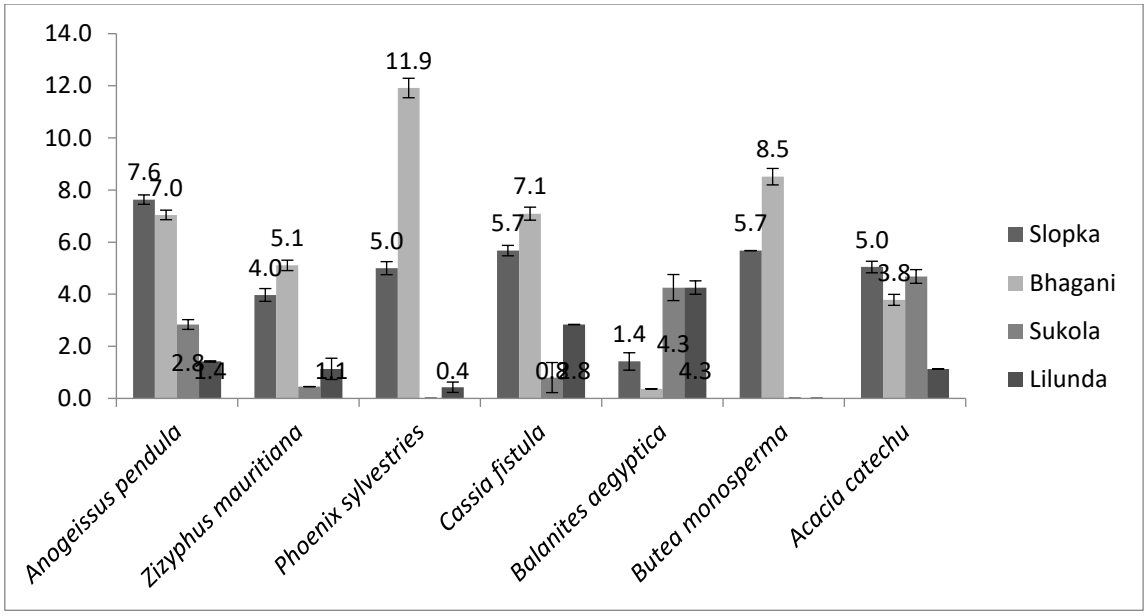

Figure 10.21: Recruitment rate of different tree species in all the four villages.

Recruitment rate of each tree species was observed in each plot. Highest recruitment rate was observed in Anogeissus pendula tree in village Slopka (7.6/ ha) followed by Cassia fistula (5.7/ha), Phoenix sylvestries (5.0/ha) and Butea monosperma (5.7/ha). Bhagani has highest recruitment rate for phoenix tree (11.9/ha), followed by Anogeissus (7.0/ha), Butea (8.5/ha) and Ziziphus (5.1/ha). Village Sukola has highest recruitment rate of Balanites tree (4.3/ha), followed by Acacia (3.8/ha), Anogeissus (2.8/ha). Balanites (4.3/ha) has the highest recruitment rate followed by cassia (2.8/ha) and Anogeissus (1.4/ha). (Figure 10.21)

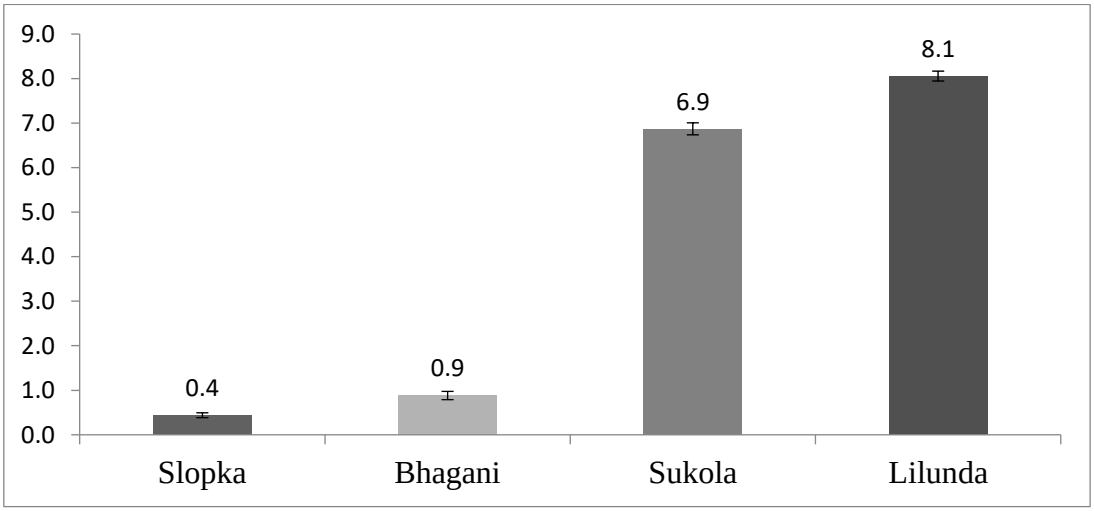

Figure 10.22: Amount of lopping pressure at four different sites of Sariska Tiger Reserve

Highest signs of lopping was found in the village Lilunda (8.1/ ha), followed by Sukola (6.9/ha) and Bhagani (0.9/ha). Slopka has the lowest signs of lopping (0.4/ha). (Figure 10.22)

10.3.6. Results of Camera trapping

In total, 102 camera traps were deployed in all four sites for 1530 camera trap nights during the whole study period. In each village site, approximately 25 camera trap locations were selected for deploying the camera trap. Photographic capture rate of each species was calculated and used for the evaluation of habitat use by wild animals. Activity pattern of wild animals and their overlap with human activity, show marked difference in each village sites respective to the amount of disturbance. A total nineteen species and human were photographed during the entire study period. (Figure 27) Highest capture rate was found for livestock (294.5/100 trap nights), followed by human (252.4/100 trap nights), chital (157.6/100 trap nights) Peafowl (144.9/ 100 trap nights) and Sambar (107.05/trap nights). (Figure 10.23)

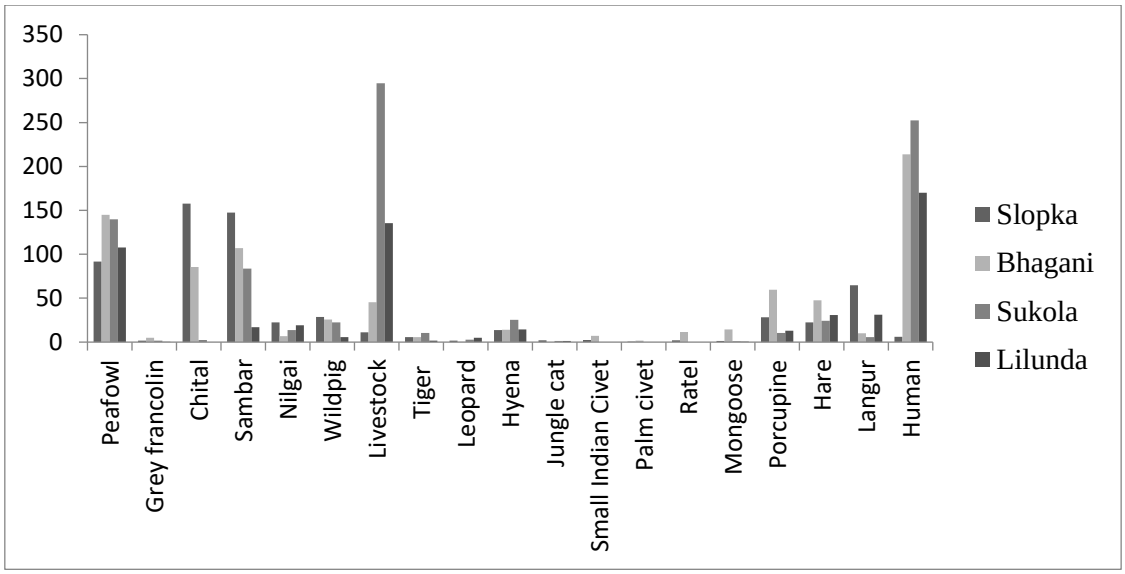

Figure 10.23: Photographic capture rate of all species in the four village sites of Sariska.

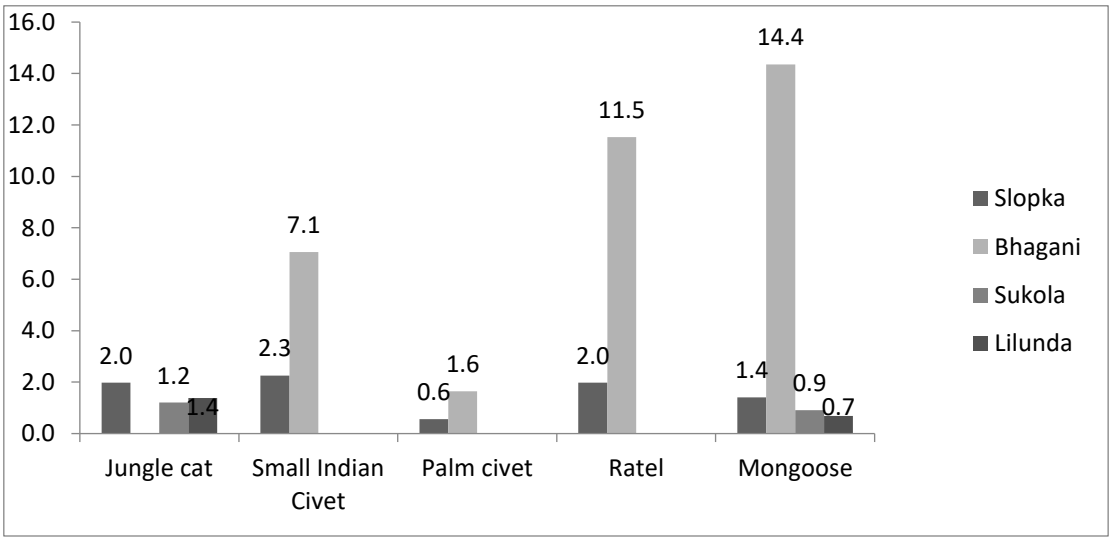

Figure 10.24: Photographic capture rate of Small carnivores in Sariska.

Highest capture rate for small carnivore was recorded from Bhagani followed by Slopka, Sukola and Lilunda. Slopka has the highest capture rate of Small Indian civet (2.3/100 trap nights) followed by

Ratel (2.0/100 trap nights), Jungle cat (2.0/100 trap nights), Mongoose (1.4/100 trap nights) and Palm civet (0.6/100 trap nights). In Bhagani highest capture rate was recorded for Mongoose (14.4/100 trap nights), followed by Ratel (11.5/100 trap nights), Small Indian civet (7.1/100 trap nights) and Palm civet (1.6/ 100 trap nights). Sukola has the capture rate of jungle cat (1.2/100 trap nights) and Mongoose (0.9/100 trap nights). Highest capture rate was found for Jungle cat (1.4/100 trap nights) followed by Mongoose (0.7/100 trap nights) (Figure 10.24).

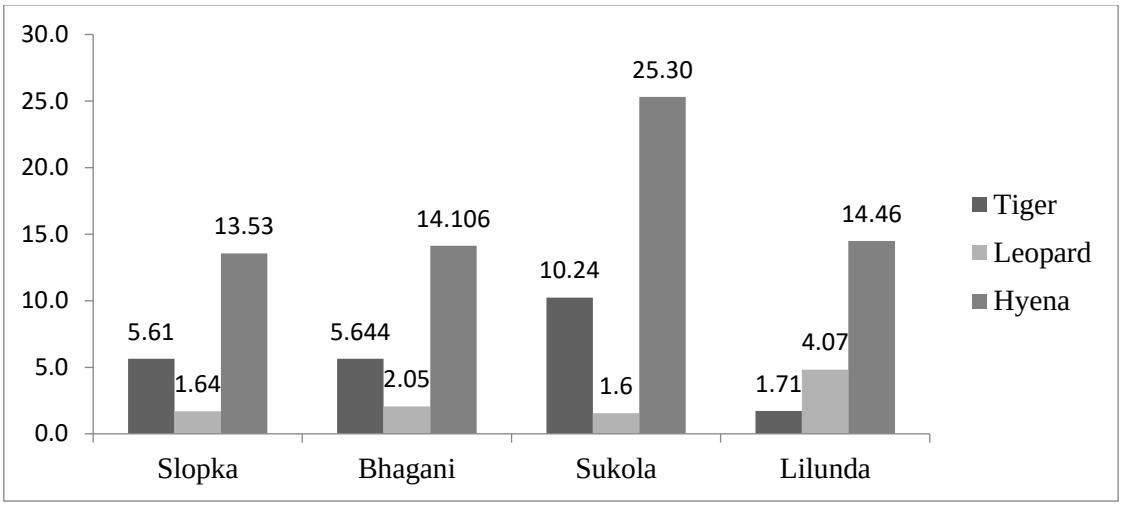

Figure 10.25: Photographic capture rate of large carnivore in all four village sites of Sariska.

Highest capture rate of Tiger (25.30/100 trap nights) was recorded from the Sukola followed by Lilunda (14.46/100 trap nights), Bhagani (14.10/100 trap nights) and lilunda (13.53/100 trap nights). Lilunda has the highest capture rate of leopard (4.07/100 trap nights), followed by the Bhagani (2.05/100 trap nights), Slopka (1.64/ 100 trap nights) and Sukola (1.55/100 trap nights). Highest capture rate of Hyena was found in the village Sukola (10.24/100 trap nights), followed by Bhagani (5.64/100 trap nights), Slopka (5.61/100 trap nights) and Lilunda (1.71/100 trap nights).(Figure 10.25)

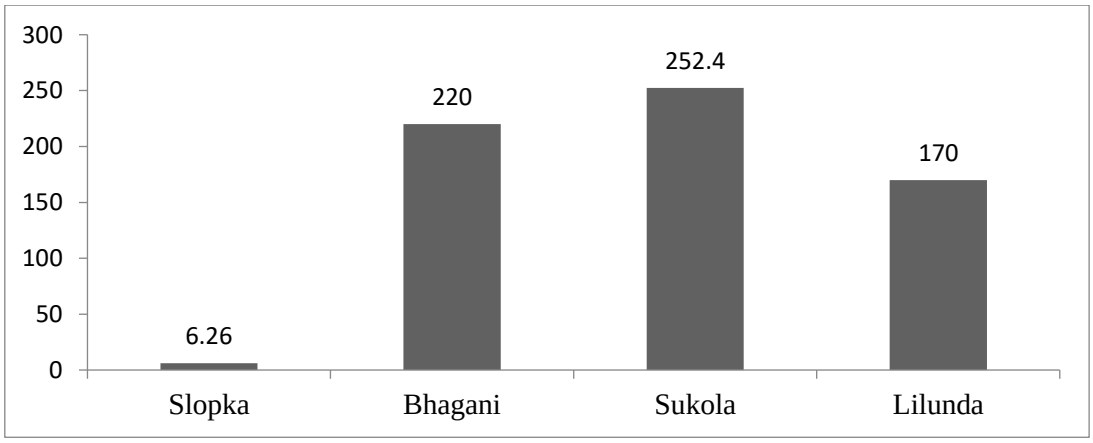

Figure 10.26: Photographic capture rate of Human in all four villages of Sariska.

Highest capture rate was found in the village Sukola (252.4/100 trap nights), Bhagani (220/100 trap nights), Lilunda (170/100 trap nights) and Slopka (6.26/100 trap nights) (Figure 30). Human capture rate was higher in Bhagani because it has a road at the periphery of its boundary. (Figure 10.26 & 10.27)

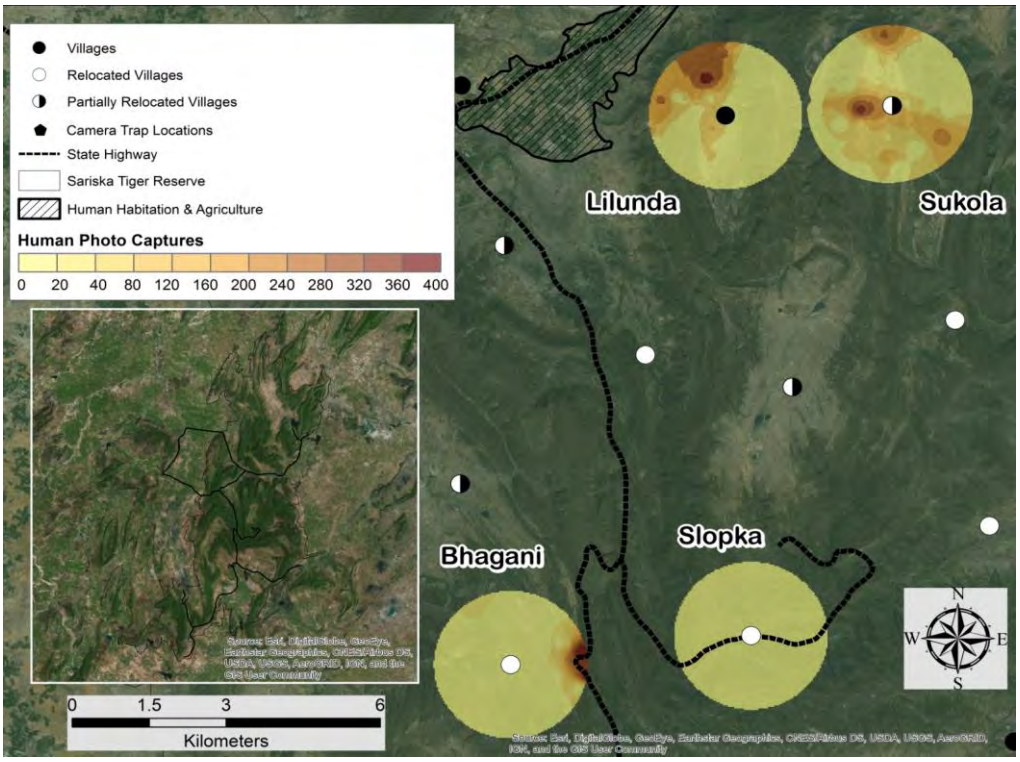

Figure 10.27: Map showing photographic capture rate of Human in four different village sites of Sariska.

