VISITATION PATTERN OF MAMMALIAN COMMUNITIES AT WATERHOLES IN TADOBA - ANDHARI TIGER RESERVE

Thesis submitted by

Yathumon M. A.

to

Saurashtra University

Rajkot - 360005 (Gujarat)

for the award of the degree of

Master of Science

in

Wildlife Science

Under the Supervision of

Dr. Parag Nigam

Dr. Bilal Habib & Dr. Gopi G. V.

भारतीय वन्यजीव संस्थान
Wildlife Institute of India

July, 2021

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DECLARATION

I, **Yathumon M. A.**, hereby declare that the research work entitled "**Visitation Pattern of Mammalian Communities at Waterholes in Tadoba-Andhari Tiger Reserve**", carried out in partial fulfilment of M.Sc. (Wildlife Science) degree of Saurashtra University, Rajkot is an original piece of research work. This research work was carried out under the supervision of Dr. Parag Nigam, Dr. Bilal Habib and Dr. Gopi G. V. at the Wildlife Institute of India from January 2021 to July 2021. I hereby declare that this work has not been submitted for any other degree of any university.

Date: 6th August, 2021
Place: Dehradun

Yathumon M. A.
XVII M.Sc. Wildlife Science

भारतीय वन्यजीव संस्थान
Wildlife Institute of India

CERTIFICATE

This is to certify that Mr. Yathumon M. A. has carried out original research titled "**Visitation Pattern of Mammalian Communities at Waterholes in Tadoba-Andhari Tiger Reserve**" in partial fulfilment of Master's Degree in Wildlife Science from Saurashtra University, Rajkot. This study was carried out under our supervision from January 2021-July 2021. We hereby certify that this work has not been submitted for any other degree to any other university.

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Place : Dehradun

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CERTIFICATE OF PLAGIARISM CHECK

It is certified that the MSc thesis titled "**Visitation Pattern of Mammalian Communities at Waterholes in Tadoba-Andhari Tiger Reserve**" submitted by Mr. Yathumon M. A. has been examined by us for plagiarism check as per UGC (Promotion of Academic Integrity and Prevention of Plagiarism in Higher Educational Institutions) Regulations. The following inferences are drawn from this check:

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Acknowledgment

I am thankful to many people for the help and support that I have received during the period of the study. I'm grateful to my parents and friends, especially Anna, Vinayan, Anoop, Joonu, Vignesh, Pranav and Sooraj who have found some time to call or message this shy to talk person. They have made me happy and feel strong during the fieldwork.

Extremely grateful to my supervisors for tolerating me and giving full background support as well as for visiting the field site, giving all the important instructions and reviews. I can't forget the experiences with them in the field.

- *Dr. Parag Nigam for adopting me as a student all of a sudden at the last moment; for giving the best advices in choosing topics, connecting with people and for personal advices.*
- *Dr. Bilal Habib for arranging all logistic and field supports, for giving the most practical suggestions for the work, for introducing to the amazing people of Mahadata lab.*
- *Dr. Gopi G. V. for the support in the fieldwork and the instructions and comments given in writing the thesis.*

Special Thanks to these people

- *Negiji for sorting all the documents and running for us, MSc students.*
- *My XVII MSc batchmates for regular reminders about the deadlines!*
- *Krishnan, Roshan, Prajakta and Akshay for accompanying me in the field and helping in the camera trapping and regular field visits.*
- *Dr. S. P. Goyal, Dr. Abhijit Das and Dr. Bivash Pandav for discussions and ideas given for the previous topics of dissertation.*
- *Dr. Jitendra Ramgaonkar, Shri Nandkishor Kale, Shri S. S. Bhagwat and other staff of Tadoba-Andhari Tiger Reserve for the field support.*
- *People in Moharli village for the happy faces and for accompanying in my occasional birding walks.*
- *Vijay, Tahir, Akash and Sweta for helping me in sorting the data.*
- *People in Mahadata lab for helping me with analysis, answering my silly doubts and giving me a space there.*

I express my gratitude to

- *Dr. Samrat Mondol (Course Director) and Dr. Navendu Page (Associate Course Director) for the help in the logistics and all instructions.*
- *The Director WII and The Dean WII for permitting me to carry out the research.*
- *Maharashtra Forest Department for granting me permission to work in the field.*

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Abstract

Waterholes are an important component of management practices in wildlife conservation, especially in arid and semi-arid regions. It is of high conservation and management significance as it is a spatially restricted resource for wildlife. I studied visitation pattern of mammals at 54 waterholes in the core zone of Tadoba - Andhari Tiger Reserve, a dry deciduous forest in the central India. Visitations of mammal species were monitored continuously for four months using camera traps. Visitation frequencies of mammals at the waterholes were checked and compared between winter and summer seasons. Influences of (i) physical attributes of waterholes, (ii) distance between the waterholes and adjacent permanent water sources, (iii) distance to nearest road and (iv) the presence of tourism in the nearest road, on the visitations of mammals at waterholes were studied. It was found that there are differences in the number of visitations, total time spent and the average time spent in a visitation between mammal species and between same species in different seasons. Size of waterholes and artificial water supplementation influenced the visitations of some mammals at waterholes. Overlaps in the temporal visitation patterns of the prey species with that of the predator species were different for ambush predators and pursuit predators.

1. Introduction

1.1.Background and Review of Literature

Water is one of the basic requirements for life. Life originated and succeeded in relation with water. Though some organisms have adapted for living in water scarce conditions, water is essential for all organisms. Wildlife in arid and semi-arid regions have both physiological and behavioural adaptations for survival with limited water. Behavioural adaptations include movement to favourable areas. In current scenario of fenced forests and high chances of negative interactions with increased human population, long distance movement of wildlife is restricted. Provision of resources in the areas where the animals have to be managed is a solution invented by people in 19th century. Construction of waterholes for wildlife is one major step in this. But this comes with costs of alterations in the behaviours of wildlife and the ecosystem and also economic costs. Hence the construction of waterholes has to be done carefully by studying the requirements of wildlife. This study is an attempt to document the relationship between use of waterholes by different wild mammals in the dry deciduous forests of Tadoba Andhari Tiger Reserve. .

Waterholes are a widely used management practice in arid and semi-arid landscapes for animals during water scarce period (Rosenstock *et al.* 1999). It started with the intention to keep the animals in specific area throughout the year for management purposes or hunting purposes (Parker & Witkowski 1999, Smit & Grant 2009).

Uses of waterholes can vary for different species. Other than the general use for drinking, species like wild pig (*Sus scrofa*) use these extensively for wallowing (Gray *et al.* 2019, Watter *et al.* 2020) while sambar (*Rusa unicolor*) use them during rutting and tigers (*Panthera tigris*) during summer months for cooling. Physical attributes of the waterholes including the size, shape, depth, etc. might influence the visitation of mammals in the waterholes. The predator activity and waterhole use have been reported to influence the activity of prey species and affects the choice of waterhole to be used by them (Valeix *et al.* 2009, 2010, Sutherland *et al.* 2018). In other words, the presence of predator species is one of the factors that influence visitation of other animals to waterhole. Animals are also known to change their behaviours in response to tourism activity (Kamanda *et al.* 2008). Besides these variables, the use of waterholes by wildlife are also governed by their distance from roads in tourism area. Spatial separation of mammal groups have been recorded between natural water sources and artificial waterholes, where they are present in same landscape (Epaphras *et al.* 2008, Smit & Grant 2009). The influence of the distance of the artificial waterhole from permanent water sources affects the visitation of specific groups of mammals.

Studies on use of waterholes by mammalian communities are limited from India. Most of the works from India take waterholes as one of the places of animal assemblages, so that their behaviours, interactions, population etc. can be studied from a small area. Waterholes are used for tourism purposes in various protected areas in India because the wildlife sightings will be high around these areas (Udaya Sekhar 2003).

This study considers visitation pattern of mammalian communities at waterholes with respect to their physical attributes, water supplementation, tourism and the location.