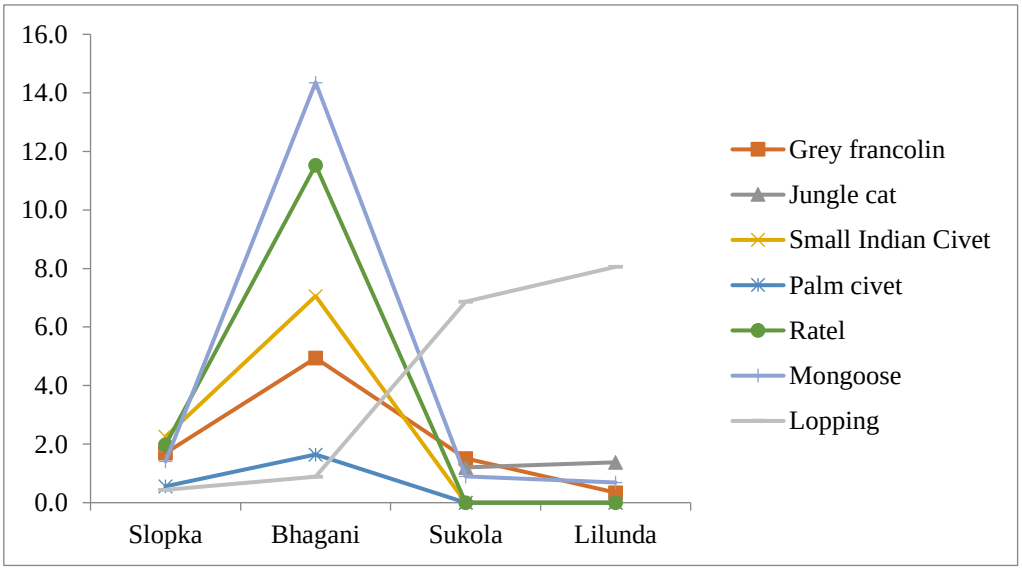

Figure 10.28: Capture rate of Small carnivores along with lopping pressure

Activity pattern of galliformes with humans in relocated village of Slopka

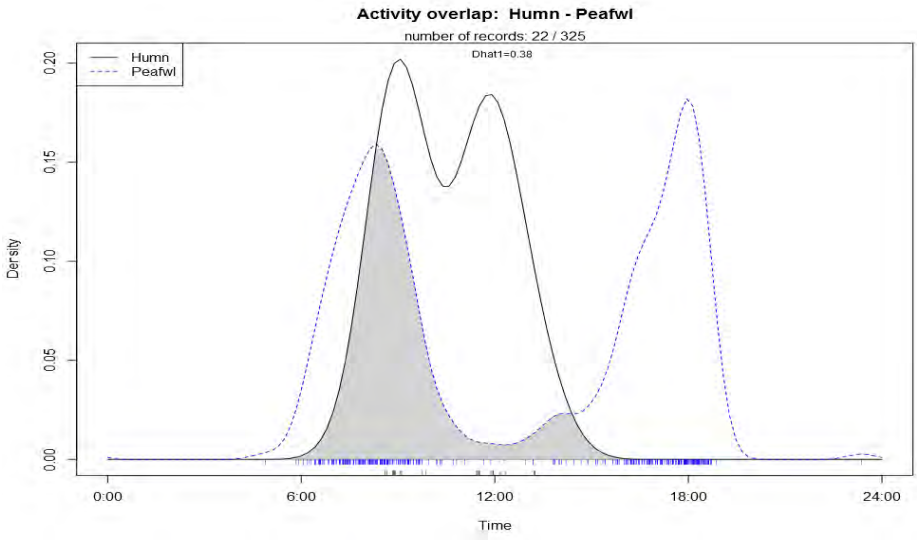

Figure 10.29: Activity overlaps of Peafowl with Human

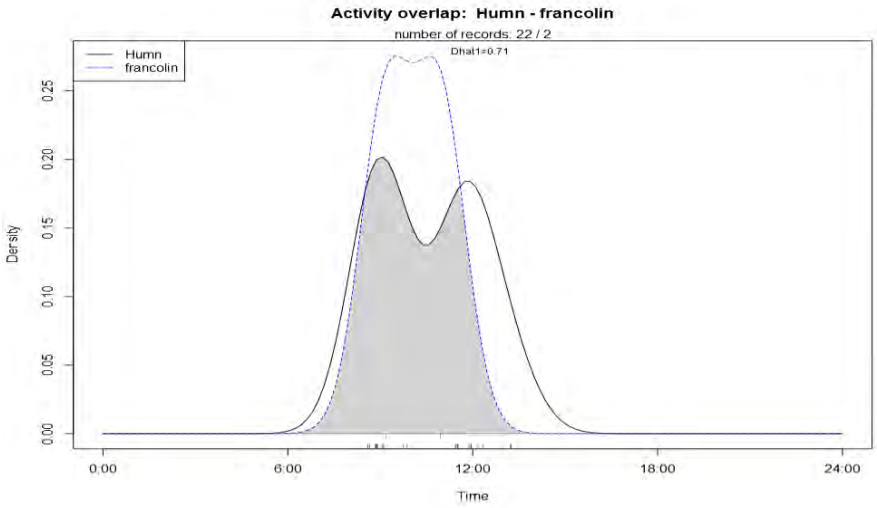

Figure 10.30: Activity overlaps of Grey francolin with human

Activity overlaps of Small carnivores with Human at relocated village Slokpa

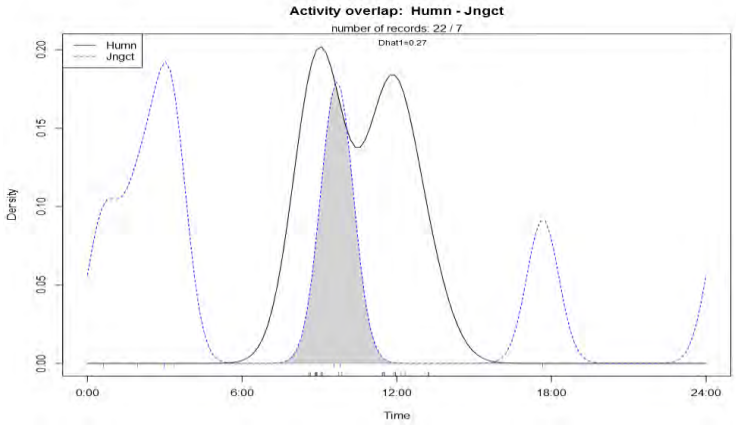

Figure 10.31: Activity overlaps of Jungle cat with Human

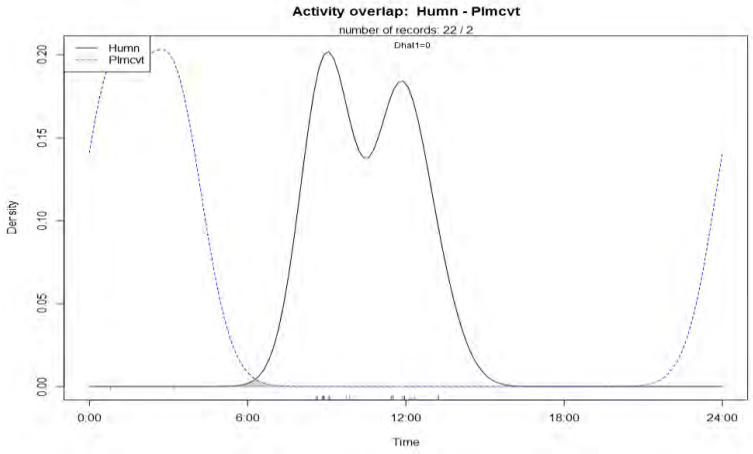

Figure 10.32.- Activity overlaps of Palm civet with Human

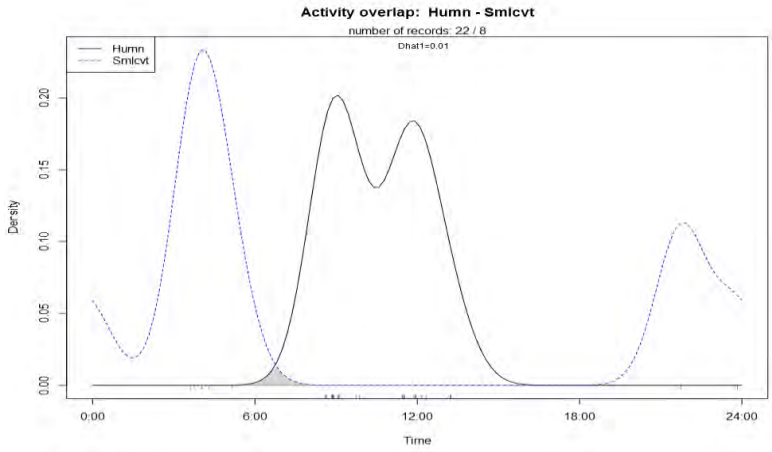

Figure 10.33: Activity overlap of Small Indian civet with Human

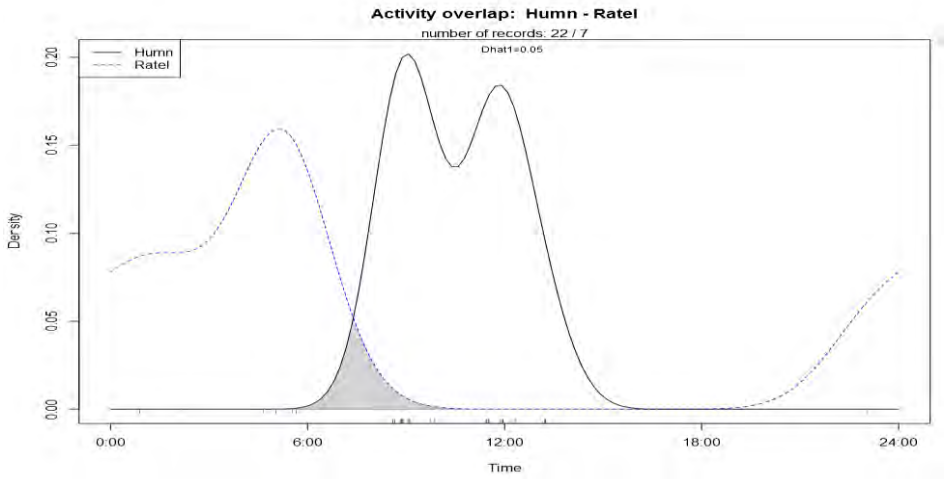

Figure 10.34 –Activity overlaps of Ratel with Human

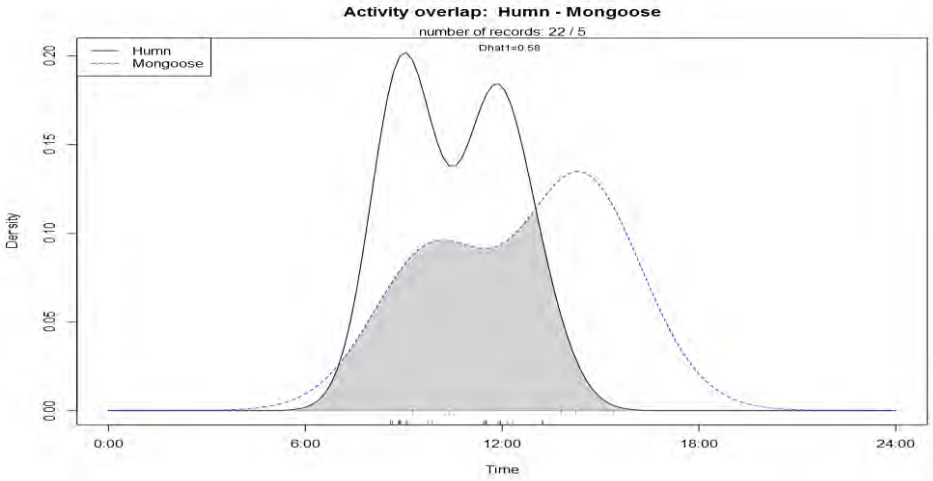

Figure. 10.35. - Activity overlaps of Mongoose with Human

Activity pattern of galliformes with humans in relocated village of Bhagani

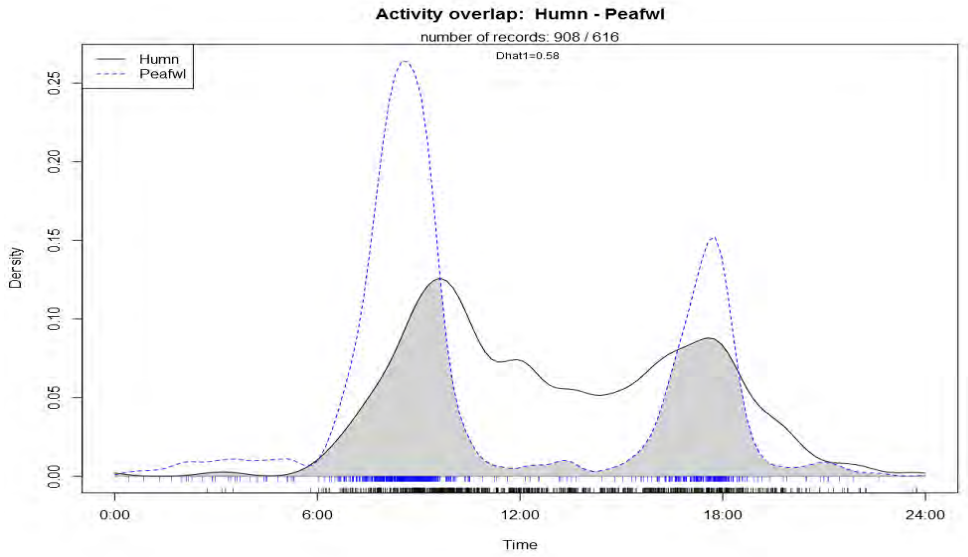

Figure 10.36: Activity overlaps of Peafowl with Humans

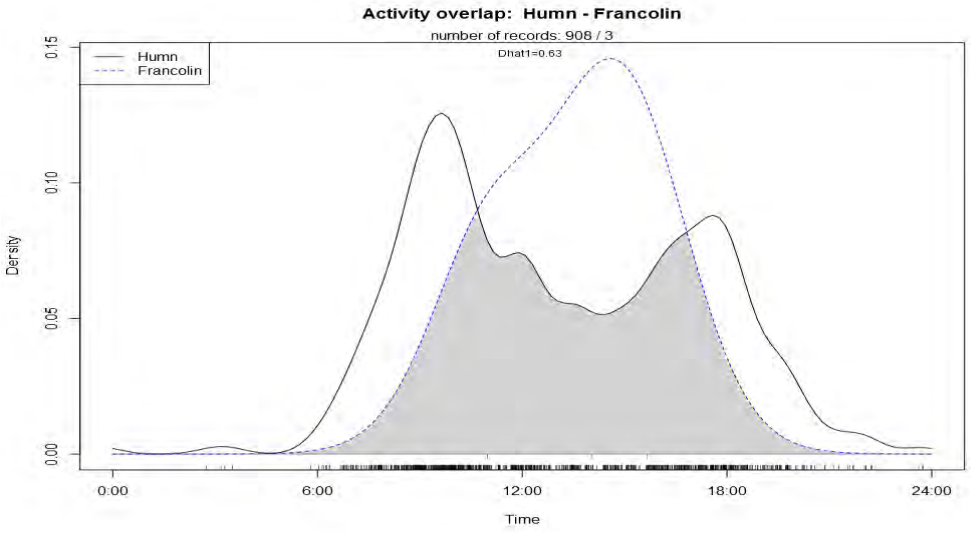

Figure 10.37: Activity overlaps of Grey francolin with Humans

Activity overlaps of Small carnivores with Human at relocated village Bhagani

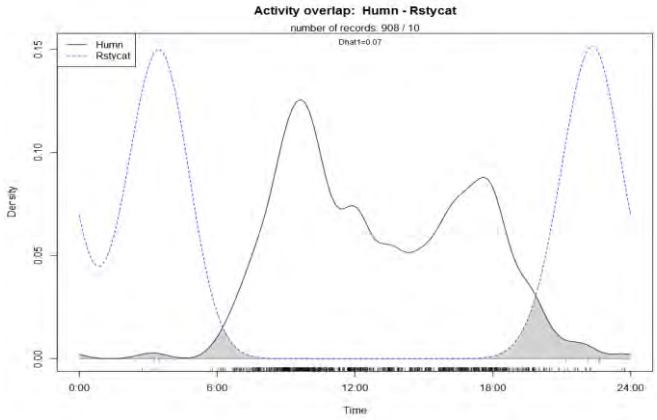

Figure 10.38: Activity overlaps of Rusty spotted cat with Human

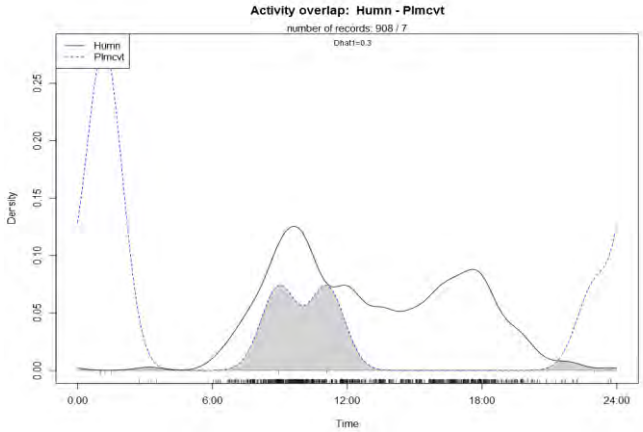

Figure 10.39.: Activity overlap of Palm civet with Human

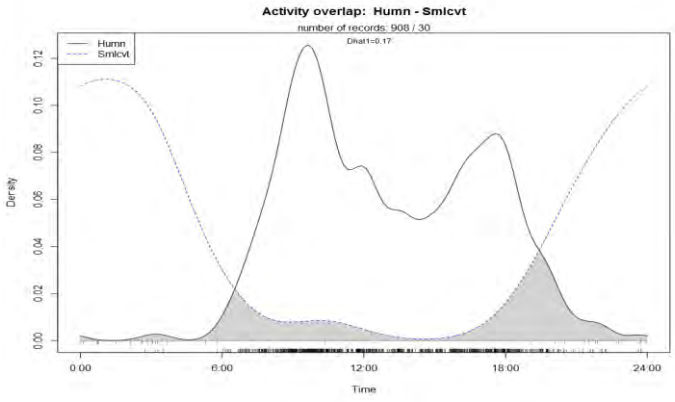

Figure 10.40: Activity overlaps of Small Indian civet with Human

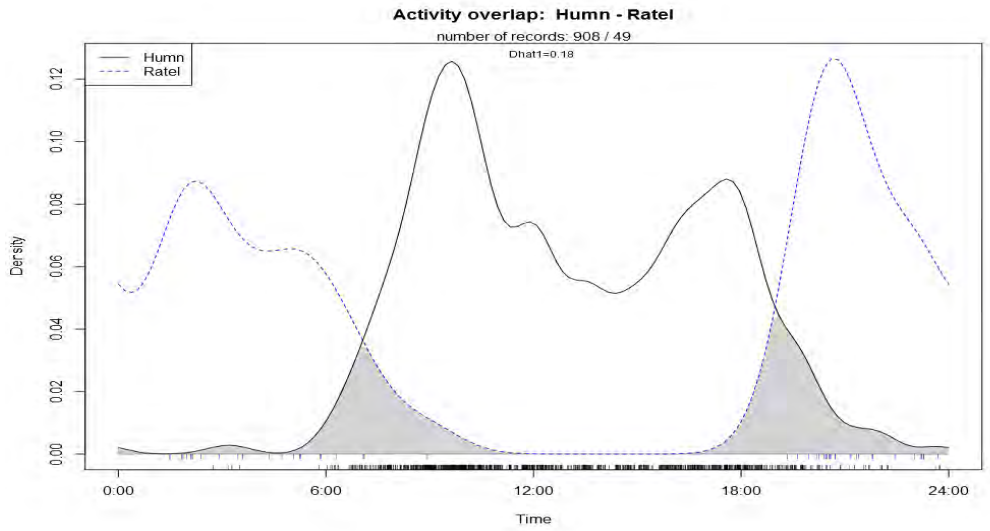

Figure 10.41: Activity Overlaps of Ratel with Human

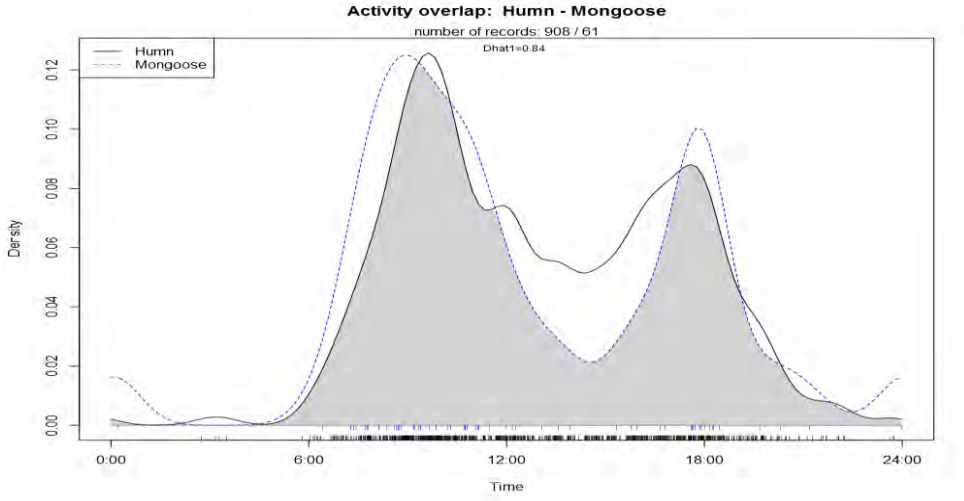

Figure 10.42: Activity overlaps of Mongoose with Human

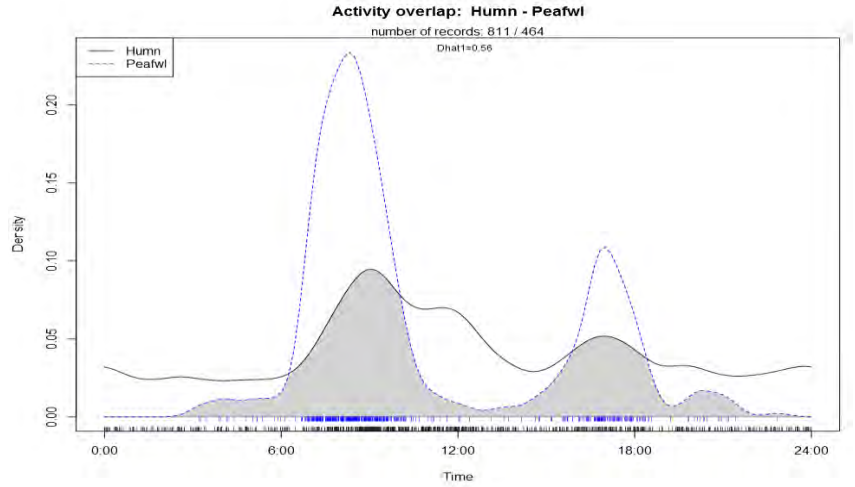

Figure 10.43.: Activity overlaps of Peafowl with Human

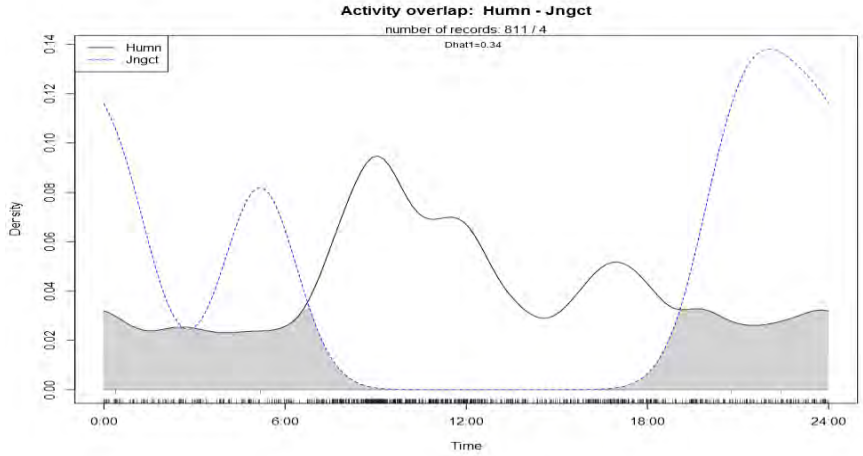

Figure 10.44: Activity overlaps of Jungle cat with Human

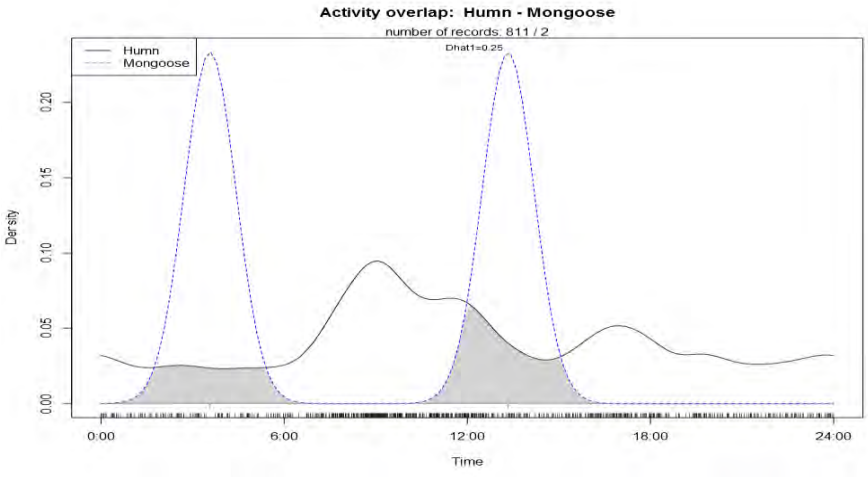

Figure 10.45: Activity overlaps of Mongoose with Human

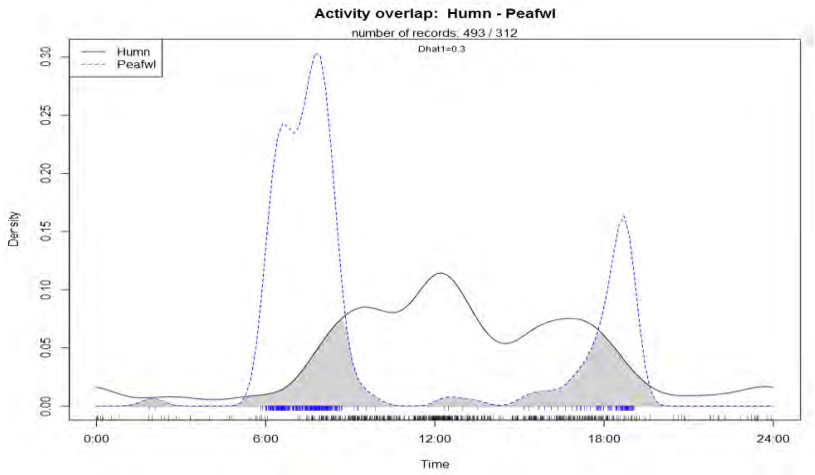

Figure.10.46: Activity overlaps of Peafowl with Human

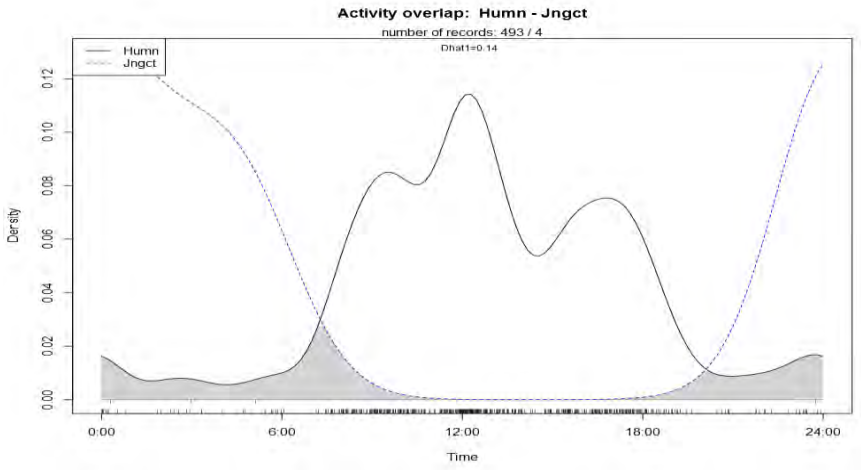

Figure 10.47: Activity overlaps of Jungle cat with Human

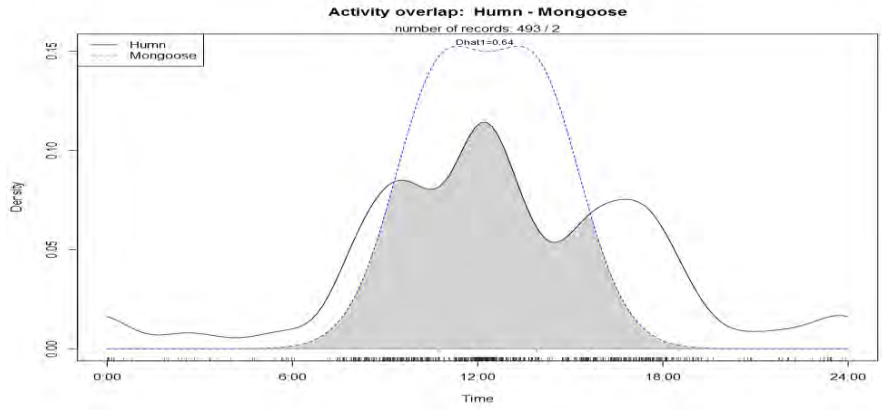

Figure 10.48: Activity overlaps of Mongoose with Human

10.4. Discussion

10.4.1. Effect on Galliformes

As for most wildlife, the single most serious threat to the survival of galliformes is habitat loss, degradation and fragmentation. In fact, they are the most important indicator species and their presence or absence in an area is a good indication of the health of the ecosystem. In this current study assessment of their population was carried out in the Sariska tiger reserve of Rajasthan. Previous studies showed that Sariska has the highest density of peafowl as well as grey francolin (Kidwai et al., 2011). But in Sariska there are 31 villages which are considerable threat for all wildlife as well as ground birds. This reserve has faced high disturbance as form of human presence, biological extraction and grazing pressure. Most of the studies shows that presence of human and livestock has negative impact on galliformes (Bhattacharya et al., 2007). This study was carried out in the relocated and non-relocated villages of Sariska to see the abundance and habitat use of galliformes with respected to disturbance.

The density of ground bird was estimated highest (331.4 ± 75.5) in the village Bhagani which has been relocated 10 years before followed by Slopka (240.4 ± 56 .5), relocated more than 40 years ago. The other two non-relocated sites were Sukola which is partially relocated has the density of 180.7 (± 48.7) birds per sq. Km. The density of galliformes estimated to be 181.3 (± 43.9) per sq km in the village Lilunda. It shows that there is a significant difference in density of ground birds (galliformes) with relocated village to non-relocated village and very less difference among non-relocated villages. But two relocated village has obvious difference in ground bird density. We also compute the peafowl density for each village sites. The density of peafowl found to be highest in Bhagani (158.72 ± 45.6) followed by Lilunda (124.7 ± 38.2), Sukola (115.05 ± 27.4) and Slopka (108.89 ± 32.17). In case of peafowl two non-relocated villages has the highest density than the relocated villages of Slopka. It can be explained by species biology and their specific habitat uses in the study site. In case of galliformes the highest density was observed in two relocated villages because grey francolin (n=23, 20), painted Spurfowl (n=6, 4) and red Spurfowl (n=3, 1) constitute most of the sighting other than peafowl. Where in case of non-relocated site most of sighting made on peafowl. This difference can be observed in encounter rate of each species at different habitat types in different village site. The encounter rate of grey francolin is 4.62 & 4.72/ km in Butea mixed forest and 2.57 & 2.87/Km in Ziziphus mixed forest in Slopka and Bhagani respectively. But in non-relocated village site amount of Butea mixed forest and Ziziphus mixed forest is very less compare to relocated villages. The abundance of grey francolin is also affected by shrub cover and ground cover layer where painted Spurfowl and red Spurfowl both are mostly restricted to riverine forest and bamboo forest. Since, peafowl is a large bodied species; it occupies wide forest areas i.e. open forest, bushland, thorn forest (Madge and Mc Gowan, 2002). Because of human encroachment into their natural territories, peafowl and humans have come into increasing contact (Madge & Mc Gowan, 2002). Peafowl is a disturbance tolerant species; mostly prefer open scrubland, degraded areas than dense forest. Previous studies show that Sariska has the highest galliformes density, peafowl (174/km^2) followed by grey francolin (40.8 /Km^2) and jungle bush quail (20 /km^2) (Gupta et al., 2011). Earlier studies on galliformes showed that they occupy non- overlapping habitats due to their preference to different habitat types. Their abundance also depends on a variety of habitat factors like tree cover, shrub cover, anthropogenic pressures etc. (Kidwai et al., 2011). Non-relocated village may have good densities of galliformes but it is mostly comprises of peafowl density. Because it fails to provide different habitat types, the abundance of other galliformes species is very less which causes low species diversity. While relocated villages has the highest densities of galliformes because it provides different habitat type which is very crucial for maintaining species diversity. As they form a significant prey base, their presence or absence can affect the abundance small carnivores.

10.4.2. Effect on Rodents

Various studies have shown important roles of rodent in the diet of many small and medium sized carnivores. They are found to play an important role by contributing 4.4% in the diet of golden jackal and 34.3% in jungle cat (Gupta et al., 2011). Some of them are the indicator of habitat quality as they mostly depend upon ground layer cover for food and shelter. Sampling of rodent was carried out at four different villages' sites of Sariska tiger reserve to investigate their diversity and abundance. Different type of habitat was selected for rodent trapping at relocated and non-relocated villages of Sariska tiger reserve. The highest density was recorded from the fourteen-year-old relocated village Slopka (13.08 ±0.31) followed by Bhagani (9.72 ±1.38), Sukola (9.12 ± 0.42) and Lilunda (3.21 ± 0.71). Previous study on rodent shows an overall rodent density in winter was (22.92 ±4.65) animals/ha, and 7.81 ±2.25 (SE) animals/ha in summer. Most number of individual was captured in the village Slopka (n=12) followed by Sukola (n=10), Bhagani (n=9) and Lilunda (n=3).Most number of species was captured from the relocated village Bhagani (n=4) followed by Slopka (n=3).Earlier studies suggest that different species of rodents are restricted to specific habitat types for example *Vandeleuria oleracea* was captured only in *Anogessius* dominant forest; and *Millardia meltada* were found in *Butea* mixed forest; *Millardia gleadowi* was captured only in *Butea- Ziziphus* mixed forest; and *Golunda ellioti* was largely captured in open scrubland (Gupta et al., 2011). In this study highest number of rodents were captured in Scrubland (n=10) followed by Ziziphus mixed forest (n=9) and Butea mixed forest (n=8). Relocated village has the highest density of rodents because it provides different types of habitat which is essential for species diversity. Density of rodents might be same in Sukola (partially relocate) with Bhagani (Relocated) but the species composition is different. In Sukola most number of capture species was House mouse (*Mus musculus)* which is known to live near human habitation. While in Bhagani soft furred rat (Milardia meltada) as well as Indian gerbil (*Tatera indica*) and little Indian field mouse (*Mus booduga*) was caught from the forested areas. Only Brown rats (*Rattus norvegicus*) were capture from the non-relocated village Lilunda. It suggests that non-relocated villages might have high density of rodents but their composition was totally different. Both brown rats and house mouse are known to reside near human habitation and indicator of disturbed habitats. While in case of other species like Indian bush rat, Little Indian field mouse and soft furred rat which caught in the relocated village sites, are known to affect negative relation with disturbance. All of this indicates that presence of villages has considerable effect on species composition of small mammals and their abundance. As they are the major prey species, they can affect the abundance of small carnivore locally.

10.4.3. Effect on Vegetation structure

Vegetation sampling was carried out for evaluation of canopy cover, shrub layer and ground layer cover. In each plot amount human disturbance was also recorded. The proportion of the total number of trees showing signs of lopping was recorded. The lopping score for each tree was additionally measured on a scale of 0–4 as follows: 0, no lopping; 1, rudimentary signs of lopping; 2, up to half of the main branches lopped; 3, more than half of the main branches lopped; 4, the tree reduced to a stump. Among all four study sites Lilunda found to be the most habitat followed by Sukola. Sukola was found one of least disturb site.

Computation of vegetation structure shows that Slopka has the highest amount of Boswellia mixed forest (63.0/ ha.) followed by Anogeissus mixed forest (56.9/ha.) Butea mixed forest (53.7/ ha.) and Ziziphus mixed forest (41.4/ha) while Bhagani has most of the area as riverine forest (55.8/sq km) and Anogeissus mixed forest (55.5/ha). The other forest was mostly comprising of butea mixed forest (50.4 /sq.km) and Ziziphus mixed forest (46.7/ha.). The partially relocated village Sukola has most of its area as scrubland (40.07/ha.) followed by Anogeissus mixed (40.4/ha), Butea mixed (25.0/ha.) and acacia mixed forest (20.0/ha.). Lilunda was mostly dominated by Scrubland (45.8/ha), Anogeissus mixed (20.05/ha), acacia mixed (20.0 /ha.) and Ziziphus mix (12.2 /ha) forest. Both of the village sites show the mark difference in terms of vegetation type with relocated village. Slopka

and Bhagani both the site has very good amount of Anogeissus mixed forest. Both the non-relocate village site has most of it area as scrubland due to presence disturbance by human and their livestock. Among all across study sites Anogeissus pendula was found to be most dominant tree species (12.67/ha) followed by Butea monosperma (4.08/ha) ,Ziziphus mixed forest (4.95/sq km) and Boswellia mixed forest. The tree density of each village site was also estimated. Slopka has the highest tree density (29558 /ha). Amount shrub cover was also computed for four different sites. Slopka has the dense shrub cover (43/ha) followed by Bhagani (26.37/ha), Sukola (20.37/ha) and Lilunda (12.93/ha). Amount of shrub cover suggest that relocated village site has very minimum disturbance.

Abundance of invasive species was estimated. The results showed that Slopka has very invasive species (14.42/ha) followed by Bhagani (17.72/ha) Sukola (24.06/ha) and Lilunda (19.6/ha). These results showed that presences of human and their livestock cause considerable disturbances in different sites. Amount of human disturbance is also measure in study sites. Slopka has the least affected sites followed by Bhagani. Lilunda has the highest disturbance among all village sites. Lopping pressure was highest in Lilunda (2.84/ha) followed Sukola (2.42/ha) Bhagani. (0.31/ha) and Slopka (.0.15/ha).

10.4.4. Effect on Small carnivores

Photographic capture rate of each species was computed for all across the study site. Livestock has the highest number of capture rate followed by human, chital and peafowl. The camera trap pictures of each sites were analysed in CamtrapR to see the activity overlaps of galliformes species and small carnivores with human.

Slopka: (relocated more than 40 years ago)

In Slopka activity overlap between peafowl and human is found to be 0.38%. The most active time of peafowl was at the 8:00 AM in the morning and 2:00PM in the afternoon. The overlap between grey francolin with human was 0.71 % and most activity time grey francolin was at 10:00 AM in the morning.

The activity pattern of Jungle cat shows very less overlap with human (0.21%) and most activity time period for jungle cat is 10:00 AM in the morning which also indicate the less disturbance in the area. There is no activity overlap between palm civet with human. Being a nocturnal creature palm civet was active mostly at mid night (12:00 AM). Small Indian civet also shows very less, only 0.01% overlaps with human and it was mostly active at 8:00 PM at night. Being highly nocturnal creature ratel shows very less overlap (0.05%) and mostly active after 8:00 PM to through midnight. Mongoose shows activity overlap 0.58% with human and mostly active from 10:00 AM to 1:00PM. Because of very less disturbance animals in Slopka are active according to their biological clock.

Bhagani: (relocated 10 years ago)

In Bhagani peafowl shows 0.58% activity overlap with human and mostly active in the 8:00 AM in the morning and 5:00 PM in the evening. Grey francolin shows 0.63% activity overlap with human and mostly active after 12:00AM in the morning to 5:00 PM in the evening. Activity overlap of Rusty spotted cat with human is very less (0.07%) and show activity after 8:00PM in the evening. Being a highly nocturnal creature palm civet shows very less activity overlap (0.03%) and starts their activity after 12:00 AM. The overlap between activity patterns with human was 0.17% in case of small Indian civet and they start showing activity after 6:00PM in the evening to throughout the night. The activity overlap of Ratel with human is only 0.18% and mostly they start active after 6:00 PM in the evening to throughout the night. Mongoose shows high activity overlap of 0.84% with human and most active at the 10:00 AM in the morning and 5:00 PM in the evening. Activity pattern of animals in Bhagani shows very less affected by human presence or disturbance.

Sukola (Partially relocated)

Sukola was partially relocated and people are still living in these villages and causing a considerable amount of disturbance to the wild animals. The activity overlap of peafowl with human was 0.56% and they are mostly active at 8:00AM in the morning and 5:00PM in the evening. The activity overlap of jungle cat was found to be 0.34% with human and they are most active after 6:00 PM in the evening to till 12:00 PM in the night. Activity overlap between mongoose with human was 0.25% and they show most activity at 6:00 AM in the morning and 1:00 PM at the noon. In Sukola peafowl and jungle cat seems like not so affected by human disturbance but other species of small carnivores are highly affected by the disturbance. Peafowl and jungle cat both are tolerant to human disturbance and reside mostly near to human habitation for easy available food sources. Mongoose is a versatile predator with high adaptability of human disturbances. In fact, they live very close to human habitation. But other wildlife species like Small Indian civet, Palm civet and ratel are known to affect by disturbances.

Lilunda (Not relocated)

Village lilunda is located inside the national park and causes significant disturbances to the wildlife of the park. The activity pattern of peafowl has very less (0.3%) overlap with human because they actively avoid human presence. Their activity time shows two peaks, one at the 7:00AM in the morning and another one is the 6:00 PM in the evening. The activity pattern of jungle cat with human shows minimum overlap of 0.15% by actively avoiding human presence. They start active at 12:00 AM in the night and stop activity before 5:00AM in the morning. The activity pattern of mongoose shows very high overlap (0.64%) with human. They are the most active at the 12:00 PM in the afternoon. The village lilunda seems to have very high amount disturbance since most of the species which are known to tolerate some amount of disturbance (e.g. –Peafowl, Jungle cat) are also actively avoid human presence by sliding their temporal activity. Except mongoose which are mostly active during day time and shows significant overlap with human activity pattern. Presence of villages inside the protected areas not only causes disturbance to that area but also to the surrounding areas, which makes the whole area unsuitable for many species. This can lead to local extinction of species from a particular area.

CHAPTER 11
POLICY IMPLICATIONS

Approximate mean age of first reproduction of reintroduced tigers in Sariska was comparatively higher (65.33 months) than reported tiger populations from Indian sub-continent. Mean time of first reproduction after reintroduction (31.33 months) was comparatively higher than reintroduced population of Panna. This may be due to scarce availability of inviolate areas suitable for raising cubs. Sariska tigress have taken comparatively longer time to explore and identify areas suitable for breeding resulting in larger home ranges and higher time of first parturition.

11.1 Creation of Inviolate Core

It would be crucial to relocate the prioritized villages in Sariska to create an inviolate core (national park area) for long term conservation of tigers in this landscape. Creation of inviolate core (national park, approximately 400 sq. km) free from disturbance may act as a source for the entire greater Sariska tiger population and would be crucial to maintain source-sink dynamics in this landscape (Figure 11.1).

Moreover, our simulations suggest that the existing small tiger population may crash within 40 years even under highly managed scenario, if the current birth rate continues. Village relocation is essential to create more inviolate space to accelerate the birth rate. Small isolated population without any natural connectivity or without natural dispersal of tigers such as Sariska are vulnerable to extinction even if they have good prey base. Active population management such as supplementation at regular interval is necessary for long term persistence of tigers in Sariska.

11.2 Management Actions Required for Formation and Maintenance of Inviolate Core

Our long-term research indicates recovery of wild ungulate and tiger population following relocation of 565 families from the reserve. Three of the five reintroduced tigresses in Sariska littered after a gap of 4-6 years of reintroduction and have been effectively utilizing the inviolate areas created after village relocation. Currently the population have grown to 14 individuals in Sariska. This have been possible due to the relentless persuasion and efforts of the forest department in relocating about 565 families until now resulting in creation of more inviolate space for tiger breeding. Our long-term study on reintroduced tigers in Sariska documented signs of herbivore population recovery following the relocation and consequently reducing livestock grazing pressure in forest land. Livestock density have decreased by more than 50% over last seven years. Earlier scientific studies have documented recovery of tiger and their prey population following relocation and removal of livestock from major tiger habitats.

However, there are still 7 villages with an estimated 5000 livestock inside the national park, the best available tiger habitat. Although, the livestock density has decreased, the current livestock density is really high (~70-80 livestock/ sq. km). Heavy livestock grazing is not only detrimental to the habitat, but also creates competition for wild ungulates and can cause human-animal conflict. Tigers require inviolate space free from human disturbance for breeding. Presence of villages are an impediment for tiger breeding inside the core area.