1.2. Objectives and Questions

1. ***To determine the visitation pattern of mammals at waterholes***
    1.1. What are the visitation frequencies of different mammalian species at waterholes?
    1.2. Is there a change in visitation pattern between seasons?
2. ***To assess the effects of waterhole attributes, presence of natural waterholes and tourism on the visitation frequencies of mammalian communities.***
    2.1. Do the physical attributes of artificial waterholes influence the visitation of mammalian communities?
    2.2. Does the tourism affect visitation pattern of mammalian communities at waterholes?
3. ***To study the visitation pattern of prey species at waterholes with respect to predator activity***.
    3.1. Does the activity of top predators around waterholes influence the visitation frequency of prey species and subordinate predators in the waterholes?

2. Study Area

Tadoba- Andhari Tiger reserve (TATR; 19.993° to 20.499° N and 79.193° to 79.678° E) is a southern tropical dry deciduous forest in the Central Indian landscape (Champion & Seth 1968). TATR it is situated in the civil district of Chandrapur in Eastern Vidarbha Landscape of Maharashtra state in India. Total area of the Tiger reserve is 1727 km^2 with a core area of 625.4 km^2. This core area comprising of Tadoba National Park (116.55 km^2) and Andhari Wildlife Sanctuary (508.85 km^2) was established as Tadoba-Andhari Tiger Reserve in 1994 (Figure 1). Forest composition includes bamboo dominated forests, miscellaneous dry deciduous forests with *Terminalia elliptica, Madhuca longifolia, Sterculia urens, Diospyros melanoxylon, Tectona grandis, Schleichera oleosa, Mangifera indica*, etc.

Two perennial rivers in TATR are Andhari and Erai. Erain river gives raise to one of the major water sources in the park Erai reservoir, which is outside the core area. Tadoba, Jamni, Moharli and Navegaon lakes are the big perennial waterbodies inside the core. Vasant Bandara, Bhanushkindi, Khatoda, etc. are the small streams running through the core area (Habib et al. 2019). But they dry up during summer leaving some pools in between.

The area has three major seasons in a year – winter, summer and monsoon from October to March, April – May and June – September respectively. Temperature in summer goes as high as 47°C during the peak and in winter it goes down till 12°C (Habib et al. 2019).

Study area receives an annual rainfall of 1245mm (Climate-Data.org 2020). Since most of the natural water sources available for wildlife are ephemeral, waterholes are made and managed by forest department to ensure year-round availability of water for wildlife in the area (Management Plan, TATR). The core area consists of 5 forest ranges with 86 waterholes in them. This study was carried out in the three forest ranges in the core – Moharli, Tadoba and Kolara and covered a total of 60 waterholes.

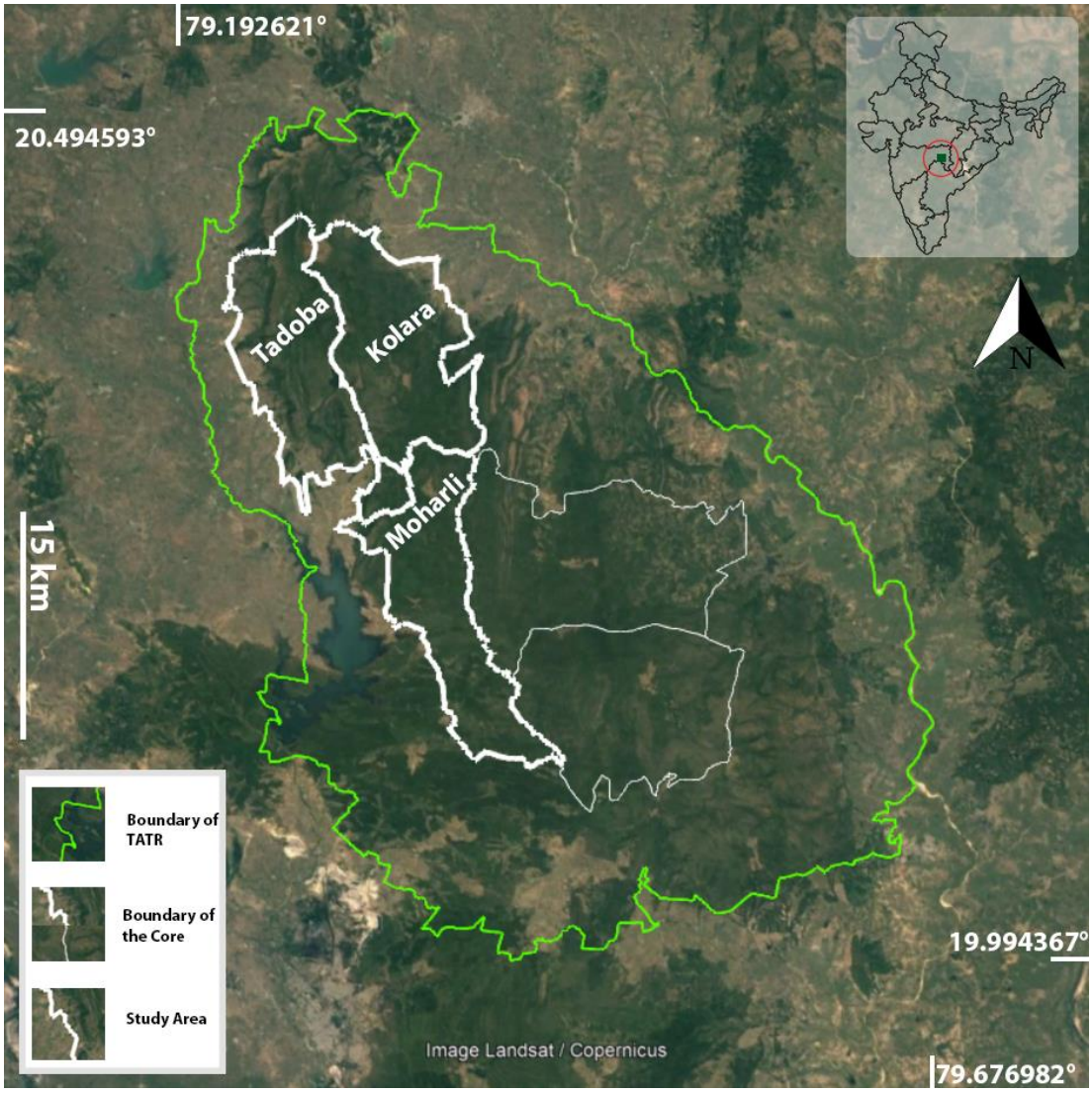

Figure 1: Map showing the Study area, core boundary and buffer boundary of TATR

Previously, waterholes were refilled using water brought by tanker vehicles however in the recent years, automatic solar pumps were implemented in many places.

High chances for animal sightings in Tadoba Andhari Tiger reserve, especially for tigers, attracts lot of tourists to the park. Tourist safari vehicles are allowed only in predefined roads at specific times in morning and evening every day inside the core zone. Since chances for Tiger sightings are high around waterholes, safari vehicles gather near these places.

3. Study Design

3.1. Field Methods

Selection of Waterhole

All waterholes inside the core area were mapped and 60 waterholes were selected in three out of five ranges for the intensive study (Figure 2). The selection of ranges for intensive study were based on reconnaissance survey, animal use, availability of different classes of waterholes, study time frame and based on the availability of logistics and manpower.

Heavily used areas of waterholes by animals were identified by looking at the signs on ground. Cuddeback C1 cameras with white flash were used for monitoring the visitations of mammals. They were placed on trees or poles at a height of 0.5m from the ground where it was pointed at, in order to completely cover the heavily used areas. More number of cameras were used in waterholes which were big and had multiple drinking points which could not be covered by a single camera. Cameras were set in photo mode with 5 seconds delay after each capture. At night delay had become 25-30 seconds since the cameras had to recharge the flash capacitor. Cameras capture the date and time of the photos in metadata as well as a watermark in the photos. Camera traps were active in the waterholes from 02-02-2021 to 31-05-2021. Cameras were checked regularly at an interval of one week and functionality was ensured. Cameras were retrieved from waterholes which got dried up during the study. Some waterholes which were rejuvenated as the summer started were also monitored.