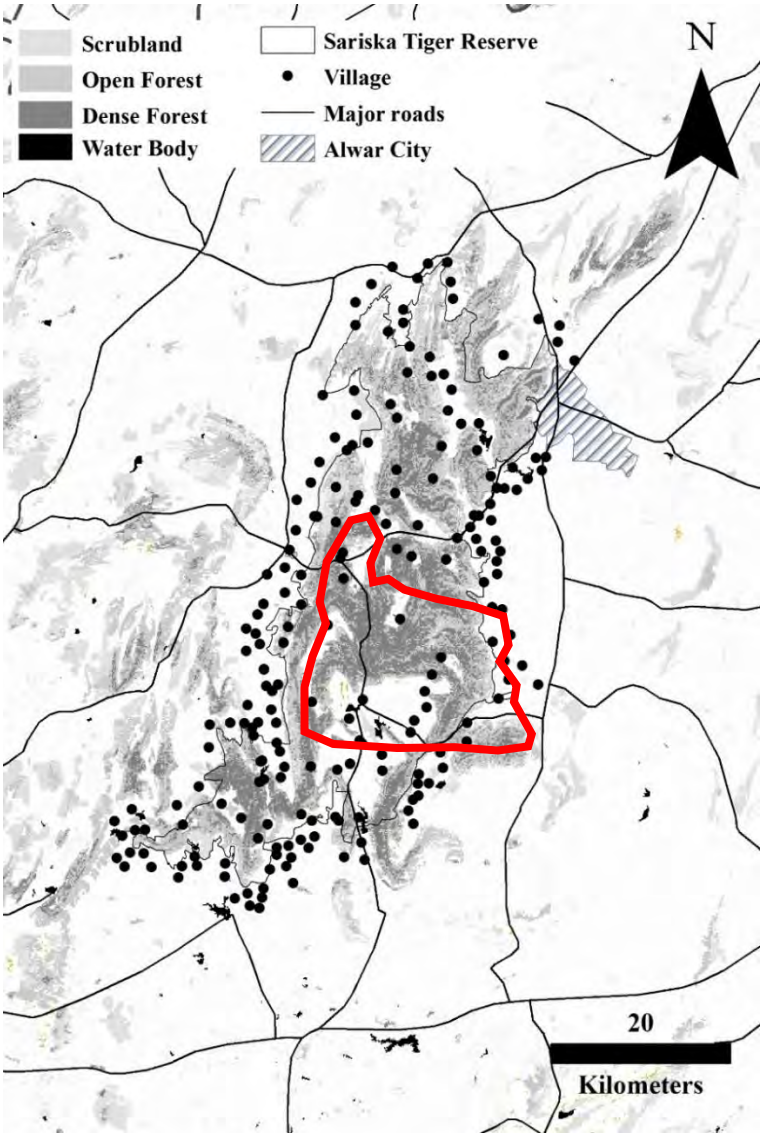

Figure 11.1. Red line indicates the potential highly managed inviolate core

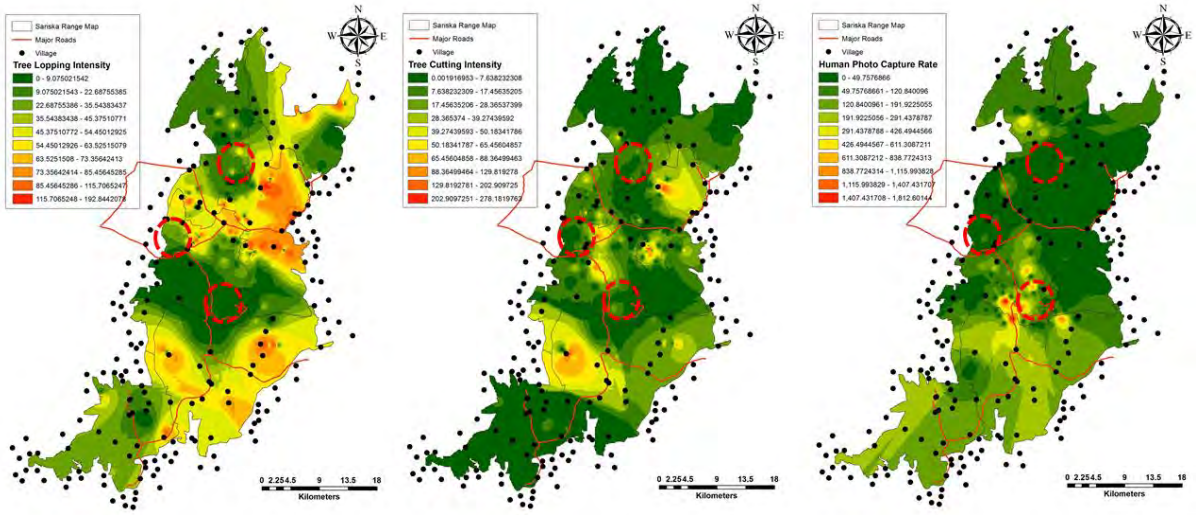

Figure 11.2. Litter spots of reintroduced tigresses against anthropogenic disturbance shows tigresses choose sites with minimal disturbance

11.3 Village relocation

Once, these six prioritized villages are relocated, management should concentrate on complete removal of livestock from these areas and increase man power in at least four chawki (Rotkala, Sukola, Kankwadi and Bana) for further management of these newly created inviolate areas.

11.4 Weed eradication

Eradication of weed is extremely crucial, especially *Cassia tora* and *Lantana camara* from the national park. Sukola offers complex terrain, however, is infested with *Lantana sp. Lantana sp.* should be removed from Sukola following the relocation of Sukola village. There has been an invasion of *Cassia tora* in the Sariska valley resulting in low growth of grass. It is recommended to manually remove *Cassia tora* from the valley.

11.5 Supplementation

Sariska's tiger population is vulnerable to extinction due to its isolation and small size even if it is highly managed. Supplementation in a highly managed scenario with no prey loss and human induced tiger mortality will be crucial for long term survival of the population. Although, ecological carrying capacity of tigers based on prey abundance is comparatively higher, our findings suggest it may be a gross over estimate as suitable breeding area are less to accommodate these many tigers in Sariska.

11.6 Active Population Management

Since most of the individuals belonging from the founder population are old, supplementation with special consideration to age-sex dynamics should be undertaken in future. Sariska's tiger population holds great potential but necessarily calls for adaptive management in future years.

Table 11.1: Age-sex structure and status of individual tigers as of 31.06.2018

Tiger ID	Age (as on June.2018)	No. of litters produced	Current Status (as on June 2018)
ST1 (M)			Dead
ST2 (F)	~ 14.3 yrs	2	Alive
ST3 (F)	~ 11.8 yrs		Alive
ST4 (M)	~ 13.3 yrs		Alive
ST5 (F)	~ 10.8 yrs		-
ST6 (M)	~ 11.8 yrs		Alive
ST7 (F)	~ 6.3 yrs		Alive
ST8 (F)	~ 6.3 yrs		Alive
ST9 (F)	~ 7.3 yrs	1	Alive
ST10 (F)	~ 7.3 yrs	1	Alive
ST11 (M)	~ 4.3 yrs		Dead
ST12 (F)	~ 4.3 yrs		Alive
ST13 (M)	~ 4.3 yrs		Alive
ST14 (F)	~ 4.3 yrs	1	Alive
ST15 (M)	~ 2.8 yrs		Alive

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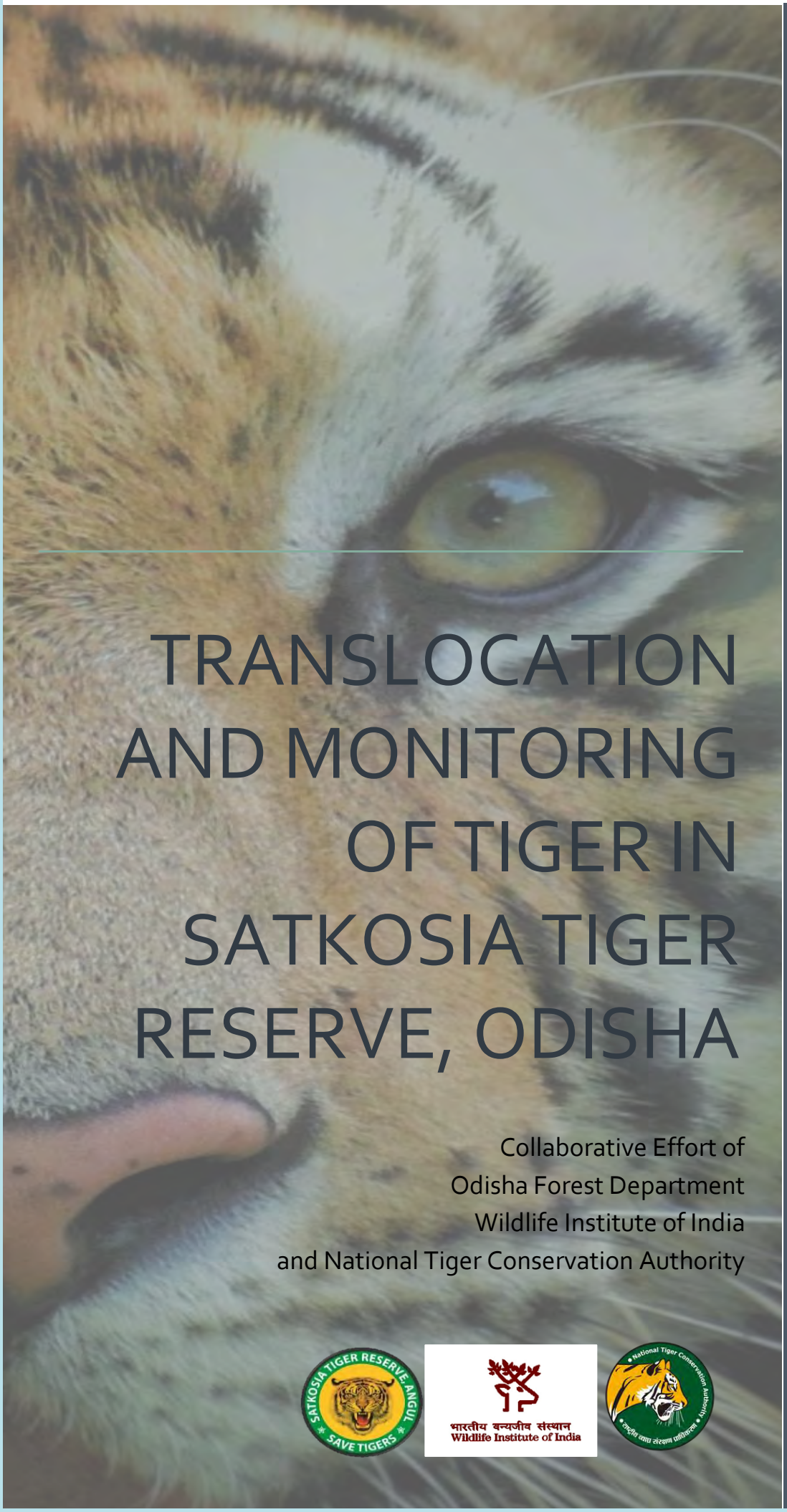

TRANSLOCATION AND MONITORING OF TIGER IN SATKOSIA TIGER RESERVE, ODISHA

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BACKGROUND

Satkosia Tiger Reserve (SKTR) is the meeting point of two bio-geographic regions of India: the Deccan peninsula and the Eastern Ghats [*Chhotanagpur plateau* (6B) and *Eastern Ghats* (6C) biotic Provinces]. The area north of Mahanadi is classified under *Garhjat hills* and that of south under Eastern Ghats. SKTR was originally established as Wildlife Sanctuary in 1976 and was declared as Tiger Reserve in 2007, comprising two adjoining Wildlife Sanctuaries: the Satkosia Gorge Sanctuary and the Baisipalli Sanctuary. The reserve area is contributed from four districts: Angul, Cuttack, Nayagarh and Boudh. It is also a part of Mahanadi Elephant Reserve. It has an area of 963.87 km^2 which will increase in future to 1136 km^2 upon the approval of proposal sent to the State Government. There are 136 villages inside the Tiger Reserve out of which 118 villages are in the Satkosia region. Of the 118 villages, 104 villages have been excluded by reorganizing the area. There are five villages in the core area, of which one village, Raigoda, has already been relocated.

FLORA

The area of Satkosia Tiger Reserve supports moist deciduous forest, dry deciduous forest and moist peninsular Sal forest. There are over 400 plant species comprising of 126 trees, 98 shrubs, 125 herbs and 51 climbers. The main tree species are Sal (*Shorea robusta*), Jamun (*Syzigium cumini*), Bija (*Pterocarpus marsupium*), Sisoo (*Dalbergia latifolia*), Arjun (*Terminalia arjuna*), Asan (*Terminalia tomentosa*), Dhaura (*Anogeissus latifolia*), Siris (*Albizia lebbeck*), Bandhan (*Ougeinia oojeinensis*) and Haldu (*Adina cordifolia*). Salia (*Bambusa arundinaceae*) and Daba (*Dendrocalamus strictus*) are the commonly occurring bamboo species.

FAUNA

The fauna includes Elephant, Tiger, Wild dog, Sambar, Spotted Deer, Bear, Barking Deer, Gaur, Leopard, Jackal, Giant Squirrel, Porcupine, Indian hare etc. The Gorge also has muggars, turtles, terrapins, crabs, molluscs besides other aquatic life forms and amphibians. A good diversity of avifauna can be seen inhabiting this place, including migratory birds. Resident birds include the Hornbills, Peafowls, Kingfishers, Egrets, Cormorants, River terns, Owls, Pigeons, Myna, Sunbirds, Eagle, Crow, Pheasants etc. The migratory birds include Brahminy ducks, Indian Skimmer, Bar-headed geese etc.

CLIMATE

Three distinct seasons are experienced in the Tiger reserve. The winter starts from November and lasts till middle of February followed by summer which continues up to middle of June. This is followed by rainy season spanning till September. The bulk of precipitation occurs during June to September through the south-west monsoon. The average number of rainy days in a year is 100 out of which, 70 are confined between June to September. The annual average rainfall varies from 1250 mm to 1700 mm. The advent of summer is usually experienced from March when temperature starts rising. Summer months are very hot. Maximum day temperature varies from 45°C to 47°C in month of May and June. When monsoon withdraws in the month of October, the winter sets in. The coolest month is December when temperature during the night varies between 6°C to 11°C.The humidity is generally high in the Tiger Reserve. It is generally 80 % in August, September, and October, while in other months the humidity is around 75 % .

TIGER POPULATION

Owing to a number of threats faced by tigers, today only 3% of the historic number occupies only 7% of the historic range. In India, the Sariska Crisis of 2004 and Panna Crisis of 2009 are the examples where the entire population of tigers vanished due to poaching and other threats. Translocation, despite all the criticism it has received and high costs involved, proved to be successful method to bring back tigers in the Panna and Sariska landscape.

Over the time, Tiger population in Satkosia Tiger Reserve declined, leaving only two individuals. Odisha Forest Department had decided to augment the tiger population in STR. The need to establish a viable, free-ranging tiger population in Satkosia Tiger Reserve by relocating wild tigers from other habitats and by providing secure and conducive environs for them led to the conception of the project "Augmentation and Recovery of Tiger Population in Satkosia Tiger Reserve, Odisha", a collaborative effort of Odisha Forest Department (OFD), Wildlife Institute of India (WII) and National Tiger Conservation Authority (NTCA). Following are the objectives of the project:

- To develop an inviolate space of ca. 500 km^2 in the core area and improve habitat quality in STR.
- To supplement the prey population through appropriate habitat management, translocation and conservation breeding program (if needed).
- To successfully release 08-10 tigers through supplementation in a phased manner over a period of 10 years in STR.
- Monitor and study these introduced tigers in ecological, demographic and management perspectives using radio telemetry (VHF, UHF and GPS/Argos radio collars), and other relevant sampling procedures. This includes monitoring response of co-predators and prey population using scientifically established protocols.
- To undertake community participation and eco-development activities towards safeguarding tiger population in the long-term.

APPROVAL AND LEGAL SANCTION

As a part of this initiative, it was decided to translocate three pairs of tigers from different tiger reserves of Madhya Pradesh. The proposal of tiger augmentation was submitted to NTCA vide letter No. 4446 dated 20.09.2016, which was approved vide letter No. 15-30(8)/2015-NTCA of NTCA, Govt. of India. The PCCF (Wildlife) & Chief Wildlife Warden, Madhya Pradesh vide his office letter No.1306 dated 20.02.2018 conveyed the approval of the Government of Madhya Pradesh for sparing three pairs of tigers to STR, Odisha. In a meeting held on 13.03.2018 at Bhopal, the Chief Wildlife Warden, Madhya Pradesh involving representatives of OFD, MPFD, NTCA and WII agreed to spare one pair of tigers each from Kanha, Panna and Bandhavgarh Tiger Reserves. The MoEF & CC, Govt. of India vide letter No.1-30/2018 WL dated 23.5.2018 conveyed the approval in accordance with the provision under Section-12 of the Wildlife (Protection Act, 1972) for tranquilization and translocation of six tigers from Madhya Pradesh to Satkosia Tiger Reserve.

FOUNDER INDIVIDUALS

A number of things are necessary while selecting founder individuals:

- A feasibility study and background research.
- An assessment of the taxonomic status of the tiger to be re-introduced
- Identification, assessment and prioritization of the genetic and geographic closeness to the proposed reintroduction population
- Assessment of the impact of removal of the individuals on host population
- Identification of history of habitat connectivity to the proposed area of reintroduction and the existing corridors, in case of absence of genetic information
- Preference should be given to the animal from the wild populations, closely related genetically to the original native stock, showing similar ecological characteristics to the original population.
- Sub-adult tigers, both male and female, which have become independent and likely to establish their territories should be intensively monitored and selected for reintroductions.
- Care should be taken not to select breeding individuals from the host population.
- Captive tigers may also be selected after training in their captive environment.
- All tigers should be monitored with the radio-collars and monitored intensively.

Kanha Male (T1)

Bandhavgarh Female (T2)

CAPTURE AND TRANSLOCATION

In the first phase of the project, two tigers – one adult male from Kanha Tiger Reserve (KTR) & one sub-adult female from Bandhavgarh Tiger Reserve (BTR) were translocated from Madhya Pradesh to STR in June 2018. In translocation programs, young tigers (<3 years) are most suitable because translocation mimics natural dispersal patterns of animals in this age group. These tigers were brought in covering sufficiently long translocation distances. Both the translocated tigers were equipped with GPS collars with remote data download capabilities that enable researchers to evaluate the success of the translocation, closely monitor movements, and quickly respond to any potential conflicts in the future.

CAPTURE AND TRANSLOCATION OF T1 (KANHA MALE)

A team consisting of Wildlife Veterinarians and Forest officials, including supporting staff of Satkosia Tiger Reserve as well as Scientist and Researchers from Wildlife Institute of India was constituted to undertake the entire process of capture, transportation, release and monitoring of the tiger. NTCA protocol was followed for tranquilization and transportation of the animal.

The young adult male tiger MB-2 was located on 19.06.2018 in the Kanha Tiger Reserve, Madhya Pradesh. Pre-capture health assessment of the tiger was done by the local staff of Kanha Tiger Reserve. Briefing for the entire operation started at 11:34 a.m. on 20.6.2018. After the duties were assigned and entire protocol was briefed, the stretcher team left for base camp at 11:49 am. The tranquilization team left the base camp at 12:10 pm. First dart was made at 12:15 pm and the tiger was immobilized by 12:34 pm. Tranquilization of the tiger was carried out by the expert tranquilization team from Kanha TR, Pench TR, Veterinary Assistant Surgeon from Satkosia TR, and External Ph.D. Research scholar from Wildlife Institute of India. The stretcher team left to bring the tiger at 12:37 pm and arrived at the base camp at 12:42 pm. In the next 11 minutes, radio-collaring, morphometric measurements, pug impressions and collection of biological samples was done by WII team led by Dr. K. Ramesh. Vital parameters were continuously monitored by the veterinary team and ambient temperature was maintained by spraying water and continuous fanning. After reversal of anesthesia, the tiger was transferred in the cage at 12:53 pm and was loaded in the specialized transportation vehicle by 1:09 pm. The transportation vehicle, along with veterinarians, officials from Satkosia TR and team of Wildlife Institute of India left the Forest Rest House, Mukki Gate at 2:55 pm. After leaving from Kanha Tiger Reserve at 2:58 pm on 20.06.2018, the vehicle arrived at Satkosia Tiger Reserve, Odisha at 2:34 pm on 21.06.2018. Prey was released into the prey chamber of soft-release enclosure at 3:28 pm. The animal was released into the enclosure-I at 4:12 pm.

The entire operation was carried out in the presence and guidance of Dr. Sanjay Kumar Shukla (Chief Conservator of Forests & Field Director, Kanha Tiger Reserve), Dr. Sudarsan Panda (RCCF, Angul Circle & Field Director, Satkosia Tiger Reserve), Dr. K. Ramesh (Scientist, Wildlife Institute of India). The veterinary team comprised of Dr. Akhilesh Mishra (Wildlife Veterinarian, Pench TR, M.P.), Dr. Sandeep Agrawal (Wildlife Veterinarian, Kanha TR, M.P.), Dr. K.K. Sahu (Veterinary Assistant Surgeon, Satkosia TR) and Dr. Prayag H.S. (External Ph.D. Research Scholar, Wildlife Institute of India). Among the officials of Kanha TR, Dr. K.S. Bhadoria (Joint Director), Ms. Anjana Suchita Tirkey (Deputy Director, Kanha TR), Dr. Rakesh Shukla (Research Officer), S. K. Khare, S. K. Sinha, Ranjit

Singh Uikey, S. K. Mishra, S. K. Sendram, Assistant Directors, Range Officers and the staff of Kanha Tiger Reserve were present. The research fellows of WII who are engaged to implement the project (Mr. Rabi Sankar Pal, Mr. Gatikrishna Behra and Ms. Vaishali Vasudeva) and the experienced researcher from Panna (Mr. Supratim Dutta) were present at the spot of capture and radio-collaring. Officials from Satkosia TR included Md. T. Rahman (DFO), Subhendu Prasad Behera (ACF), Raja Kishore Swain (ACF), Ghanshyam Mohanata (Range Officer) and forest staff.

CAPTURE AND TRANSLOCATION OF T2 (BANDHAVGARH FEMALE)

The sub-adult tigress from Bandhavgarh Tiger Reserve that was weaning away from mother was identified for capture and translocation. Tracking of the tigress and cage preparation started on 25.06.2018 in the Bandhavgarh Tiger Reserve, Madhya Pradesh and was located around 1:30 pm on 27.06.2018. Pre-capture health assessment of the tiger was done by the local staff of Bandhavgarh Tiger Reserve. The team reached the capture site at 2:06 pm on 27.06.2018. First dart was made at 1:26 pm. Tranquilization of the tiger was carried out by the experts Dr. J. P. Tripathi, Dr. Bharti, and Dr. Nitin Gupta. Radio-collaring was done by Dr. K. Ramesh, Scientist, Wildlife Institute of India and was completed in 4 minutes at 2:24 pm. Morphometric measurements, pug impressions, collection of biological samples was done. Vital parameters were continuously monitored by the veterinary team. After reversal of anesthesia, the tiger was loaded in the specialized transportation vehicle by 2:36 pm. The transportation vehicle, along with veterinarians, officials from Satkosia TR and team of Wildlife Institute of India left Bandhavgarh Tiger Reserve at 5:17 pm. After leaving from Bandhavgarh Tiger Reserve on 27.06.2018, the vehicle arrived at Satkosia Tiger Reserve, Odisha at 8:30 pm on 28.06.2018. Cage was unloaded at 9:05 pm and the animal moved from cage to the enclosure-II at 9:24 pm.

Entire operation was carried out in the presence and guidance of Mr. M.K. Pathak (Field Director, Bandhavgarh Tiger Reserve), Dr. Sudarsan Panda (RCCF, Angul Circle & Field Director, Satkosia Tiger Reserve), Dr. K. Ramesh (Scientist, Wildlife Institute of India). Veterinary team included Dr. J. P. Tripathi, Dr. Bharti, and Dr. Nitin Gupta. Officials from Satkosia TR included S. Md. T. Rahman (DFO, Satkosia Wildlife Division), Subhendu Prasad Behera (ACF), Raja Kishore Swain (ACF), Ghanshyam Mohanata (Range Officer), Dr. K.K. Sahu (Veterinary Assistant Surgeon, Satkosia TR), Dr. Prayag H.S. (External Ph.D. Research Scholar, Wildlife Institute of India), and forest staff. Experienced researchers from Panna TR (Mr. Supratim Dutta) and Sanjay TR (Mr. Raja Sekar) were present at the spot of capture and radio-collaring.

MANAGEMENT IN SOFT-RELEASE ENCLOSURE

THE ENCLOSURE AND MONITORING SYSTEM

SKTR Management, with scientific inputs from Wildlife Institute of India selected Raigoda Range as the release site. The selected site has sufficient prey base and waterbodies. A special enclosure of 2ha was constructed to keep the translocated tigers until release. The enclosure was divided into two connectable enclosures- one for the male tiger and the other for female tiger. In addition, there are two prey chambers for releasing the prey inside the two compartments. There are adequate number of trees inside the enclosure and waterhole and straw sheds have been provided. The fenced boundaries are covered with straw and netlon (Agrinet) to block the view of humans and vehicles outside the enclosure. There are bullet CCTV cameras and PTZ cameras for continuous monitoring of the tigers for any signs of stress. Six camera traps were installed around the enclosure to monitor the animals visiting the area. Three *machans* near the enclosure were used for 24x7 monitoring. Solar fencing and trenches were used to prevent entry of elephants in the close vicinity of the enclosure. The water in the water holes was being regularly changed.

MONITORING OF TIGERS

During the period animals were kept in enclosure, they were continuously monitored with the help of CCTV cameras and dedicated field staff making observations from camouflaged tree-top *machans*. The behavior and health of the animal was also being monitored by Veterinarians. A log of daily activity, movement and behavior was also prepared. The prey was being released into the prey chamber at regular intervals as decided by the officials with inputs from WII team.

T1 (KANHA MALE)

During the time in enclosure the tiger spent an average of 13 hours every day sleeping, 1.25 hours sitting and resting and an average of 5.5 hours walking and roaming around the enclosure (Figure 1). During the initial ten days, most of the time was spent in sleeping which declined towards the last one week and was mostly spent in walking around. Sometimes it sat near water hole, but mostly it was for short durations of 10-15 minutes. Similarly short time was spent in the pool. For resting, it mostly used the maize plantations under the tree and rarely used the shed provided in the enclosure.

It was observed that sleeping activity was confined between 8 am and 12 midnight while walking and movement was mostly confined between 3 am to 9 am. Usually it took few minutes of rest between its strolls around the enclosure. It was never found pacing the enclosure, indicating normal psychological state. It had established its own trail around the enclosure while moving and most of the movements were confined to that trail.

T1 was observed to be good at killing. It could kill the prey in first attempt. Mostly it was provided with wild boar. It was found to consume its kill over 2-3 days. Health of the animal was found to be good and it did not fall sick during its time in enclosure. Upon the arrival of T2 (tigress from Bandhavgarh TR), the urine of the female collected during translocation was sprayed around the enclosure wall of T1 to make him aware of the presence of a female tiger. Next morning, T1 was observed to inspect those spots where the urine was sprayed.

Table 1: Details of Prey released in the enclosure for T1.

T1	DATE & TIME OF RELEASE	DATE & TIME OF KILL	DATE & TIME OF FEEDING
1.	21.06.2018 (3:45 pm)	21.06.2018 (8:50 pm)	21.06.2018 (08:50 pm) 23.06.2018 (2:50 pm)
2.	23.06.2018 (6:15 pm)	24.06.2018 (12:27 pm)	24.06.2018 (01:00 am) 24.06.2018 (10:40 am) 25.06.2018 (01:18 am)
3.	28.06.2018 (2:15 pm)	28.06.2018 (7:44 pm)	28.06.2018 (07:44 pm) 01.07.2018 (07:11 pm)
4.	04.07.2018 (08:10 am)	-	05.07.2018 (08:19 am)

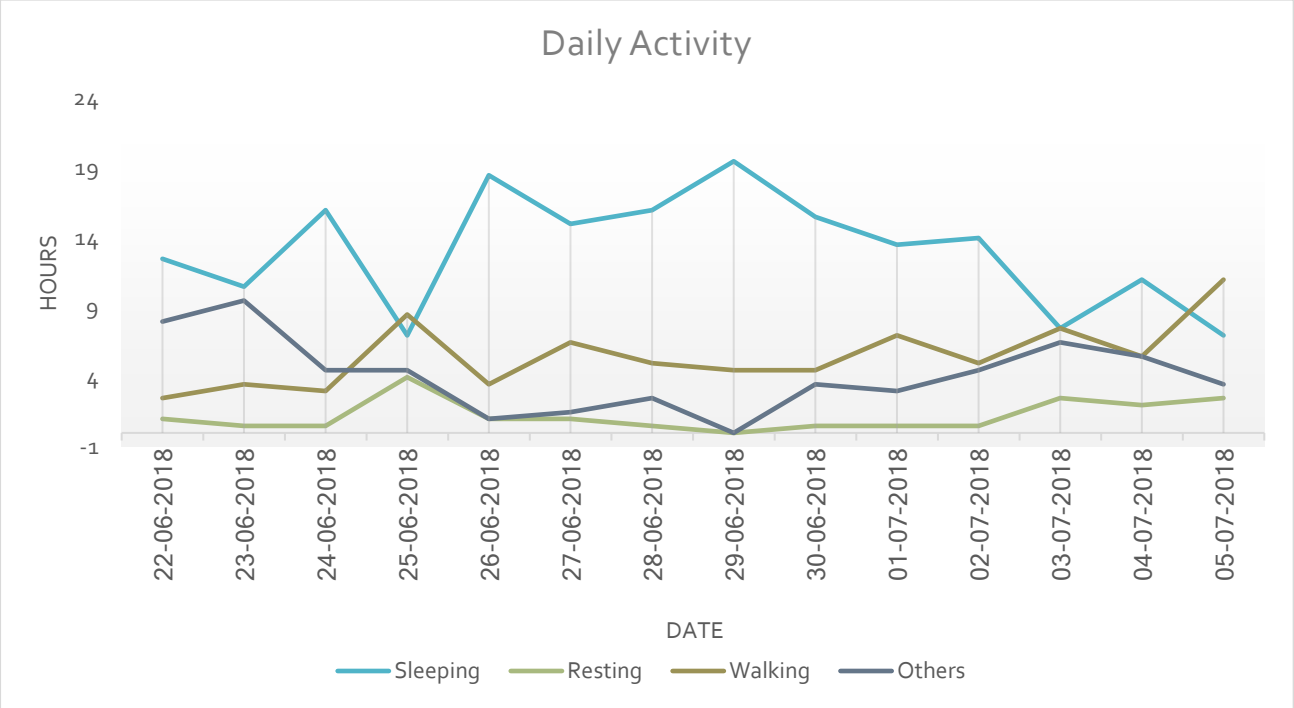

Figure 1: Daily activity of T1 in the enclosure

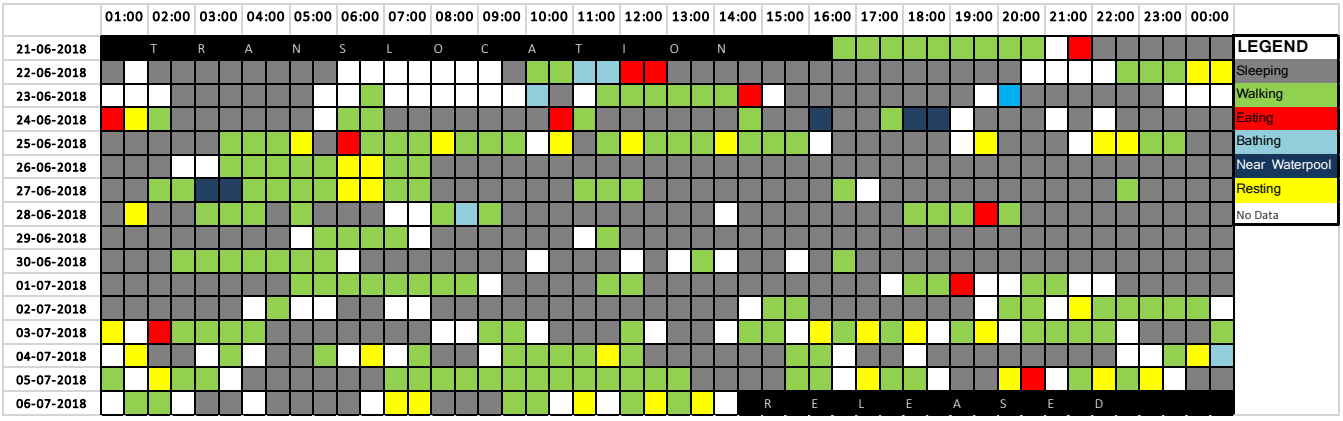

Figure 2: Activity of T1 in enclosure on half hourly basis

T2 (BANDHAVGARH FEMALE)

T2 was found to have a different behavior pattern than that of T1. But like T1 it spent more time sleeping and resting, followed by moving and roaming around the enclosure. Good amount of time was spent in water-bathing, resting and sitting beside water hole. During its initial days in the enclosure, it even claimed the tree 2-3 times, spent some time sitting there and came down. At times, it rolled sideways on the ground while relaxing. During rains it most often used the shed than using the tree as shelter.

It took her several attempts to kill the prey and mostly appeared playful hunting strategy. In the beginning, even the goat could intimidate her. As the time passed by, it could kill the wild boar as well. Whenever two wild boar were provided it would kill both on the same day. After killing the first prey it used to hold it in its mouth for few minutes, before taking it to a secure place, mostly the bushes, for hiding. At times it even played with the prey after killing it. The next step would be to find the second prey and kill it. It was quite noticeable that after killing the prey it would take it to the water hole and then eat it. Sometimes it would inspect the prey chamber and even sit near the gates.

Table 2: Details for Prey released in the enclosure for T2.

	Prey Release Date and Time	**Kill Date and Time**	**Feeding Date and Time**
1.	**29.06.2018 (**05:58 pm**)** (One Wild Boar)	**30.06.2018 (**12:33 pm**)**	**30.06.2018 (**02:24 pm; 08:08 pm**)**
2.	**03.07.2018 (**9:00 am**)** (Two wild boars)	**03.07.2018 (**04:47 pm**)** **09.07.2018 (**10:25 am**)**	**03.07.2018 (**05:14 pm**;** 11:00 pm**)** **04.07.2018 (**3:50 pm**;** 4:00 pm**)** **05.07.2018 (**05:56 am**;** 12:45 pm**)** **09.07.2018 (**10:45 am**;** 07:10 pm**)** **10.07.2018 (**01:30 pm**;** 07:04 pm**)** **11.07.2018 (**05:35 am**;** 03:24 pm**;** 07:03 pm) **12.07.2018 (**02:30 pm**)**
3.	**17.07.2018 (**04:12 pm) (One wild boar)	**17.07.2018 (**04:26 pm)	**17.07.2018 (**07:30 pm**)** **18.07.2018 (**10:35 am**;** 10:38 pm**)** **19.07.2018 (**03:10 pm**)**
4.	**22.07.2018** (Two wild boars)	**22.07.2018**	-
5.	**28.07.2018** (Two wild boars)	**28.07.2018**	-
6.	**06.08.2018** (One Wild Pig)	**06.08.2018**	-
7.	**11.08.2018** (One wild boar and one Chital)	**11.08.2018**	-

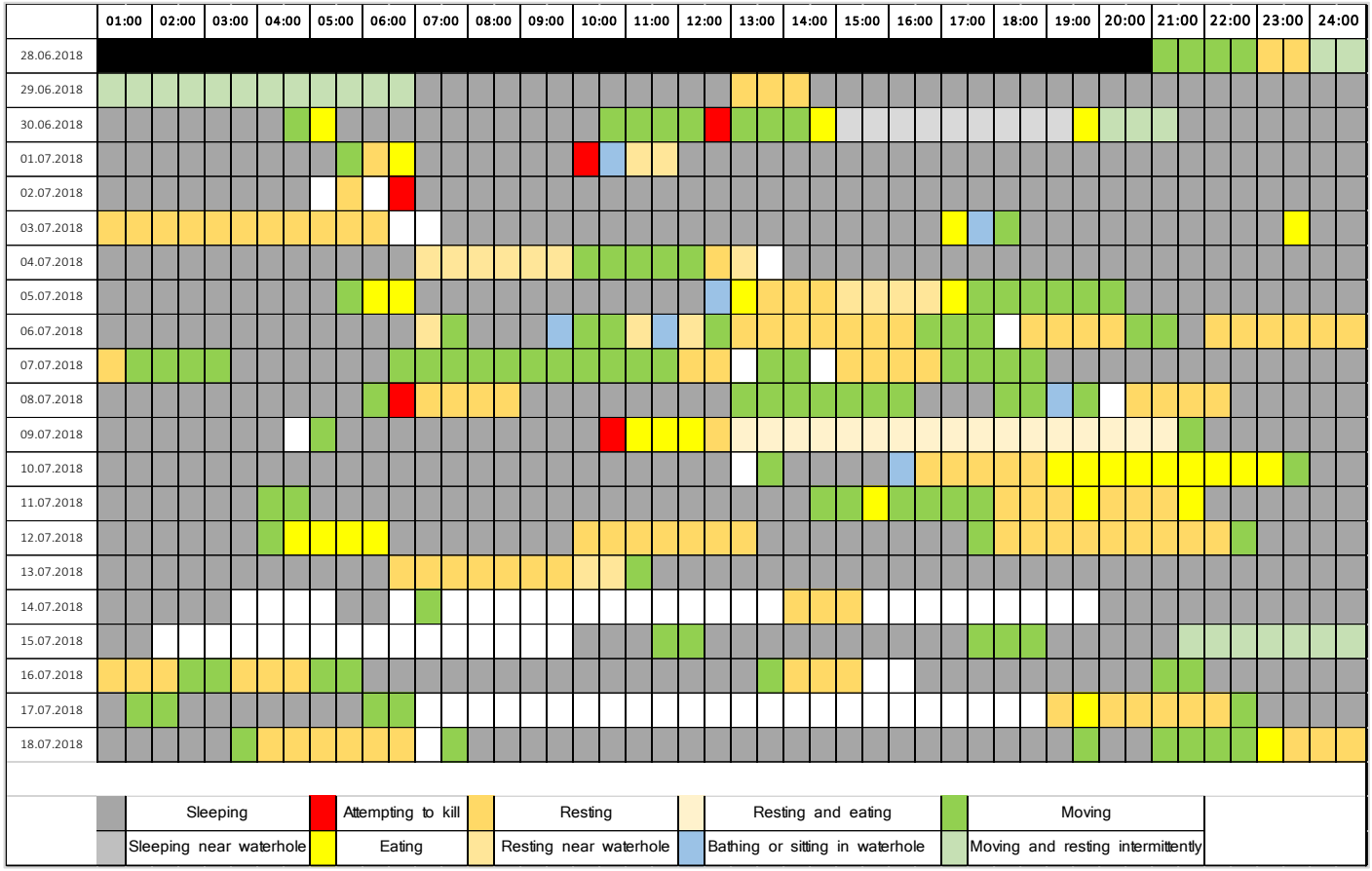

Figure 3: Daily activity of T2 inside the enclosure.

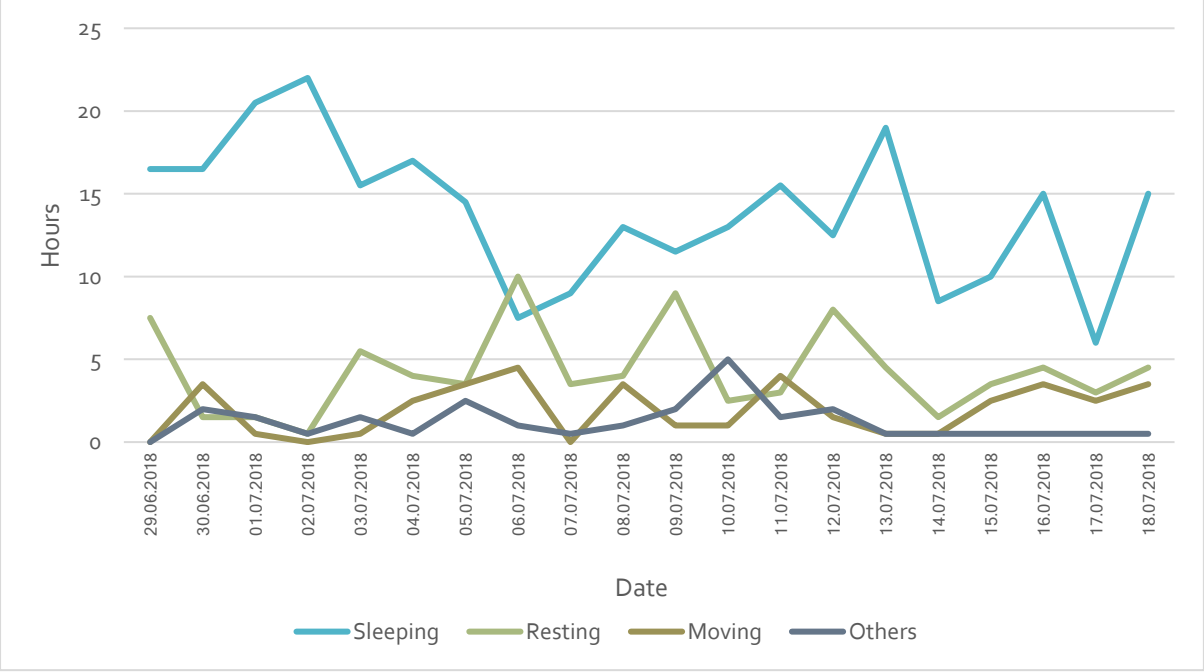

Figure 4: Major activities of T2 inside the enclosure.