To check the size of waterholes, two measurements were taken for each waterhole. Longest distance was considered as length and longest distance right angle to length was considered as breadth. Bosch GLM 500-2 50M laser distance meter was used for these measurements. Depth at the center of the waterhole was measured by rope, marked with measurements tied on a pole.

Forest types within 100 m from the waterhole were classified as DDF, bamboo and grassland. The percentage of perimeter covered by trees or bamboos within 25m distance from the perimeter of waterhole was taken as tree cover, and rest of the percentage of perimeter was classified as grass cover.

Ease of accessing the waterhole was ranked based on the terrain and substrate characters around the waterhole. It was termed as 'approach' and ranked from 0 to 100, zero being extremely difficult to access and 100 being the easiest.

Waterholes were classified into two, based on the presence of tourism in the adjacent roads. Distance to the road from the waterhole was measured using Bosch GLM 500-2 50M laser distance meter. Waterholes were classified into two based on the presence or absence of water supplementation using solar pumps. Distance between waterholes and other bigger water sources like lakes and streams, where camera trap monitoring was not carried out, was measured using QGIS 3.18.2 (QGIS.org 2020).

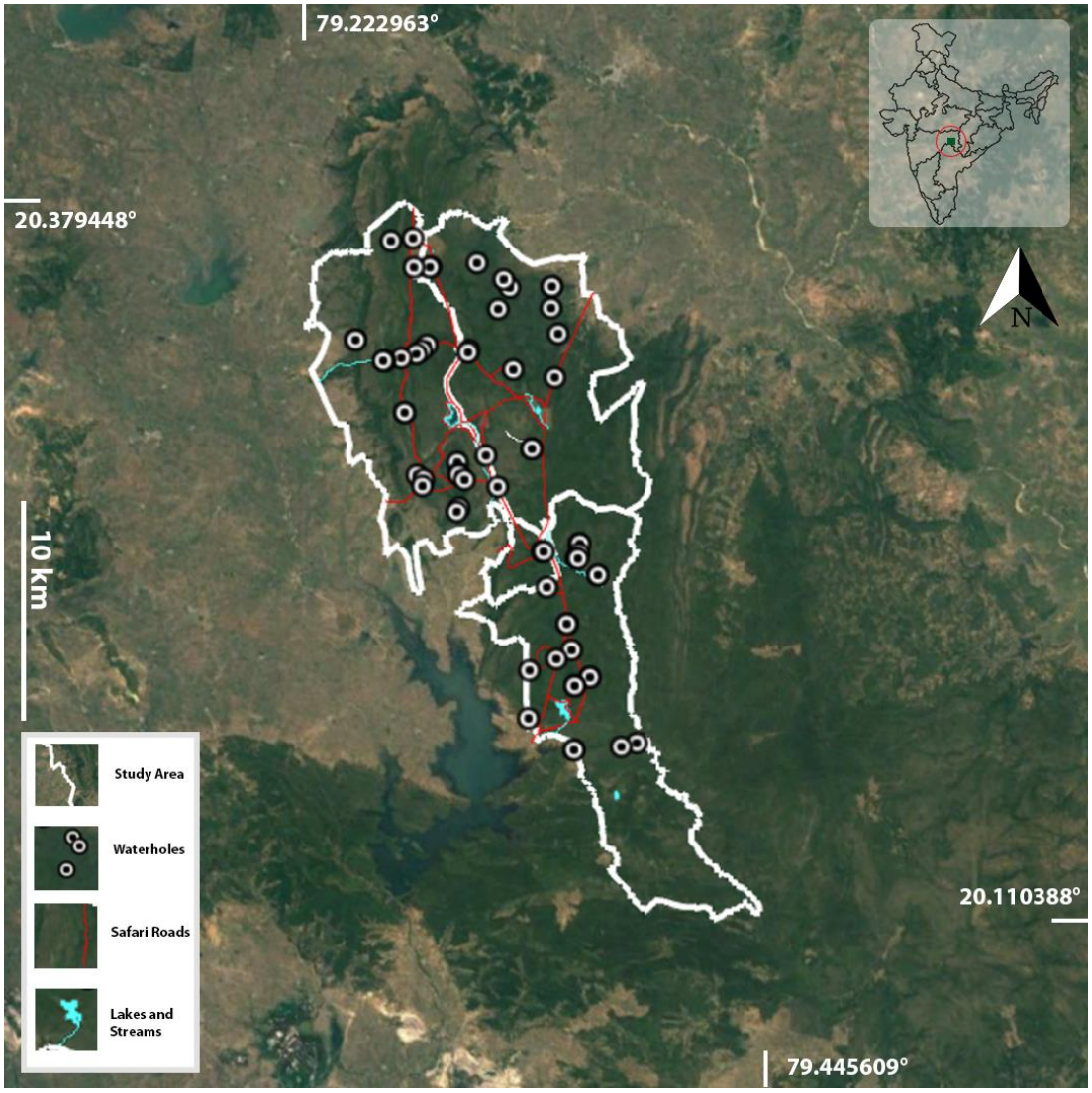

Figure 2: Distribution of waterholes overlaid with the permanent water sources and the safari road network in TATR

Waterholes were classified into three based on their construction history. Natural waterholes without human anthropogenic modifications for storing water were termed as 'natural waterholes' (figure 3C). Those waterholes which were modified by excavating or blocked the flow for storing more water for longer period were termed as 'modified waterholes' (figure 3B). Waterholes which were constructed completely by humans were termed as 'artificial waterholes' (figure 3A).

Figure 3: Types of waterholes; A- Artificial Waterhole, B- Modified Waterhole, C- Natural Waterhole

Photo Captures and Categorization

The total photographs captured in the present study across all waterholes was 4.80 lakhs. These photgraphs were classified into two major categories; (i) those from first 15 days of each month as first half and (ii) the other 15 days as second half. Only the first half (1-15 days of each month) of data were used for this work because of the

time limitation. All the photographs from camera traps of different waterholes were placed in a folder with the respective waterhole IDs. Photographs inside the main waterhole folder were sorted into subfolders with species names, based on all the mammal species present in each photo. ExifPro 2.1 software was used for sorting the photos manually. Only those series of photos where the mammals came near the waterholes were selected and those which the mammals were moving far from waterholes were avoided if photo of the same species was not captured near waterhole in the short time span from those photos. Photographs with error in the time were not used for analysis to avoid further complications leaving photos from only 54 locations out of 60. A record table with Waterhole ID, name of the species, Date and Time of capture and difference in time from the previous photo was created using camtrapR (Juergen & Niedballa 2020) package in R.

3.2. Analytical Methods

Data exploration and statistical analyses were done using both Microsoft excel(Microsoft Corporation 2020) and R4.0.5 (R Core Team 2021). Actual number of visitations of all the species for 10 days in selected waterholes were calculated manually. This number was compared to the number of visitations given by different minimum delta time values. 600 seconds of minimum delta time was giving the closest number of visitations to that of the actual number of visitations. Hence 600 seconds was used as minimum delta time for the total dataset. Record of same species after an interval of 10 minutes is considered as a different visitation to that of first one. Time spent by each species per visitation was calculated by finding the difference in time between first photo of the visitation and last photo of the same visitation.

Visitation data of mammals were divided into two as winter and summer data consisting of records from February - March and April – May months respectively. Since the average time spent / visitation was similar in both the seasons, number of visitations was taken as response variable for further analyses. Number of visitations was taken separately for both the seasons and standardised for the trap days.

General Linear Model was used to test how number of visitations were influenced by the habitat, presence of tourism, ease of approach, tree cover, grass cover, length, breadth, shape, mode of construction, water supplementation, distance to nearest waterholes and distance to road. Since none of the models gave a significant result, the command ‘dredge’ in the package ‘MuMIn’ in a global model was run to test all possible combinations within the global model. It gave a table of the models sorted according to AIC values. The best models from the output were selected based on the lowest AIC values (all models with delta AIC <2 were selected). Only those species with more than 1000 visitations were selected for this testing. Linear regression was done on the selected models to test the significance.

Major preys of the three predator species were identified and the overlap in the visitation was checked. Command ‘activityOverlap’ in package ‘camtrapR’ for the record table, made in the beginning were used for the study and same was done between three predator species also.

4. Results

Objective 1

Number of visitations for all the species across two seasons from all 54 waterholes after standardizing for the trap days was 27673. Species wise numbers of visitations are given in the figure 4. Table with the number of visitations at each waterhole is attached in the appendix A.

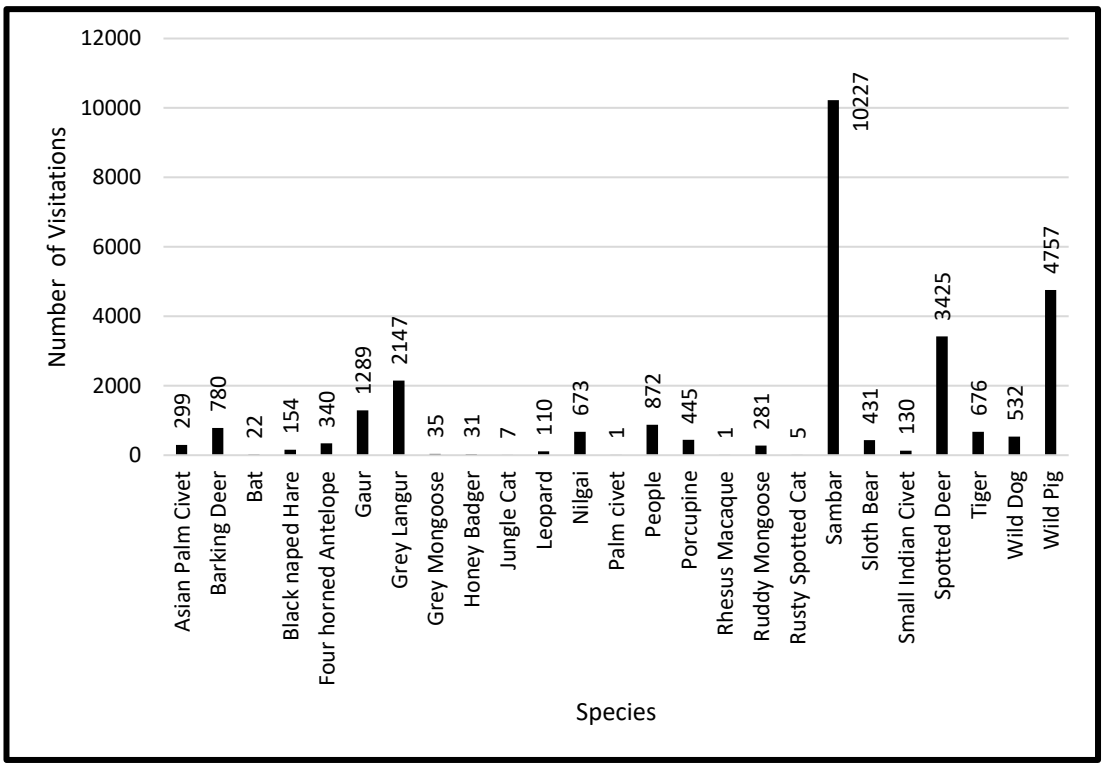

Figure 4: Number of visitations in both seasons

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Total time spent by all the species across both the seasons from 54 waterholes after standardising for the trap days was 8765184 seconds (2434.8 hours). Total time spent by all the species are given in the figure 5.

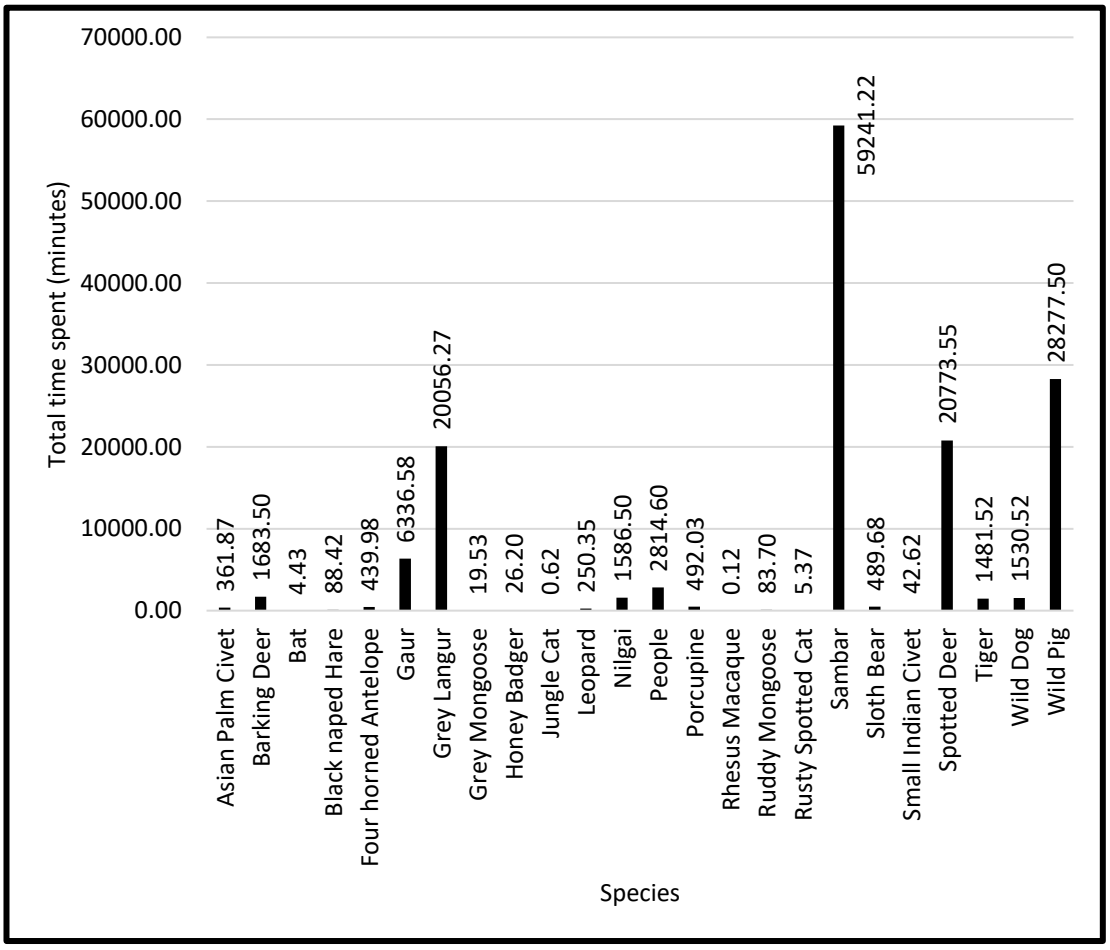

Figure 5: Total time spent by mammal species across the seasons.

Average time spent / visitation by each species at 54 waterholes is given in the figure 6.

Detailed table with each waterhole is given in the appendix B.