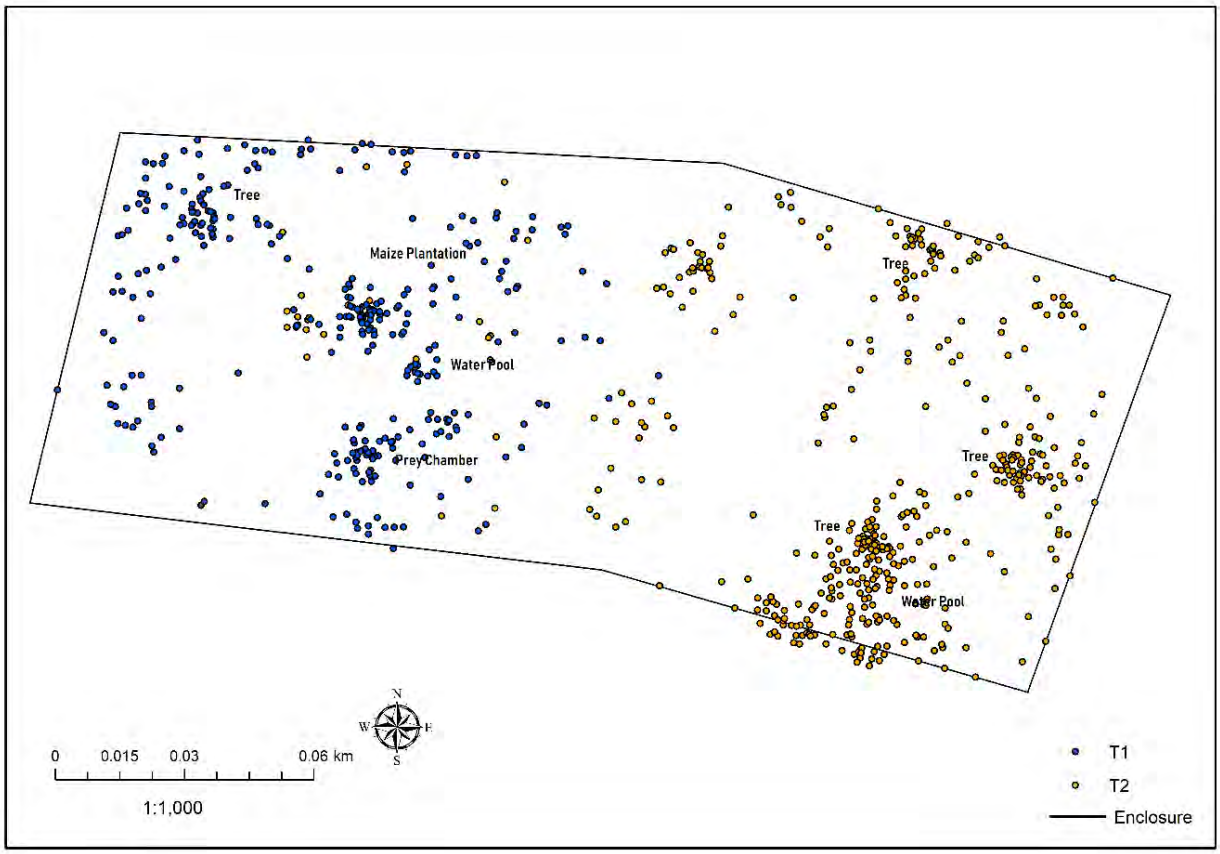

Figure 5: Movement of T1 and T2 inside the enclosure (approximate measurements). No. of locations=336 for T1 and 834 for T2.

RELEASE PROCESS

The translocated tigers were planned to be released in area with sufficient prey, and naturally low tiger densities (<1 tiger/100 km^2). Reduced tiger densities increase the likelihood for establishing a territory.

RELEASE OF T1 (KANHA MALE)

T1 was kept in enclosure for a period of 16 days (21 June-5 July) and considering the normal health of the translocated tiger T1 and its acclimatization to the climate of Satkosia, it was decided in a discussion between Mr. Anup Kumar Nayak (NTCA Member Secretary), Dr. Sandeep Tripathi (PCCF Wildlife), Dr. Sudarsan Panda (APCCF and Field Director, Satkosia Tiger Reserve), and Dr. K. Ramesh, (Scientist, Wildlife Institute of India) to release T1 into the wild on 6th July, 2018.

Before the release, camera traps and PIP were checked to be in proper place and the activity of the animal was being monitored through CCTV cameras. The enclosure gates were opened at 1:15 pm to allow tiger to escape. Mild disturbance was created to push the animal towards intended direction. The entire process took 52 minutes and tiger left the enclosure at 2:06 pm. The movement of the animal was quick and did not involve inspection of its surroundings. Without spending much time near the enclosure, it jumped over the trench and moved nearly 1 km south east. It stayed there for few hours before exploring its new habitat.

During the release, Shri Suresh Chandra Mahapatra (Additional Chief Secretary, Forest and Environment Department), Dr. Sandeep Tripathi, Dr. Sudarsan Panda, DFO Satkosia, DFO Angul, Veterinarians and Researchers from Wildlife Institute of India were present.

RELEASE OF T2 (BANDHAVGARH FEMALE)

T2 was kept in the enclosure for a period of 49 days (28 June to 16 August) in order to allow for the male to settle down and to acclimatize the animal for relatively more moisture environment. It was released into the wild on 17th August, 2018. Before the release PIP was prepared near the enclosure gate to capture pug impressions and camera traps were strategically placed to capture the detailed stripe patterns of the animal. The gates of the enclosure were opened around 2:50 pm and the tigress moved out of enclosure at 3:20 pm. It carefully inspected the perimeter of the enclosure before finally moving towards the south west of the enclosure.

During the release, Dr. Sandeep Tripathi, Dr. Sudarsan Panda, Dr. K. Ramesh, DFO Satkosia, DFO Angul, Veterinarians and Researchers from Wildlife Institute of India were present.

MOVEMENT PATTERN OF T1

In the month of July, it travelled 89.7 km and an average of 3.6 km per day. Minimum distance travelled was 500 m and maximum was 10.5 km in a day. In the month of August, total distance travelled was 159.53 km and an average of 5.5 km per day. Maximum distance per day for the month of August was observed to be 14.14 km and minimum was found to be 440 m. Days with less movement correspond to the feeding phase after kill. In such case, hourly movement was observed to be 10-50 m. Greater distances were covered during the exploration phase. Hourly movement for the month of July and August reveals that the animal was most active between 1500 and 2000 hrs. In all cases it avoided human habitation and human presence. Most of the time the movement was along the nullahs and became somewhat predictable after a month.

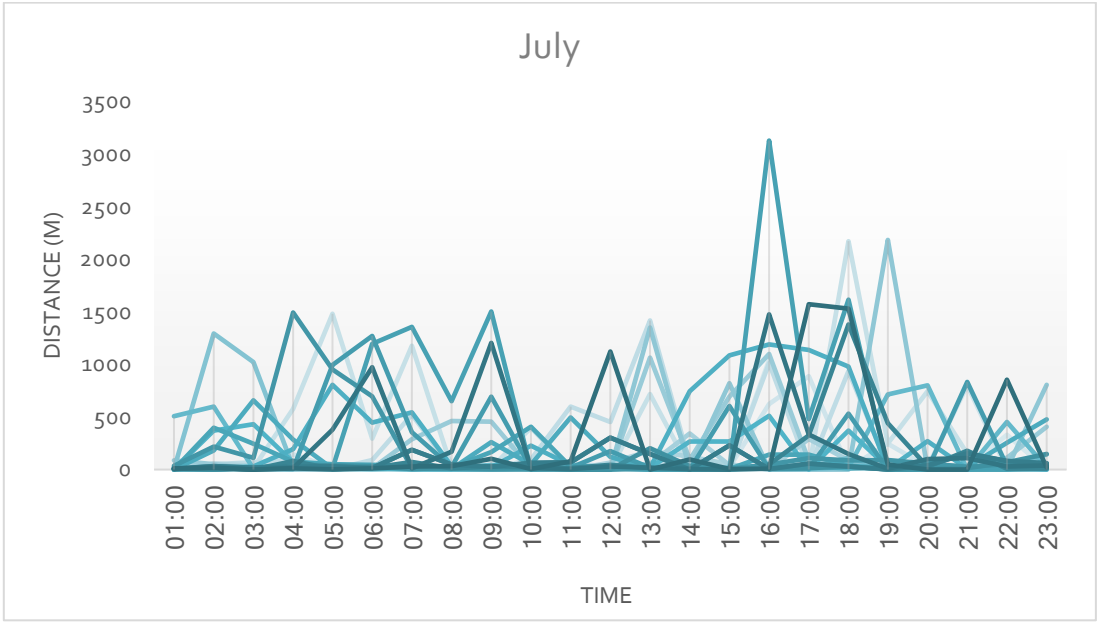

Figure 6: Hourly movement of T1 for the month of July.
The lines indicate different days (lighter to darker) from 6 July 2018 to 31 July, 2018.

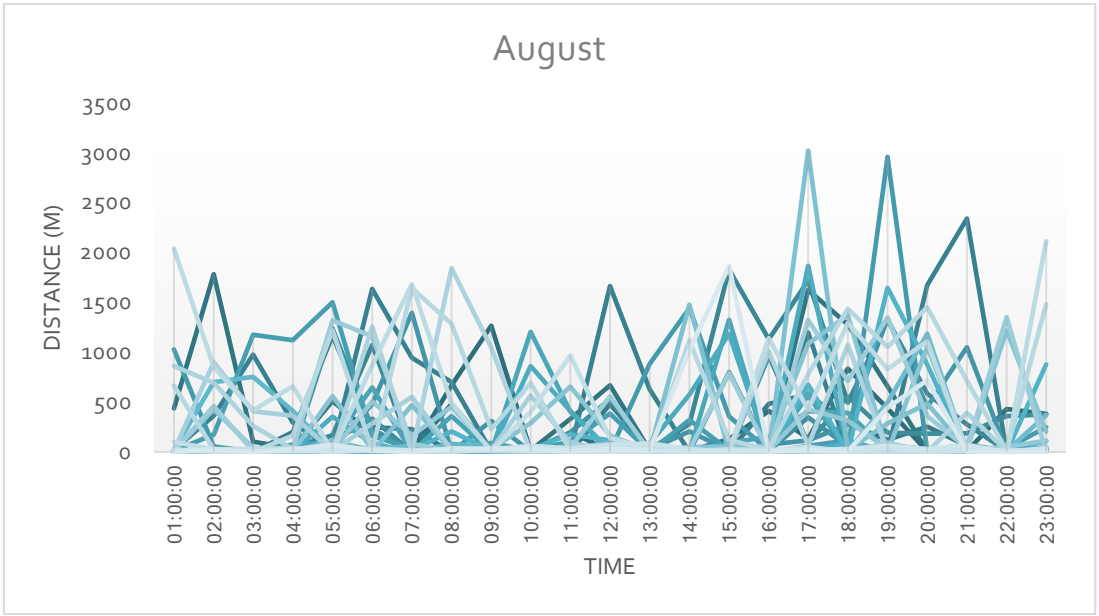

Figure 7: Hourly movement of T1 for the month of July.
The lines indicate different days (lighter to darker) from 1 August, 2018 to 29 August, 2018.

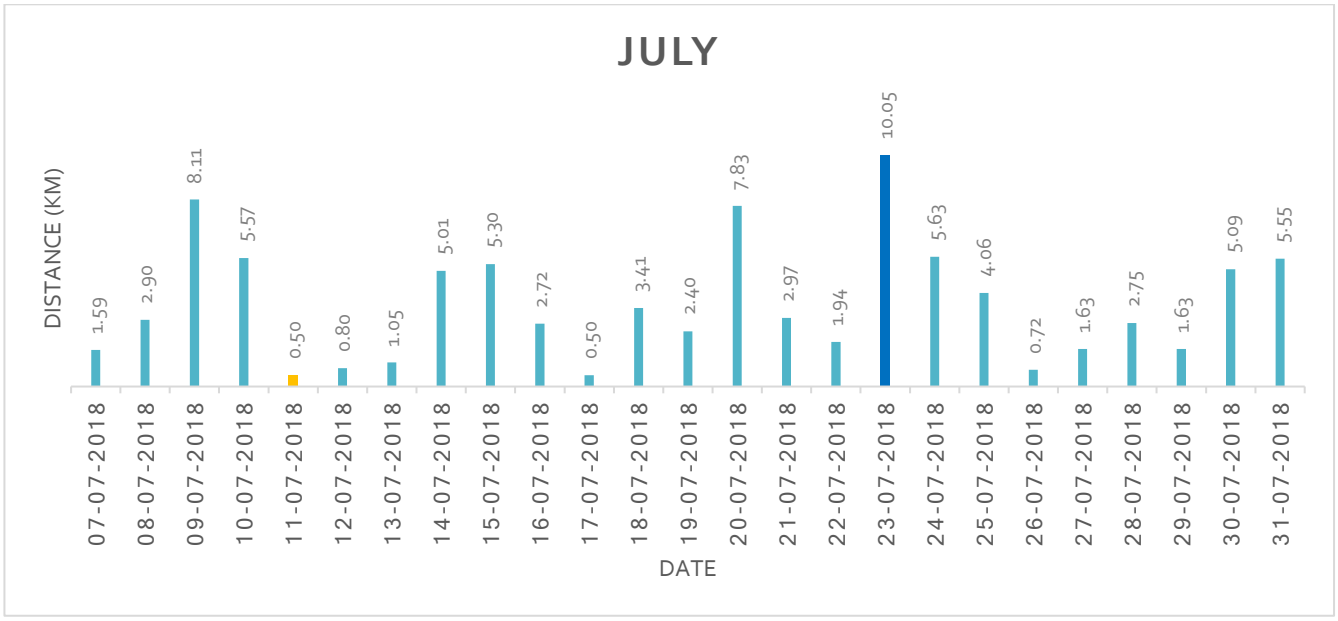

Figure 8: Total daily movement of T1 for the month of July.
Blue bar and orange bars indicate maximum and minimum distance travelled in a month.

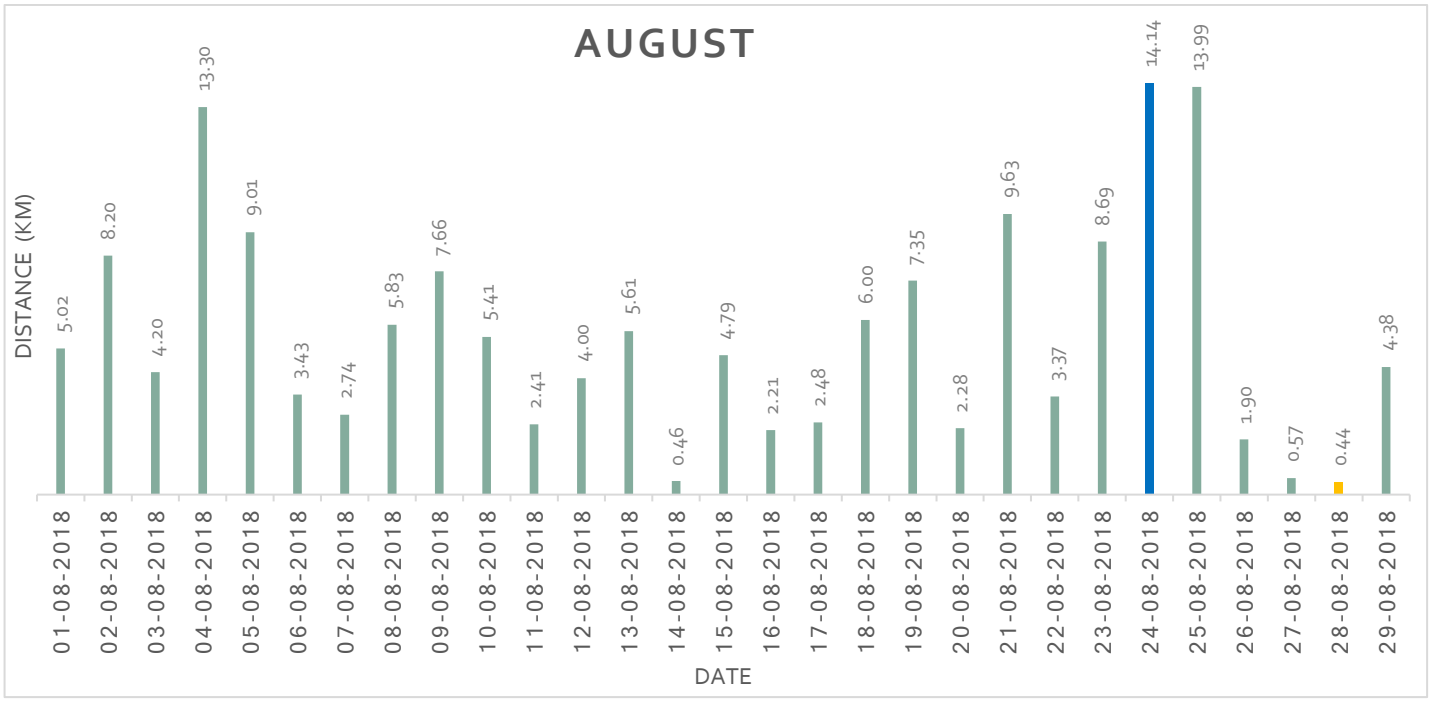

Figure 9: Total daily movement of T1 for the month of August.
Blue bar and orange bars indicate maximum and minimum distance travelled in a month.

Movement of T2

Between August 17 and 29, it travelled 81.6 km in total and an average of 6.8 km per day. Average distance covered per day is nearly double that of T1. Minimum distance travelled was 2.1 km and maximum was 10.2 km in a day, although rate of movement within a day was less for female as it was found to be stationed in a place for long period, even in the absence of kill. Overall movement was found to be linear as compared to T1. Initially, the movement was along the roads and trails, which was however not observed later on. Moving through roads and trails, it was thus quite frequent to come into areas of cultivation and outskirts of villages.

It can be observed that there is less movement between 1-3 am and 9-12 pm. Most of the movement is between 2 pm and 7 pm.

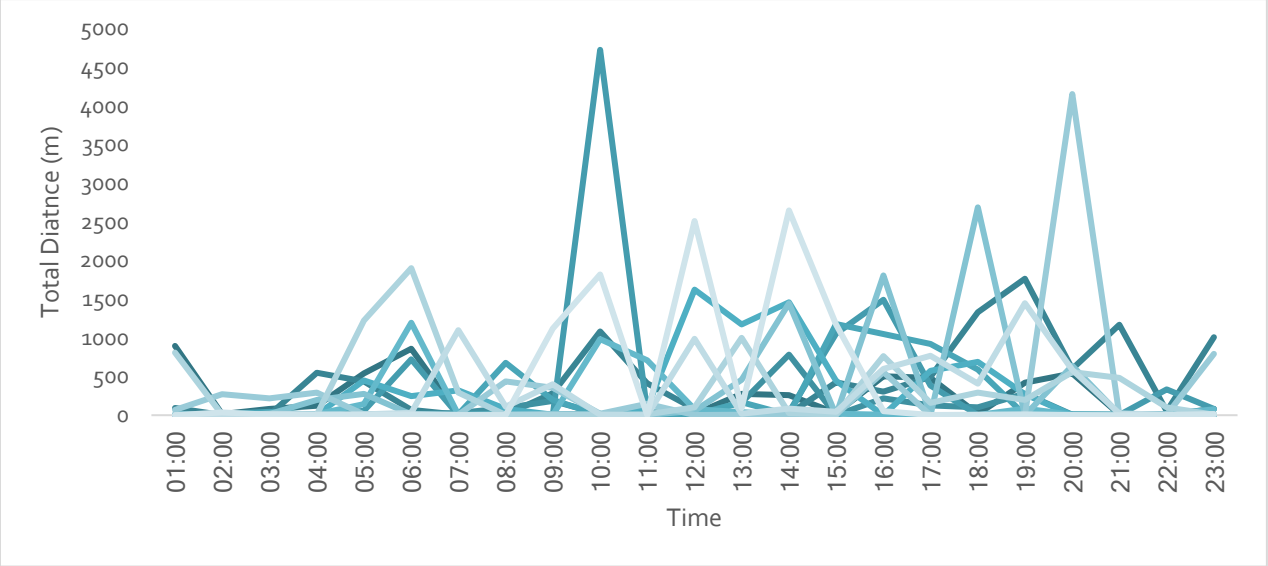

Figure 10: Hourly movement of T2 for the month of August

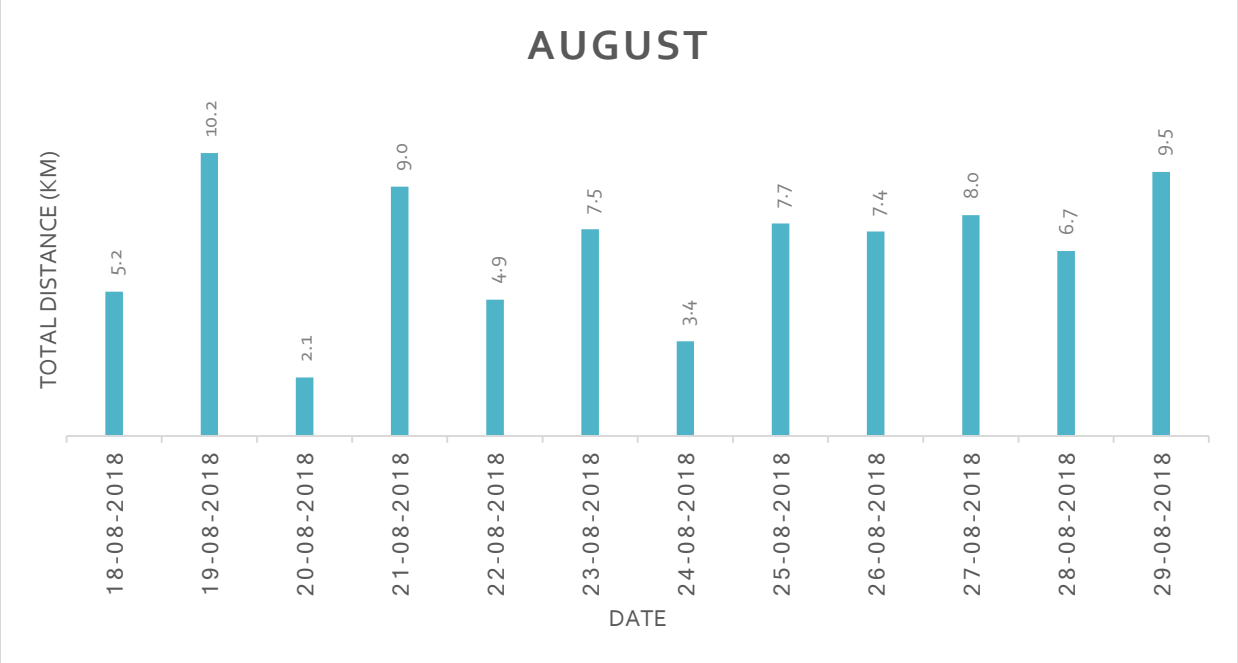

Figure 11: Daily movement of T2 for the month of August

HOME RANGE

For T1, the area explored each week was different, as it spent different amount of time in different areas, during exploration. For T1, at the end of 8 weeks after release, the total home range comes down to 116 km², while for T2, it is 177.94 km². It is to be noted that the T2 is still exploring and the estimate is biased by linear movement for longer distance. Actual home range of T1 and T2 would be estimated after T2 has settled down. However, it appears that T2 has met the resident female and this interaction may have pushed the animal far from release site, as there were photographic evidence of resident female inspecting the enclosure area.