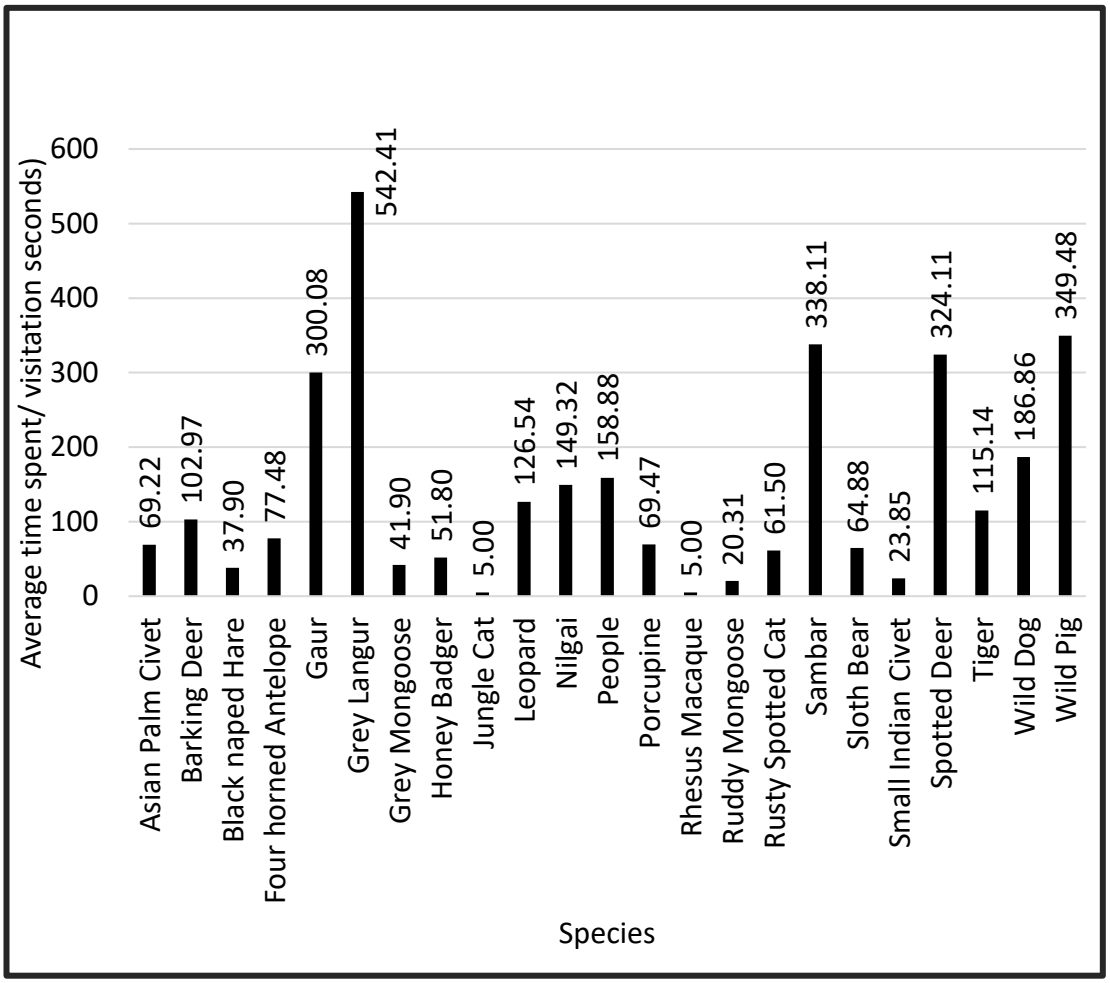

Figure 6: Average time spent/ visitation by mammals across the two seasons

Number of visitations by each species at all the waterholes in winter and summer seasons are plotted in the figure - 7 for comparison.

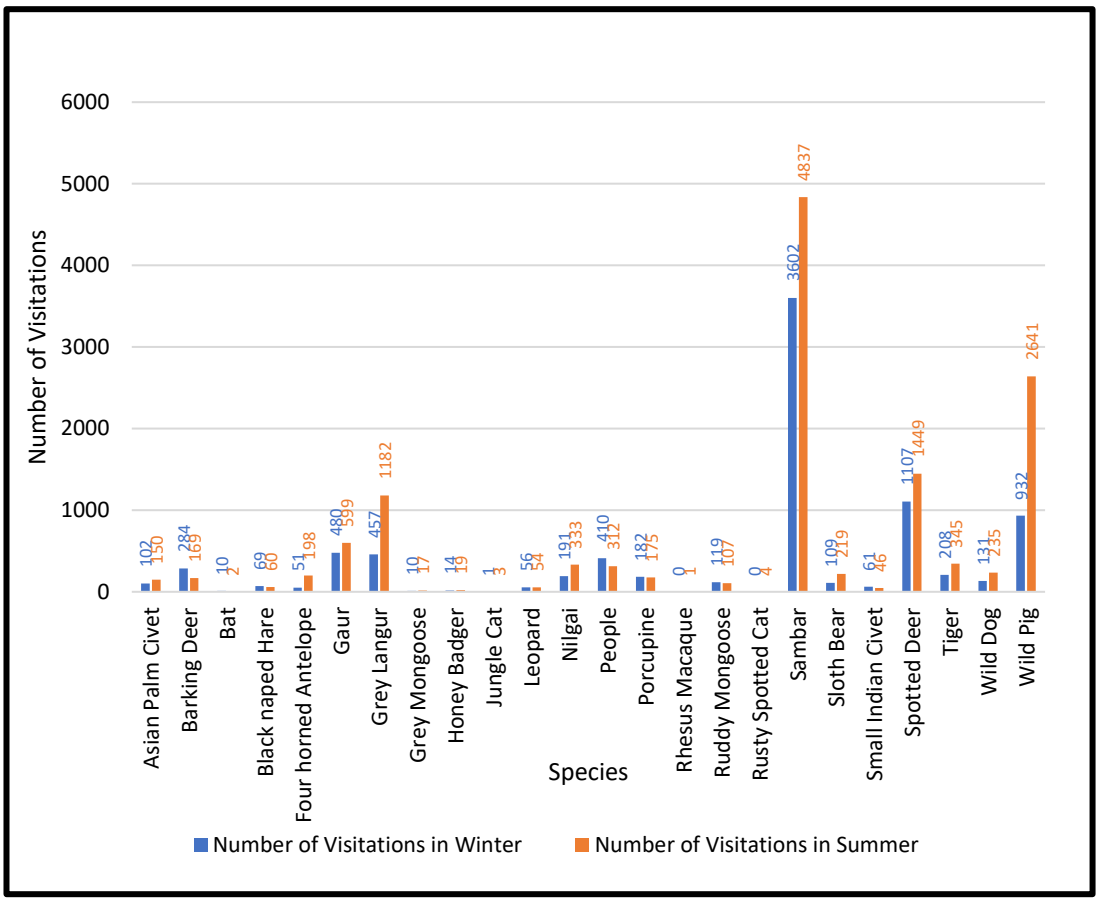

Figure 7: Difference in the number of visitations between winter and summer seasons.

The species that visited waterhole maximum number of times was sambar with 10227 visitations in 3186 trap days followed by Wild pig (2304 visitations). The species visited the least number of times was Rhesus macaque (*Macaca mulatta*) with only 1 visitation. This is explained by their low abundance in TATR (based on relative abundance from camera trap data, Jhala *et al.* 2018). Visitations of mammals at waterholes increased in summer by 151% from the visitations in winter (8685 visitations in winter and 13149 in summer). Average time spent/ visitation varied

depending on the species. Maximum variation in the number of visitations was recorded for Wild pig with 283 % increase (932 visitations in winter and 2641 in summer). Another species with more than 200 % increase in visitation in summer than winter was Grey Langur (*Semnopithecus entellus*) (457 visitations in winter and 1182 in summer).

Total Time spent by all the species in waterholes during winter is 2401584 seconds (667.1 hours) whereas total time spent in summer increased by 180 % and became 4329481 seconds (1202.634 hours). Total time spent by each of the species at all 54 waterholes are given in figure 8.