T1		T2	
WEEK	AREA (km²)	WEEK	AREA (km²)
Week 1	12.84	Week 1	97.9
Week 2	5.6	Week 2	Current Week
Week 3	27.2		
Week 4	31.82		
Week 5	46.34		
Week 6	15.5		
Week 7	31.7		
Week 8	Current Week		
Week 1-8	**116.32**	**Week 1-2**	**177.94**

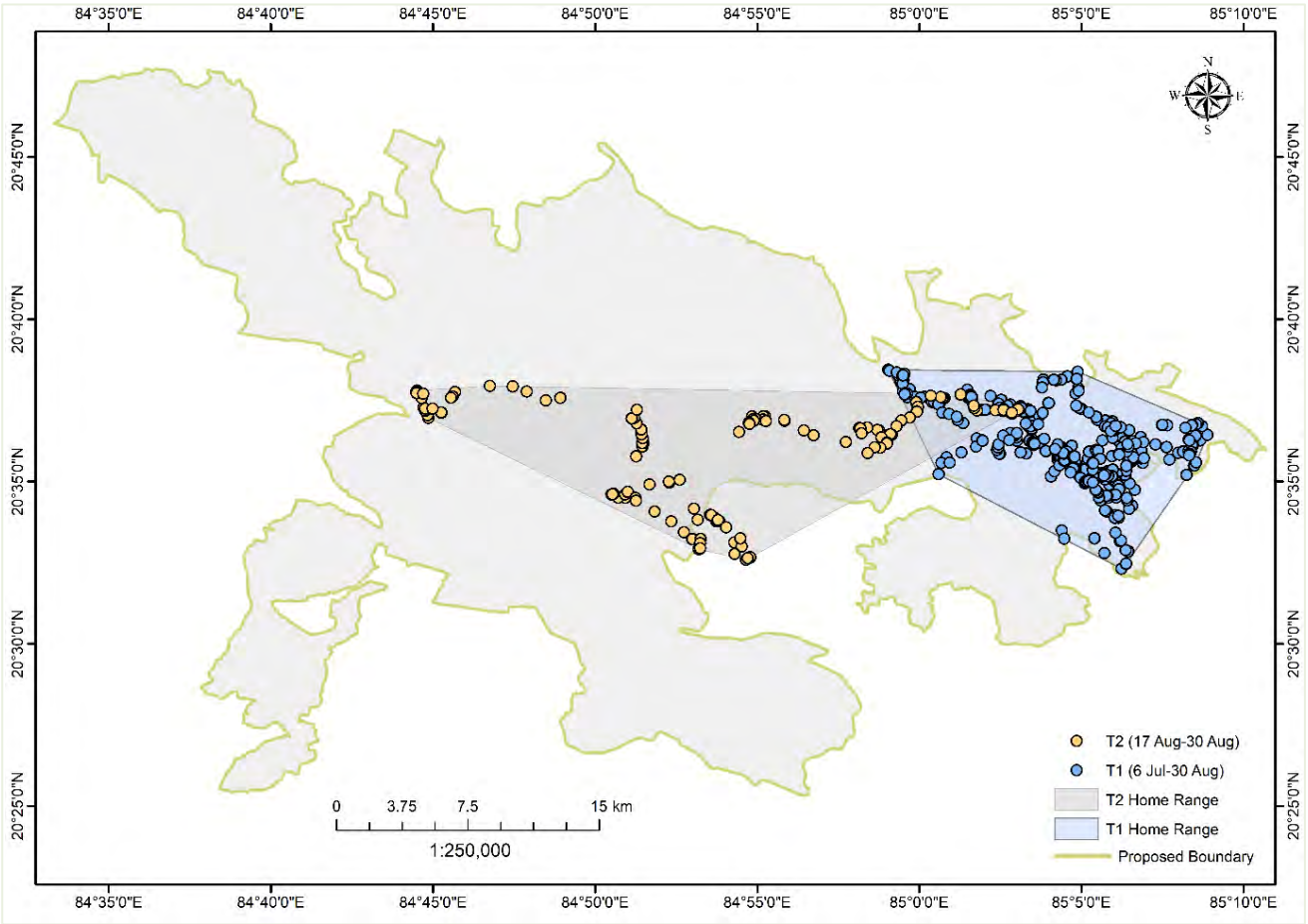

Figure 11: Home range and movement pattern of T1 and T2. Boundary indicates reorganized boundary of Satkosia Gorge Sanctuary (Proposed).

PREY KILL IN WILD

T1 since release, made one kill every week and preferred Wild boar and Sambar. It was found that it hid its kill using tree branches and dense ground vegetation. Feeding days ranged between 3 and 4.

S. No.	Date of Kill	Prey Species	Duration of Feeding
1.	11.07.2018	Sambar	4 days
2.	16.07.2018	Wild Boar	3 days
3.	25.07.2018	Sambar	4 days
4.	06.08.2018	Wild Boar	3 days
5.	16.08.2018	-	2 days
6.	26.08.2018	Sambar	4 days

Since release T2 killed a small goat and a calf on the forest and agriculture interface area.

S. NO.	Date of Kill	Prey Species	Duration of Feeding
1.	23.08.2018	Domestic Goat	2 days
2.	29.08.2018	Domestic Calf	2 days

RISKS AND OPPORTUNITIES

RISKS

- Translocation of T1 and T2 was the first inter-state translocation of tigers, wherein Tigers from Central Indian Landscape have been brought to Eastern Ghats. Although climate, vegetation cover and prey base are good for tiger habitat, there was a risk of translocated tigers taking more time to adapt to a completely different landscape and accordingly change their hunting habits and behavior.

- Satkosia Tiger Reserve faced a decline in tiger population due to killing and poaching activities, mostly of prey species. Electrocution also occurs sporadically. Same risk could still be existing for the newly translocated tigers.

- A number of villages exist inside the TR which are dependent on forest resources. This poses a risk both for the tigers and the villagers. Human animal conflict could be a hurdle in the relocation of tigers.

- Return of the translocated animals to their original home ranges (e.g., homing). Such behavior is not uncommon in cats but the sub-adult tigers and adult transients tend to overcome such strong homing instincts.

- Increased risk of disease transmission due to interspersion of villages and livestock.

- Potential confrontations with local dominant animals is another risk. But in this case, there was strong evidence for presence of one tigress in Satkosia TR. Interaction of the tigress with the translocated would be favorable to the overall program.

OPPORTUNITIES

- The translocation program provides an excellent opportunity to save the gene pool of the tiger in Satkosia Tiger Reserve. This would result in an increase in the tiger population, where it had declined to one or two individuals.

- Introducing the top predators can bring stability in the food chain of forest ecosystem.

- Introduction of newer individuals will also invite dedicated efforts aimed at improving habitat quality, security and protection from illegal activities, benefitting the entire flora and fauna of the forest and more activity and enthusiasm in the ground staff and forest officials.

- It presents a good chance to create awareness among local community regarding Tiger Conservation and Wildlife in general.

- It will give an insight into reasons that lead to the decline of tiger population in the first place.

FUTURE DIRECTIONS

- As outline in the Detailed Project Document, efforts are required to augment wild prey through active habitat management and translocation from other areas where possible. Chital and Wild Pig are recovering rapidly but support may be required for recovery of Sambar. We can consider first assessing the habitat quality in terms of forage dynamics and nutrient values, and habitat manipulation activities may be considered. This can be carried out as a part of the ongoing project without additional cost. However, resource needs to be mobilized for prey augmentation as it would involve disease screening.
- Because, SKTR is interspersed with villages and the tigers are likely to pose challenges to livelihood activities of local people, focused efforts on **Community Engagement and Eco-Development Programme**. This will negate the negative response of the people and to prevent accidental death of tiger and other wildlife to electrocution and other preventive measures by the local communities. Satkosia Tiger Foundation should be strengthened and staffed for various activities towards this end, and a separate budget should be sought either from central government or state CAMPA for this activity. A dedicated project with national and/or international funding may also be explored. It appears that much of the success in the recovery program relates to the way people are engaged towards mobilizing positive response and habitat management. We may have to undertake Micro Plan exercise in all the villages that may come under the proposed Biosphere Reserve area as these people directly and indirectly interact with the wildlife species and habitat.
- Post-release monitoring is primarily being done by ground tracking and satellite data transmission. There is still a need for strengthening the tracking team with trained Veterinarians. Although one Veterinarian has been posted, he requires practical experience of dealing with wild animals and support should be sought from Nandankanan Zoological Park, and the **Special Veterinary Unit** should be totally equipped with all necessary tranquilizing drugs, tranquilizing equipment, medicines and transportation facility to deal with emergency and regular situations. This should also include **Captive Elephants** that can be used in wild elephant habitats and support may be sought from other States where captive elephants are used in wild elephant habitats.
- Further translocation of tiger would be effective if we manage to keep the above requirements in place and meanwhile, it would be helpful to gauge the ground situations in terms of the animal behavior, people response and operational preparedness/effectiveness. It is also important to **Re-design the Camera Trapping Strategy** – one focused on the home range of T1 and resident female, and other on the entire area, so that we can take informed decision if we need to respond to crisis situation and to predict breeding outcome in the reintroduced tiger population.
- The terrain complexity and other support mechanism including political will and administrative support certainly enable the conducive atmosphere to make this project another successful model. If the loose ends are tightened and the gaps are addressed, it is certain that Satkosia Tiger Reserve would establish itself among the best in the country.

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STATUS OF TIGER AND PREY SPECIES

IN PANNA TIGER RESERVE, MADHYA PRADESH

CAPTURE-RECAPTURE AND DISTANCE SAMPLING ESTIMATES

TECHNICAL REPORT

[A component of ongoing WII-MPFD collaborative project and inputs in Phase IV of All India Tiger Population Monitoring Programme]

WILDLIFE INSTITUTE OF INDIA
PANNA TIGER RESERVE, MADHYA PRADESH
FOREST DEPARTMENT

SUBMITTED TO
NATIONAL TIGER CONSERVATION AUTHORITY,
NEW DELHI

DECEMBER 2013

भारतीय वन्यजीव संस्थान
Wildlife Institute of India

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06-09

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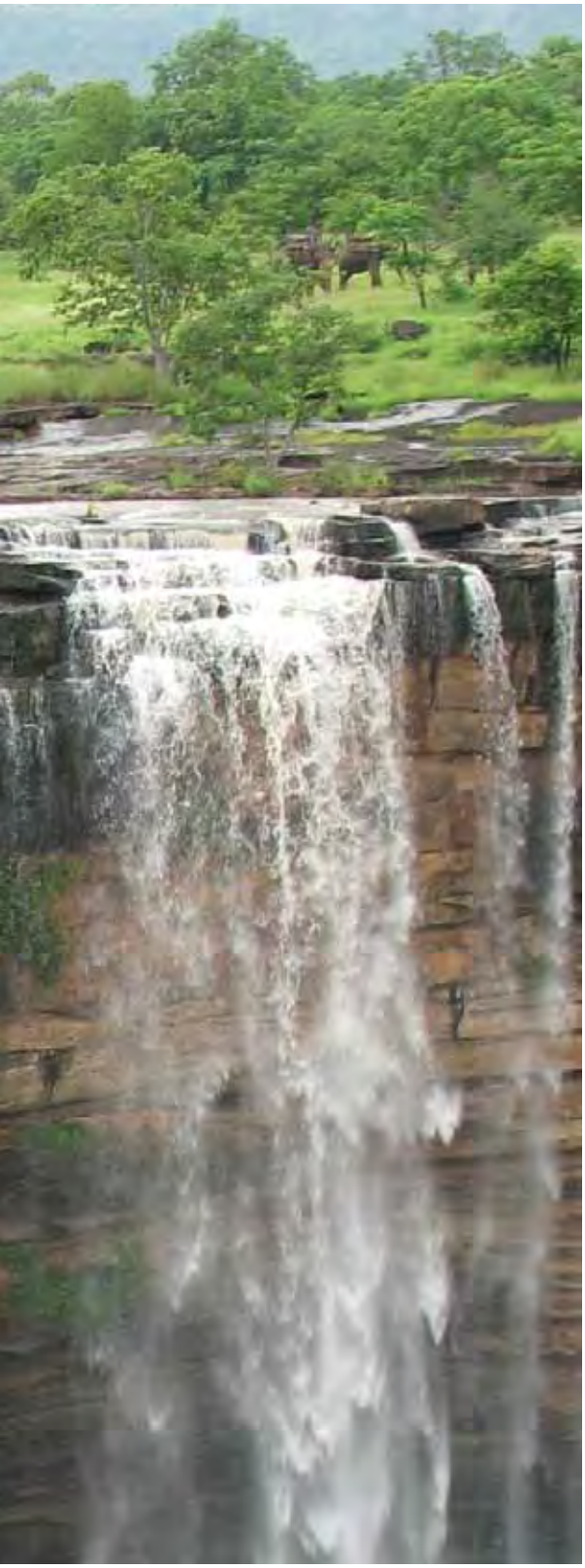
01
INTRODUCTION



1.1 Landscape Characteristics

Panna Tiger Reserve (PTR), with core area of 576 km2 and about 1002 km2 of buffer area, in north-central Madhya Pradesh (Figure 1) is located on the Vindhyan Range within the Biogeographic Province 6A Deccan Peninsula - Central Highlands (Rodgers et al. 2002). The habitat of PTR is configured by a step-like topography consisting of upper Talgaon plateau (Panna Range), middle Hinauta plateau (Hinauta Range) and lower Ken river valley (Madla and Chandranagar Ranges), separated by steep and rocky escarpments of varying height upto ca. 80m. The Ken river which cuts through the Reserve from south to north and eventually join the Yamuna in Uttar Pradesh, adds exceptional ecological and aesthetical values to the landscape (Figure 1). It is clearly an important lifeline for the Reserve's biodiversity and scores of human population surrounding the river. The geographical area of PTR falls in Panna, Chattarpur and Damoh districts of the state of Madhya Pradesh, and has contiguous forests on either side of the area, thus placing the Reserve in landscape context, particularly against the backdrop that home range of large carnivores extend to these forests (Chundawat et al. 1999). The forest type in PTR is characteristic of tropical dry deciduous element (Meher-Homji 1990), formed by a mosaic of woodlands and grasslands, and a riparian community along the water courses. The woodland is dominated by teak (Tectona grandis), teak-mixed forest and bamboo, miscellaneous type, and drier strata are dominated by Acacia-Zizyphus. As per Champion and Seth (1968), there are six forest types here; (1) Southern Tropical Dry Deciduous Teak Mixed Forest, (2) Northern Tropical Dry Deciduous Mixed Forest, (3) Dry Deciduous Scrub Forest, (4) Anogeissus pendula Forest, (5) Boswellia Forest, and (6) Dry Bamboo Brakes. Water is a limiting factor during summer season, due to which, distribution of most faunal species is skewed around sparse water sources and artificial waterholes provided by the reserve management. The PTR is almost free from human occupation, and most of 14 village enclaves have been transformed into successional grasslands. There are only three villages remaining in the core area which are also being relocated.

Figure 1:
Map of Panna Tiger Reserve

1.2 Faunal Attributes

PTR is among the important Protected Areas in the Central Indian Highlands complex, for its structural diversity and wide array of fauna, including 'the key species' Tiger. It is listed among the Regional Priority Tiger Conservation Landscape, which is defined as a low density habitat with moderate-high levels of threats (Sanderson et al. 2006). PTR also supports sizable population of Sloth Bear (*Melursus ursinus*). Other prominent carnivores are Leopard (*Panthera pardus*), Striped Hyena (*Hyaena hyaena*), Wild Dog (*Cuon alpinus*), Jungle Cat (*Felis chaus*) and Jackal (*Canis aureus*). The major ungulates that form prey for these carnivores are Sambar (*Cervus unicolor*), Chital (*Axis axis*), Nilgai (*Boselaphus tragocamelus*), Chinkara (*Gazella bennettii*), Four-Horned Antelope (*Tetraceros quadricornis*) and Wild Pig (*Sus scrofa*). The Hanuman langur (*Semnopithecus entellus*) is widespread, while Rhesus macaque (*Macaca mullata*) is found only along the forest peripheries closer to human habitations. There are over 150 birds species in PTR, and the important breeding birds include Marshall's Iora (*Aegithina nigrolutea*), White-bellied Minivet (*Pericrocotus erythropygius*), Long-billed Vulture (*Gyps indicus*) and Striated Grassbird (*Megalurus palustris*) (Jayapal et al. 2007), besides a variety of Galliformes including Peafowl (*Pavo cristatus*), Painted Spurfowl (*Galloperdix lunulata*) and Painted Francolin (*Francolinus pictus*). The area also supports over 10 species of

reptiles, and over 50 species of fishes including two globally threatened Mahseer species (Tor tor, Tor *putitora*), popularly known as 'King of Freshwater Fishes of India' (Johnson et al. 2012).

1.3 Chronicle of Tiger Status

PTR is known for its eventful conservation history for the last two decades. The area was initially recovered by village relocation program that allowed more space for tiger and other species to grow, and recently, tiger reintroduction program has facilitated recovery of tiger and the glory of the reserve. During formative years of PTR, tiger density was less than 3 tigers/100 km2 and appeared to have increased to 7 tigers/100 km2 during early 2000 (Karanth et al. 2004a). Tiger population in PTR was initially estimated based on pugmark technique, followed by camera trapping method introduced by the NTCA-WII All India Tiger Monitoring Project in 2006 when the tiger population showed drastic decline (Figure 2). The results from these estimates indicated a mean population size of 25 tiger in PTR during these years. As per the equation of Karanth et al. (2004b), carrying capacity analysis of expected number of tiger in PTR based on prey density availability concurred with the population estimate of 2001/02 i.e. 7 tigers/100 km2. Due to various reasons including poaching, the tiger population dwindled to almost none in the year 2009. In order to restore the population status, tiger population was reinforced initially with two female tigers from Bandhavgarh and Kanha Tiger Reserves during March 2009. However, once it became clear that there was no resident male in PTR and the population was functionally extinct (WII 2009/ Ramesh et al. 2009), a full-fledged reintroduction program was conceived and is being implemented with credible success (MPFD and WII 2009). Subsequently, a male was caught in Pench Tiger Reserve and released in PTR in November 2009. The initial population of three animals (one male and two females) was supplemented with two hand-reared and semi-wild females from Kanha Tiger Reserve (Ramesh et al. 2011).

These introduced animals have established in the new sites and three of the four females have yielded more than one litters in last four years. However, it is important to understand the status of tiger and associated species (such as leopard and prey species) in terms of distribution and population size so as to understand the trajectory of these species assemblage in the reserve, which is the essence of NTCA's All India Tiger Population Estimation and Monitoring Project. Also, given the known population size, the estimates obtained here would offer insights for methodological issues related to small populations. Therefore, although tiger number was known in PTR, Phase-IV activities of the larger project was implemented jointly by Wildlife Institute of India research team and PTR management.

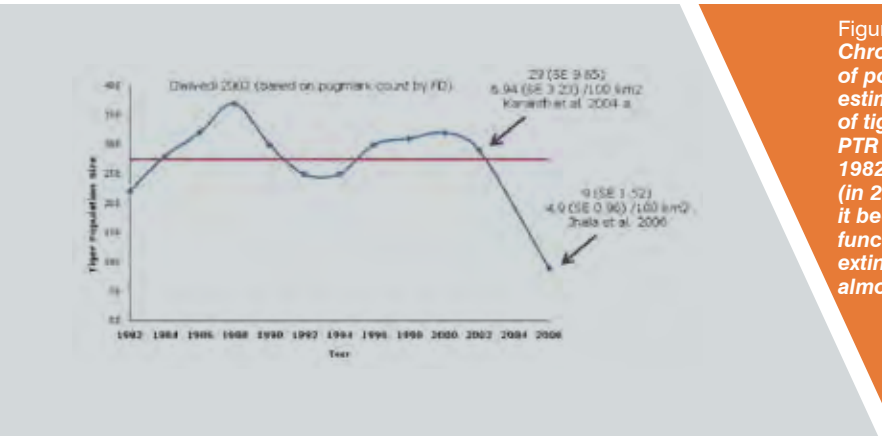


Figure 2: ***Chronology of population estimation of tiger in PTR during 1982 - 2006 (in 2008/09, it became functionally extinct with almost none)***

1.4 Objectives

The proposed report address the objectives of the Phase-IV of the NTCA project on monitoring tiger, co-predator and prey species, and is a part of the ongoing WII-MPFD collaborative project on 'Ecological Monitoring of Tiger in Panna Landscape, Madhya Pradesh'. The following were the specific objectives that are addressed in the present report:

(1) To obtain minimum number and density of large carnivores (tiger and leopard) based on photographic capture-recapture framework.