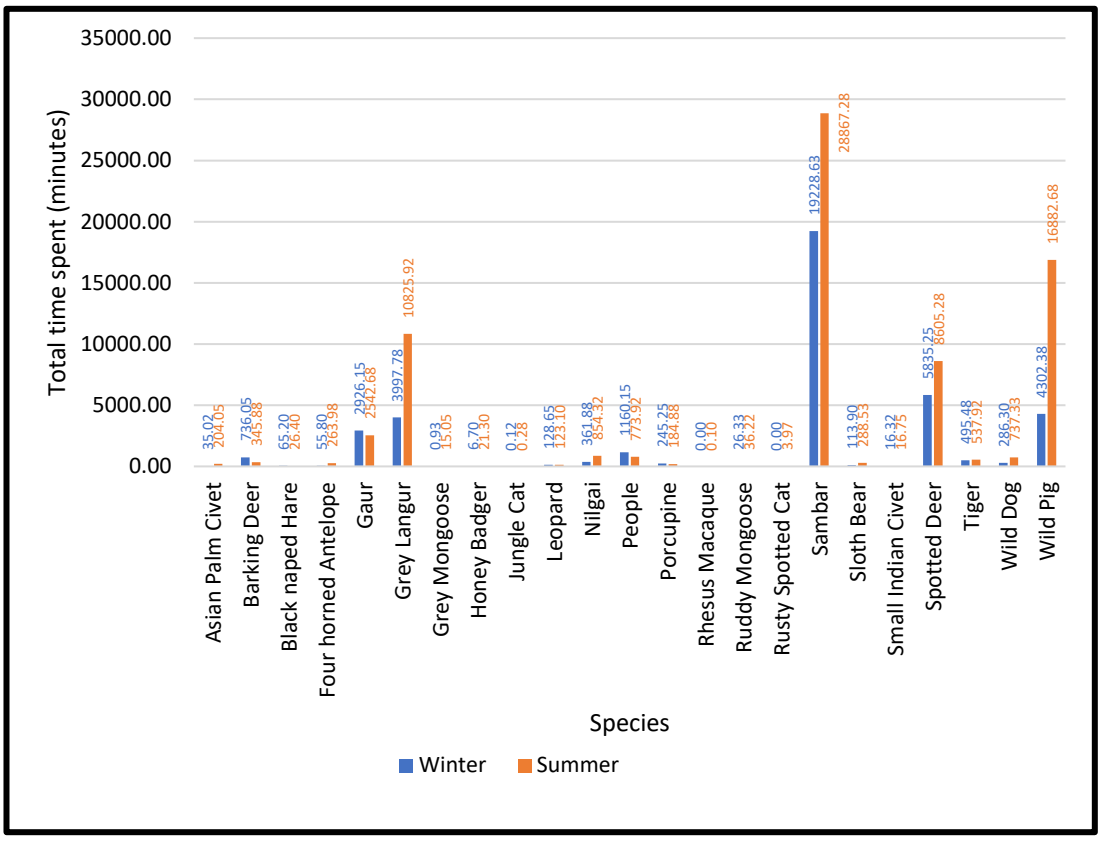

Figure 8: Difference in the total time spent by mammals between winter and summer seasons.

Average time spent / visitation for all the species in winter calculated from 5063 visitations was 274 seconds, whereas average time spent / visitation for all the species in summer calculated from 8786 visitations is 323 seconds. Average time spent /visitation for each of the specie sis given in the figure 9. Table of the same is attached in the annexure.

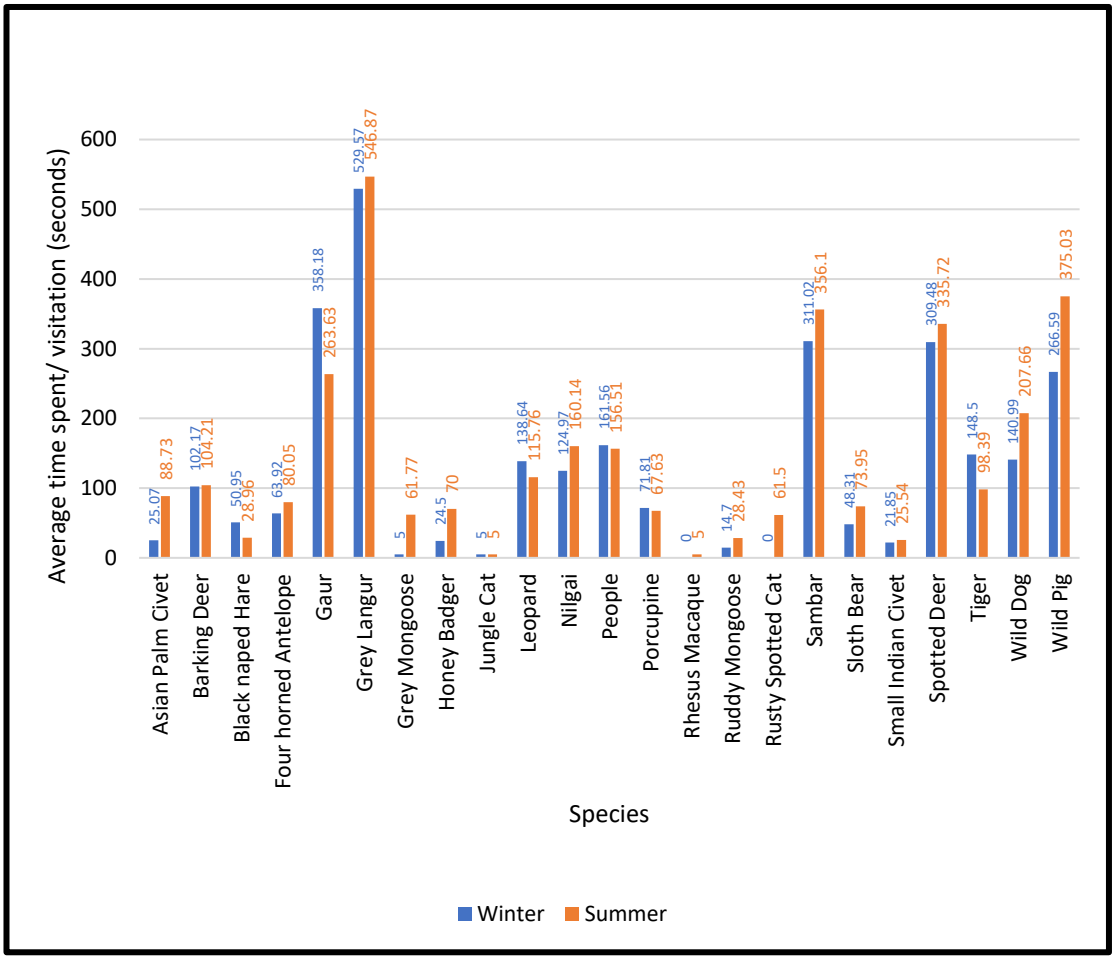

Figure 9: Difference in the average time spent / visitation by all the species between winter and summer seasons.

The species spent highest average time / visitation is Grey Langur who spent average of 542 seconds / visitation. Indian Gaur have significantly reduced the average time spent per visitation in the summer compared to winter with 36% reduction in the average time spent.

Objective 2

Influences of physical attributes of waterholes on the number of visitations of mammals at those waterholes were checked using generalised linear models. Due to the computational limitations in including all combinations of parameters, *dredge* command in the package *Mumin* was used. A global model with all the physical attributes of waterholes and numbers of visitations of mammals was created and the analysis run. Models selected from the dredge output of 639 models, based on the lowest AIC value are given in the table 1-2. The table shows serial number of the selected models, Different waterhole attributes used in the model, AIC values of each model, differences in the AIC value of the model from that of the best model(model with lowest AIC value), Akaike weight of the model etc. Only those models with delta AIC less than 2 are given here. These models were then checked for the statistical significance using linear regression. Results for all the species together and few species separately are given. Models with p-value <0.05 are highlighted with bold font in the table.

For all the species

Five Models with < 2 delta AIC values were selected from 639 models however none of the above models gave significant relationship (< 0.05 p-value) (Table 1).

Sl. No. of model	(Intercept)	Approach	Construction	Shape	Water Supplementation	Breadth	Distance from road	Grass cover	Length	Tree cover	Breadth : Length	df	logLik	AICc	delta AIC	Akaike weight
All Species																
17	426.949	NA	NA	NA	NA	6.990	NA	NA	NA	NA	NA	3	-379.614	765.708	0.000	0.056
129	435.563	NA	NA	NA	NA	NA	NA	NA	4.153	NA	NA	3	-379.806	766.093	0.385	0.047
1	512.463	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	2	-381.299	766.833	1.126	0.032
25	393.615	NA	NA	NA	+	6.790	NA	NA	NA	NA	NA	4	-379.270	767.356	1.649	0.025
81	403.429	NA	NA	NA	NA	6.600	NA	1.107	NA	NA	NA	4	-379.373	767.562	1.854	0.022

Table 1: Models with highest significance for all species

Gaur

Six models with < 2 delta AIC values were selected from 639 models. The model showed that water supplementation in the waterholes had significant effect on the visitation of Gaur with p-value <0.001. None of the other models showed significant relation (Table 2).

Grey Langur

Three models with < 2 delta AIC values were selected from 639 models. The model showed that water supplementation in the waterholes had significant effect on the visitation of Grey Langur with p-value of 0.02 (Table 2).

Sambar

Three models with < 2 delta AIC values selected from 639 models however, none of the models showed significant relation (Table 2).

Spotted Deer

Six models with < 2 delta AIC values selected from 639 models. The model with Length * Breadth + Grass cover was significant with p-value 0.02 (Table 2).

Wild Pig

Four models with < 2 delta AIC values selected from 639 models. The model with Length * Breadth got a significant p-value of 0.01 however no other models showed significant p-value (Table 2).

Tiger

Five models with < 2 delta AIC values selected from 639 models however, none of the models were significant (Table 2).

265	10	**9**	**Grey Langur**	11	265	137	25	10	**9**	**Gaur**	**Sl. No. of model**
11.703	41.637	**25.696**		-4.227	2.195	6.848	6.523	19.400	**9.826**		**(Intercept)**
NA	-0.276	**NA**		NA	NA	NA	NA	-0.166	**NA**		**Approach**
NA	NA	**NA**		+	NA	NA	NA	NA	**NA**		**Construction**
NA	NA	**NA**		NA	NA	NA	NA	NA	**NA**		**Shape**
+	+	**+**		+	+	+	+	+	**+**		**Water Supplementation**
NA	NA	**NA**		NA	NA	NA	0.287	NA	**NA**		**Breadth**
NA	NA	**NA**		NA	NA	NA	NA	NA	**NA**		**Distance from road**
NA	NA	**NA**		NA	NA	NA	NA	NA	**NA**		**Grass cover**
NA	NA	**NA**		NA	NA	0.174	NA	NA	**NA**		**Length**
0.173	NA	**NA**		NA	0.095	NA	NA	NA	**NA**		**Tree cover**
NA	NA	**NA**		NA	NA	NA	NA	NA	**NA**		**Breadth : Length**
4	4	**3**		5	4	4	4	4	**3**		**df**
-272.126	-271.609	**-272.424**		-249.059	-250.245	-250.121	-250.092	-249.784	**-250.445**		**logLik**
553.067	552.035	**551.328**		509.368	509.307	509.059	509.001	508.384	**507.370**		**AICc**
1.740	0.707	**0.000**		1.998	1.937	1.689	1.631	1.014	**0.000**		**delta AIC**
0.041	0.069	**0.098**		0.038	0.039	0.045	0.046	0.062	**0.104**		**Akaike weight**

209	729	73	913	65	**721**	Spotted Deer	265	10	9	Sambar	**Sl. No. of model**
32.559	4.985	42.663	104.410	28.651	**-7.603**		11.703	41.637	25.696		**(Intercept)**
NA	NA	NA	NA	NA	**NA**		NA	-0.276	NA		**Approach**
NA	NA	NA	NA	NA	**NA**		NA	NA	NA		**Construction**
NA	NA	NA	NA	NA	**NA**		NA	NA	NA		**Shape**
NA	+	+	NA	NA	**NA**		+	+	+		**Water Supplementation**
-3.860	0.198	NA	0.087	NA	**0.368**		NA	NA	NA		**Breadth**
NA	NA	NA	NA	NA	**NA**		NA	NA	NA		**Distance from road**
1.018	1.374	1.536	NA	1.361	**1.258**		NA	NA	NA		**Grass cover**
2.812	4.760	NA	5.155	NA	**5.001**		NA	NA	NA		**Length**
NA	NA	NA	-1.111	NA	**NA**		0.173	NA	NA		**Tree cover**
NA	-0.150	NA	-0.157	NA	**-0.162**		NA	NA	NA		**Breadth : Length**
5	7	4	6	3	**6**		4	4	3		**df**
-313.989	-311.264	-314.904	-312.382	-315.827	**-311.797**		-272.126	-271.609	-272.424		**logLik**
639.228	638.963	638.625	638.551	638.134	**637.381**		553.067	552.035	551.328		**AICc**
1.847	1.582	1.244	1.170	0.754	**0.000**		1.740	0.707	0.000		**delta AIC**
0.025	0.028	0.033	0.034	0.042	**0.062**		0.041	0.069	0.098		**Akaike weight**

Sl. No. of model	(Intercept)	Approach	Construction	Shape	Water Supplementation	Breadth	Distance from road	Grass cover	Length	Tree cover	Breadth : Length	df	logLik	AICc	delta AIC	Akaike weight
Wild Pig																
657	**6.071**	**NA**	**NA**	**NA**	**NA**	**7.513**	**NA**	**NA**	**3.045**	**NA**	**-0.184**	**5**	**-307.976**	**627.202**	**0.000**	**0.055**
666	31.283	-0.692	NA	NA	+	7.164	NA	NA	3.347	NA	-0.193	7	-305.521	627.477	0.275	0.048
665	-14.112	NA	NA	NA	+	8.012	NA	NA	3.278	NA	-0.204	6	-306.900	627.587	0.384	0.045
658	39.903	-0.446	NA	NA	NA	6.854	NA	NA	3.035	NA	-0.172	6	-307.379	628.546	1.344	0.028
Tiger																
5	34.200	NA	NA	+	NA	NA	NA	NA	NA	NA	NA	7	-223.835	464.105	0.000	0.049
17	17.081	NA	NA	NA	NA	-0.373	NA	NA	NA	NA	NA	3	-228.879	464.238	0.133	0.046
1	12.519	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	2	-230.163	464.562	0.457	0.039
129	15.702	NA	NA	NA	NA	NA	NA	NA	-0.172	NA	NA	3	-229.483	465.447	1.342	0.025
21	36.359	NA	NA	+	NA	-0.253	NA	NA	NA	NA	NA	8	-223.288	465.777	1.672	0.021

Table 2: Models with highest significance for Gaur, Grey Langur, Sambar, Spotted Deer, Wild Pig and Tiger

Effect of tourism on visitations of mammals at waterholes

Linear regression to check the influence of presence of tourism in the nearest road from waterhole in the visitation frequencies of mammals showed that there is no significant influence (p-value = 0.88)

Objective 3

Temporal overlap or separation in the visitation patterns of predator species and major prey species

Temporal overlaps in the visitations of predator species and major prey species were compared using the activity overlap plotted using R. Figure 10-28 shows overlapped temporal visitation patterns of different combinations of predator species and prey species.

Tiger

Tigers and major prey species (6 species out of 7) showed a clear avoidance in the temporal visitation pattern (Figure 10 – 16). Tiger showed two peaks in early mornings and evenings. Sambar's visitation is throughout the day with a peak in the evening. Sambar's activity peaks before Tiger in the evening and goes down by the time Tiger activity peaks up. The percentage of overlap between Tiger and Sambar is 62%.

Spotted Deer shows an overlap with the early morning activity peak of Tiger, but clearly avoids the evening peak activity. There is a 61% overlap between these two species. Barking Deer shows 70 percent overlap in the waterhole visitation to that of the Tiger with similar peak activity timings. Another major prey of Tiger, Gaur shows

66% overlap in the waterhole visitation with its predator with similar peak activity time in the evening. Two antelopes in the area Nilgai and Four-horned Antelope have peak activity at the waterhole during the afternoon. This avoids the waterhole visitation peaks of Tiger.