(2) To map occupancy of large carnivore (tiger, leopard and hyena) based on photographic capture rates.

(3) To estimate population density of prey species based on distance sampling procedure.

02
SAMPLING DESIGN AND METHODS

2.1 Photographic Capture-Recapture Sampling

Camera trap sampling design closely followed Karanth and Nicholas (2002) and was in line with the Phase IV protocol of All India Tiger Population Estimation and Monitoring Project (Jhala et al. 2011). The area has been gridded into 4 km2 area (2 * 2 km cell) and deployment of camera traps were done in three blocks during summer of 2012 and winter of 2012/2013, and in entire area during summer of 2013. During the block design, camera traps were deployed in 40 grids with 30 days of session for each block, accounting for 120 grids and 480 km2 area (Figure 3). Choice and location of camera trap deployment are critical element in the photographic capture-recapture design. Cuddeback Attack cameras with Cantered Detection Technology was consistently used in the block design and one-time sampling design, as it provided the best results with clear picture on centre of the frame, ideally suited for such purposes. The area has been surveyed since 2008 and the field team is fully familiar with the areas of tiger use and strategic places. Therefore, locations could be carefully identified and were geo-referenced using GPS and mapped using ArcGIS 10 software.

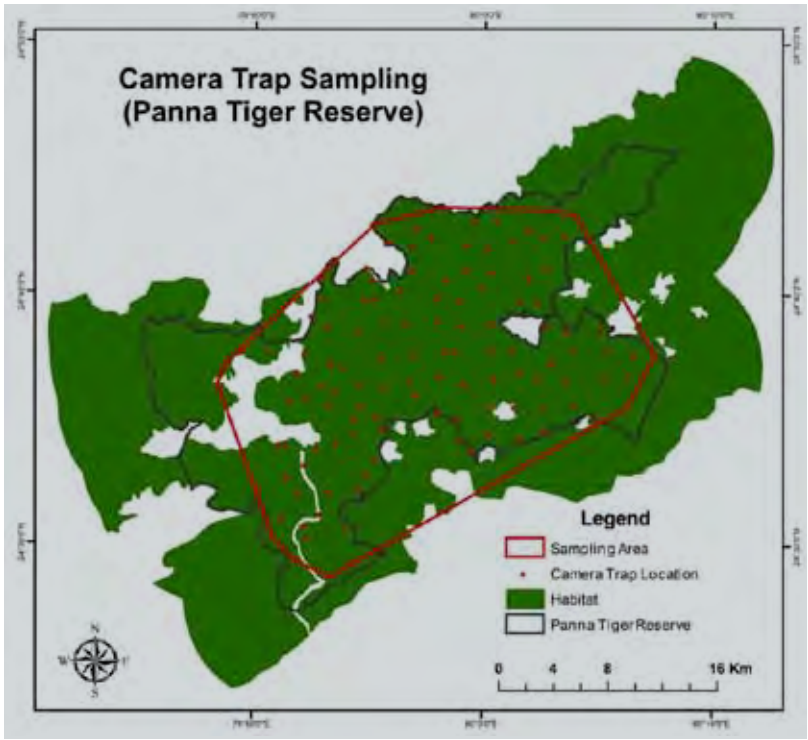


Figure 3: ***Camera trap locations and effective sample area with habitat mask***

In each of selected points, a pair of Cuddeback Attack camera traps (opposite side) were placed and monitored regularly. Placement of the camera traps was ensured such that the flashes do not affect the pictures captured by camera deployed on the opposite sideand clear pictures of both flanks of the tiger are obtained. A total of 3600 trap nights in summer 2012 and winter 2012/13, and 7200 trap nights in summer 2013 were sampled using 120 pairs of camera traps. Pictures were regularly downloaded in field using portable netbook and were catalogued in WII base camp at Hinauta. Subsequently, individual identification was done using standardized methods and creation of matrices were done based on both flanks of tiger and one side flank for leopard and hyena. The results for tiger has been presented for all the three time periods (summer 2012, winter 2012/13 & summer 2013), but for leopard and hyena, capture rates and population estimate for one season (summer 2012) has been given to provide an idea on the status of these co-predators.

Camera Trap Session	From	To	Occasion
Summer 2012			
BLOCK-1	04-04-2012	03-05-2012	30days
BLOCK-2	08-05-2012	07-05-2012	30 days
BLOCK-3	15-06-2012	14-07-2012	30days
Winter 2012/13			
BLOCK-1	02-12-2012	31-12-2012	30days
BLOCK-2	07-01-2013	05-02-2013	30days
BLOCK-3	09-02-2013	10-03-2013	30days
Summer 2013			
Total Coverage	27-04-2013	25-06-2013	60 days

Table 1: ***Details of camera trap sampling in three temporal periods***

2.2 Occupancy Pattern of Tiger, Leopard and Hyena

In order to ascertain the spatial distribution and occupancy of tiger and co-predators, the photographic capture and recapture rates were used. Summer 2012 data was converted into individual tiger captured for each grid and the frequency of occurrence i.e. total number of capture-recapture of the species for each grid was assigned. The information was converted into discrete values and mapped using ArcGIS 10. The result was expected to present the pattern in spatially explicit form, so as to provide inputs for management strategies .

2.3 Prey Density Estimation

Ungulates and other prey species were estimated using line transect surveys in conjunction with distance sampling methods. A total of 41 lines transects were laid across the PTR systematically along 4*4 grid cell. It was ensured that these transects covered all the different habitats of prey species. These line transects vary in length between 1.85 km and 2.1 km, suited for efficient sampling for prey species in such habitats. Counts were done following distance sampling protocol (Buckland et al. 2001) and was analysed using Distance Ver.5.0 software (Thomas et al. 2009). Each transect was walked in the morning between 6:00 am and 8:30 am and was repeated for minimum of three times in both summer and winter seasons. The count included visual encounter of prey species along with group (cluster) size, sighting distance and sighting angles for each observation. Also prey species were classified as adult male, adult female, juvenile, or unknown. Data was analysed for individual species and for administrative units i.e. Range Boundary.

03
RESULTS

3.1 Population Estimate of Tiger and Co-Predators

Camera trap data, converted into 'X matix', was subjected to Closure Test (Otis et al. 1978) in order to test for closure assumption. Results revealed that the dataset was amenable to closure assumption for all the sampling period [summer 2012, Z = 2.74441, p = 0.99697; winter 2012/13, Z = 2.85725, p = 0.99786 and summer 2013, Z = 0.10979, p = 0.54371]. In terms of capture history, 11 individual tigers were captured in summer of 2012 (3600 trap nights) and 2013 (7200 trap night), with total recaptures of 44 and 79 pictures, respectively. However, in winter 2012/13 (3600 trap nights), 13 tigers with total recapture of 113 pictures were obtained.

Table 2: ***Summary of population estimates for tiger during summers of 2012 and 2013, and winter of 2012/13***

Season	Model	Individual Tiger	Capture Probability	Population Size	Standard Error	95% CI
Summer 2012	Mh-Jacknife	11	0.12	12	2.93	12-29
	Mo-Null		0.13	11	0.45	11-11
Winter 2012/13	Mh-Jacknife	13	0.25	15	2.59	14-27
	Mo-Null		0.30	13	0.02	13-13
Summer 2013	Mh-Jacknife	11	0.12	11	1.00	11-11
	Mo-Null		0.12	11	0.07	11-11

Using Density software 4.46 ver., these estimates were translated into 1/2MMDM density of 1.42/100 km2 (SE 0.21) for summer 2012, while it was 1.16/100 km2 (SE 0.08) for winter 2012/13 and 1.14/100 km2 (SE 0.10) for summer 2013. Density estimate based on habitat masked Spatially Explicit Capture Recapture (SECR) model provided density estimates of 2.9/100 km2 (SE 0.99) for summer 2012, 1.54/100 km2 (SE 0.44) for winter 2012/13 and 1.59/100 km2 (SE 0.50) for summer 2013.

Other co-predators, leopard and hyena, were photo-captured in all the seasons, but the estimates could only be obtained for summer 2012. The estimate for summer 2012 yielded a minimum of 53 individual leopards and 102 hyenas, with total captures of 89 and 361 respectively, for these two animals. These records provided SECR based density of 12.2/100 km2 (SE 0.02) for leopard and 15.1/100 km2 (SE 0.02) for hyena.

Figure 4:
Space use pattern of tiger in PTR (Summer 2012 camera trap results)

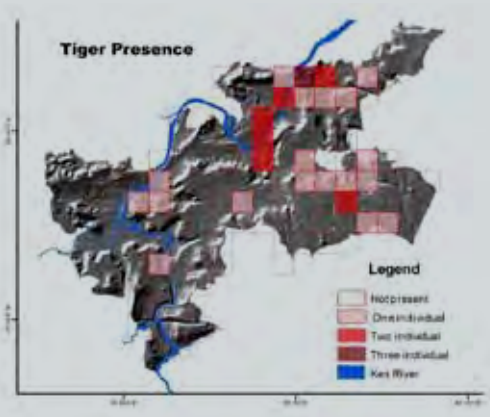


Figure 5:
Intensity of use by tiger in PTR (Summer 2012 camera trap results)

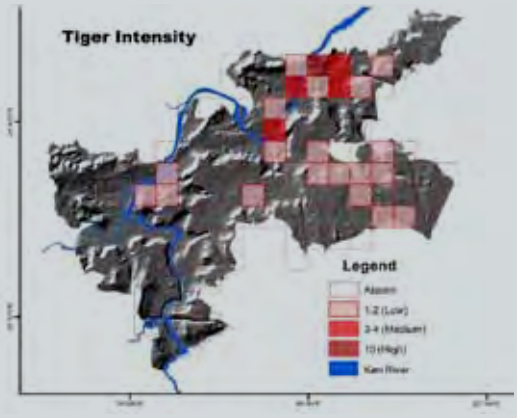
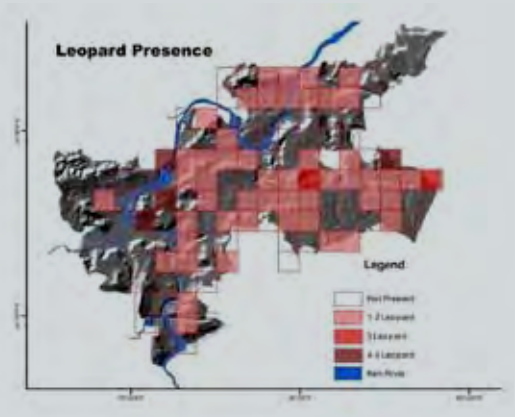


Figure 6:
Recent occupancy pattern of tigers (2012/13 telemetry results)

Figure 7:
Space use pattern of leopard in PTR (Sum. 2012 camera trap results)



3.2 Spatial Pattern of Tiger, Leopard and Hyena Occupancy

Space use of tiger appears to be restricted, but it is increasingly expanding through the available habitat in the area. It is evident from the camera trap results obtained in summer 2012 when the space use was skewed towards few areas (Figure 4 and 5), as compared to recent years when it has expanded to most of the available habitats (as discerned from radio-telemetry based home range mapping) (Figure 6). The increasing population is only likely to occupy remaining unoccupied habitats. Leopard and hyena range widely in PTR. Of the two species, hyena is more readily found however it exhibits intensive selection for certain areas (Figure 7 and 8).

Figure 8:
Space use pattern of hyena in PTR (Sum. 2012 camera trap results)

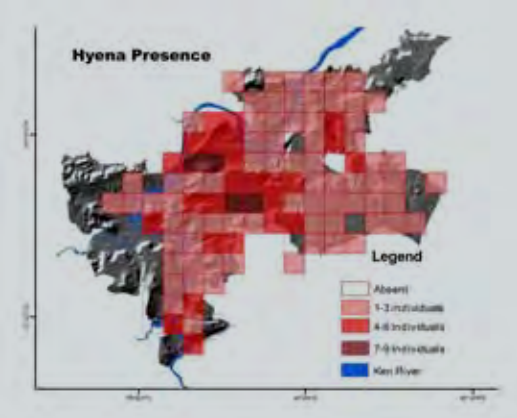


Table 3:
Population estimates for prey species in winter 2012/13 in PTR

Species	Count	Selected Model	Estimated Individual Density (N/Km²)	SE	Encounter Rate (N/Km)	CV %
Langur	41	Half normal cosine	14.4	3.0	0.3	12.4
Peafowl	28	Uniform cosine	8.2	2.4	0.4	23.9
Sambar	78	Hazard rate simple polynomial	8.7	2.2	0.5	17.7
Wild pig	18	Hazard rate cosine 5% right truncation	7.5	4.0	0.3	13.2
Chital	31	Negative exponential cosine 5% right truncation	5.0	1.8	0.4	20.5
Nilgai	72	Negative exponential cosine	9.5	1.9	0.4	12.6
Chinkara	11	Half normal simple polynomial*	4.2	1.2	0.2	18.0
Cattle	45	Hazard rate simple polynomial	118.8	62.7	0.5	22.1

Table 4:
Population estimates for prey species in summer 2013 in PTR

Species	Count	Selected Model	Estimated Individual Density (N/Km²)	SE	Encounter Rate (N/Km)	CV %
Langur	46	Half normal simple polynomial right truncation at 200m	23.2	4.5	0.5	12.3
Peafowl	40	Hazard rate cosine*	84.8	42.0	0.8	18.7
Sambar	50	Negative exponential cosine right truncation at 90m	16.0	4.6	0.5	16.8
Wild pig	17	Half normal simple polynomial	6.1	2.0	0.3	08.1
Chital	37	Uniform cosine right truncation at 50m	58.5	20.3	0.4	25.6
Nilgai	61	Negative exponential cosine right truncation at 127m	7.7	1.9	0.4	08.1
Chinkara	22	Negative exponential cosine right truncation at 53m	15.0	6.2	0.4	22.8
Cattle	21	Negative exponential cosine	60.1	21.2	0.3	14.0

Table 5:
Range wise population estimates for prey species in winter 2012/13

Species	Individual Density (Standard Error) in Ranges					
	Panna	Hinauta	Madla	Gaharighat	Chandranagar	Kishangarh
Sambar	10.9(8.1)	6.5(3.0)	1.4(0.6)	11.6(5.8)	0.5(0.4)	2.3(1.5)
Nilgai	2.1(1.2)	2.2(0.9)	4.2 (2.2)	8.9(6.3)	20.1(12.4)	6.6(2.4)
Chital	1.4(0.9)	1.7(1.3)	3.0(1.6)	5.7(8.37)	*	*
Chinkara	*	*	2.0(1.0)	*	*	*
Wild pig	4.8(3.7)	1.6(1.9)	1.6 (1.1)	*	*	0.7(0.6)
Langur	10.5(4.6)	7.1(7.8)	10.7(7.0)	10.6 (7.1)	12.2(6.1)	3.4(3.0)
Peafowl	4.6(3.1)	*	0.6(0.4)	1.6(1.9)	*	*
Cattle	40.3(74.4)	*	85.3(58.3)	23.3(16.2)	118.0(99.5)	10.0(5.4)

3.3 Prey Density

The prey species in PTR include sambar, chital, nilgai, wildpig, langur, peafowl, chinkara, chowsingha and domestic and feral cattle. However, density analysis could not be performed for chowsingha due to very low detections during the sampling periods. Table 3 and 4 provide density estimates for the prey species during winter 2012/13 and summer 2013, respectively. Based on the standard error(SE) for density estimates and coefficient of variation (CV) of encounter rate, the estimates for langur, peafowl, sambar, chital and chinkara were reliable during winter, while the estimates for wild pig, nilgai and cattle were reliable in summer, although these variations could also explain seasonal habitat choice for these species. Of the ungulate species, the abundance ranking follows sambar>nilgai>wildpig>chital, although cattle scores the highest density, but occur in restricted areas (as reflected from high SE and CV) (Table 3 & 4). Density estimates obtained for different administrative units (i.e. Ranges) suggest that four ranges (Panna, Hinauta, Madla and Gaharighat) have diverse prey species with reasonable abundance, while Chandranagar and Kishnagarh ranges are deprived of diversity and are dominated by nilgai (Table 5).

_ Estimates with relatively low SE

* Model did not fit very well, perhaps due to low number of observations

*Too few or no records during sampling to compute density estimates for these species in these ranges.

04
INFERENCES AND CONCLUSION

The status of tiger and related species in PTR should be seen in the context of population extinction and recovery of the species, following a full-fledged reinforcement and recovery programme for the species. It is pertinent to mention that PTR is also one of the few places in the country where monitoring of tiger and prey species are being carried out since 1995 by various people, and with tiger reintroduction project, a detailed monitoring using VHF/GPS telemetry is being done. Beginning with three animals (one male and two females) translocated from other wild populations in 2009, and two hand-reared and semi-wild females in 2011, the population has now grown to 22 animals. In all 10 animals have been collared of which nine are still being monitored based on radio-tracking. Therefore, in the context of Phase IV monitoring, PTR offers further insights, since, the population is known and therefore the population estimation procedures can be tested here. Nevertheless, establishing long-term monitoring is an important management activity and the results presented in this report would provide strong baseline for continuous monitoring.

Camera trap sampling captured 100% of the adult and sub-adult tiger in the populations in all seasons (note: the population is known), but there was variation in recapture rates, with higher in winter and lower in summer. This possibly relates to skewed distribution of the animal in summer months and the camera locations are static. Of the models, null model was selected in all the sampling period and Mh-Jacknife model had higher standard error and over estimated the population size. Null model selection is possible due to strict adherence to closure assumption and appropriate deployment of camera locations. Most studies choose Mh-Jacknife for the estimates and the results obtained here may provide specific insights as to whether or not the population size is over estimated. Density estimates based on 1/2MMDM provided tiger density of 1.14 to 1.42/100 km2, while Maximum Likelihood Spatial Explicit Capture and Recapture methods provided density of 1.54 to 2.9/100 km2. These estimates, if compared with home range of the tigers in Panna, appeared to yield lower estimate, except for one season when the density estimate was 2.9/100 km2. Further analysis on this aspect would provide definitive answers to the variations in the observation and interpretation. The co-predators, leopard and hyena, have high density in PTR, and this is again related to diversity of prey species and habitat condition suited for co-occurrence of all these species. This is also reflected by the space use pattern of leopard and hyena. Spatial occupancy of tiger suggests that space use increases progressively, showing tendency towards occupancy of unclaimed territories. Leopard and hyena are well distributed in the sampled area, indicating health of PTR in the larger contexts.

Prey population density in PTR is comparable with other similar habitats and the current estimate provide ca. 32 ungulates/km2, dominated by sambar, followed by nilgai, wildpig and chital. Cattle also constitute substantial biomass in the area. Although the estimate is slightly lower than the previous estimates obtained in PTR, it is within the confidence limit, so the prey density in PTR can be stated as stable.

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ANNEXURE I

PHOTOGRAPHIC ID OF TIGER IN WINTER 2012/2013

T1 (T1)

T1 (T1)

T2 (T2)

T3 (T3)

T2 (T2)

T3 (T3)

ANNEXURE I

PHOTOGRAPHIC ID OF TIGER IN WINTER 2012/2013

T4 (T4)

T4 (T4)

T5 (T5)

T6 (P111)

T5 (T5)

T6 (P111)

ANNEXURE I
PHOTOGRAPHIC ID OF TIGER IN WINTER 2012/2013

T7 (P112)

T7 (P112)

T8 (P212)

T9 (P213)

T8 (P212)

T9 (P213)

ANNEXURE I
PHOTOGRAPHIC ID OF TIGER IN WINTER 2012/2013

T10 (P411)

T10 (P411)

T11 (P412)

T12 (P212)

T11 (P412)

T13 (P222)

ANNEXURE II

SAMPLE PICTURE OF OTHER ANIMALS CAPTURED IN CAMERA TRAPS

Leopard (*Panthera pardus*)

Honey badger (*Mellivora capensis*)

Jungle Cat (*Felis chaus*)

Feral cat (*Felis catus*)

Porcupine (*Hystricomorph Hystricidae*)

Asiatic wildcat (*Felis silvestris orneta*)

ANNEXURE II

SAMPLE PICTURE OF OTHER ANIMALS CAPTURED IN CAMERA TRAPS

Striped Hyena (*Hyaena hyaena*)

Indian Jackel (*Canis aureus indicus*)

Indian Wolf (*Canis lupus pallipes***)**

Wild Dog (*Cuon alpines***)**

Indian Fox (*Vulpes bengalensis***)**

Sloth Bear (*Melursus ursinus***)**

ANNEXURE II
SAMPLE PICTURE OF OTHER ANIMALS CAPTURED IN CAMERA TRAPS

Wild boar (*Sus scrofa*)

Spotted Deer (*Axis axis*)

Four horned antelope (*Tetracerus quadricornis)*

Sambar (*Rusa unicolor***)**

Nilgai (*Boselaphus tragocamelus***)**

Chinkara (*Gazella bennettii)*

ANNEXURE II
SAMPLE PICTURE OF OTHER ANIMALS CAPTURED IN CAMERA TRAPS

Gray langur (*Semnopithecus entellus*)

Indian Peafowl (*Pavo cristatus*)

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