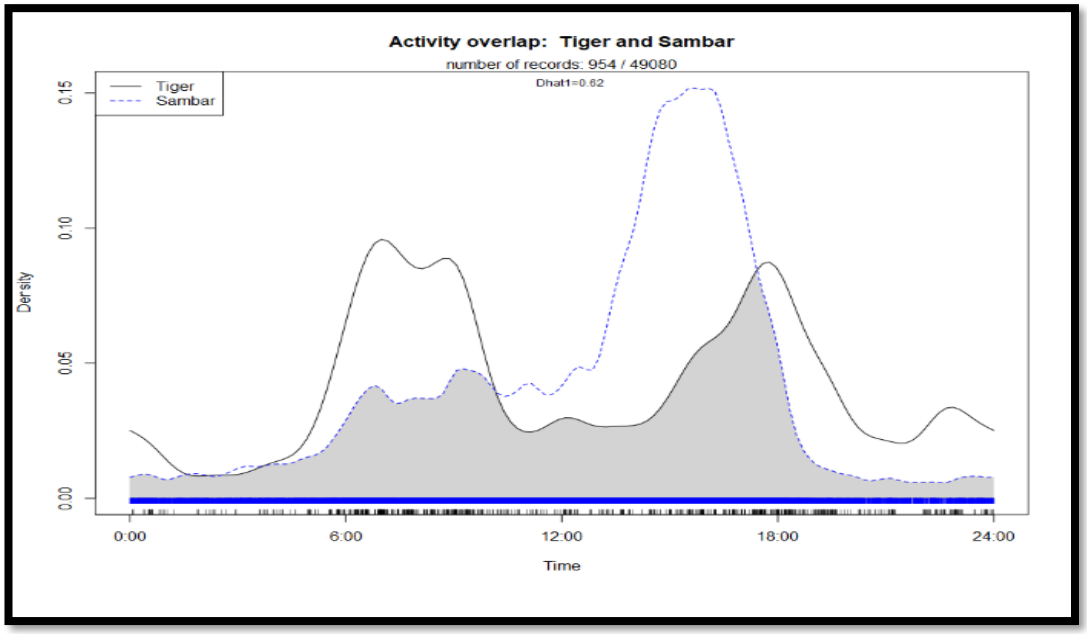

Figure 10: Visitation overlap between Tiger and Sambar

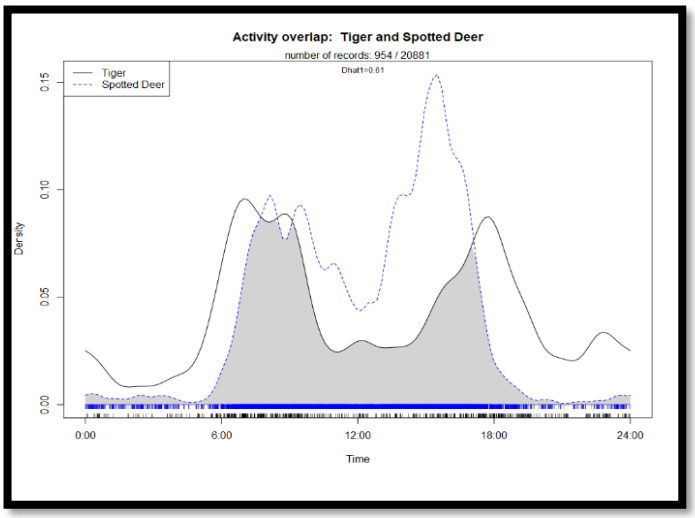

Figure 11 Visitation overlap between Tiger and Spotted Deer

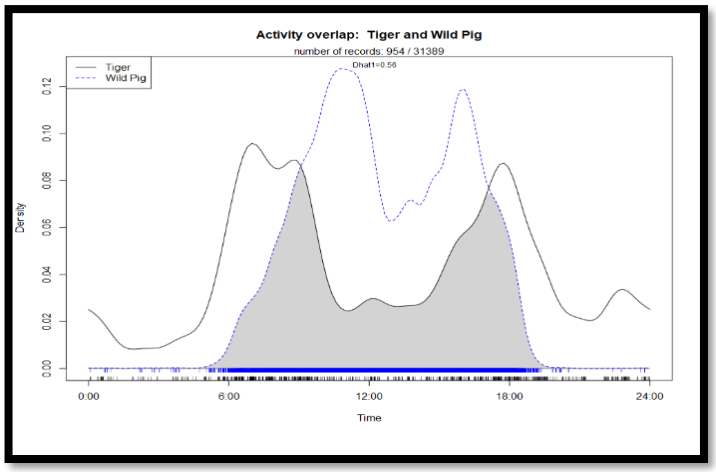

Figure 12 Visitation overlap between Tiger and Wild Pig

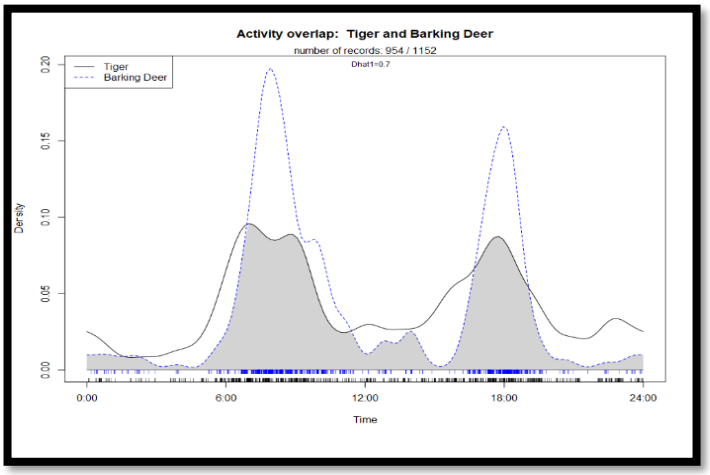

Figure 13 Visitation overlap between Tiger and Barking Deer

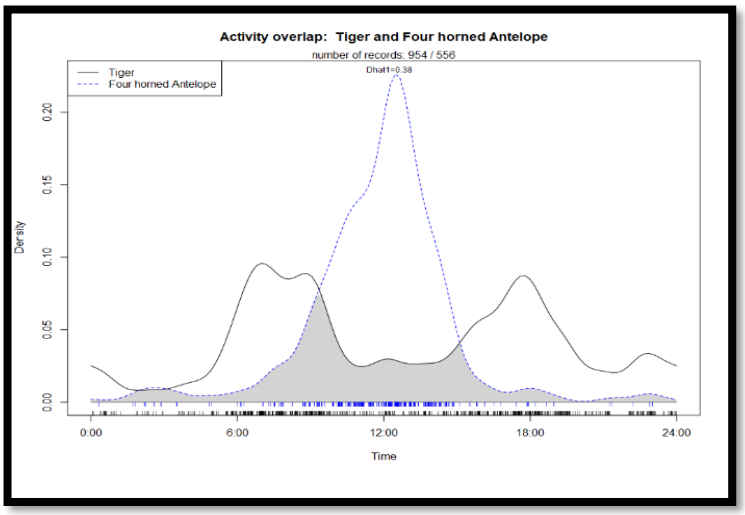

Figure 14 Visitation overlap between Tiger and Four-horned Antelope

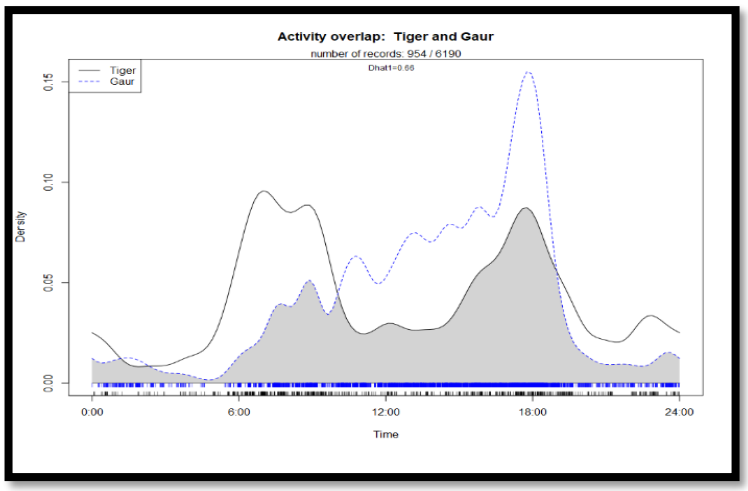

Figure 15 Visitation overlap between Tiger and Gaur

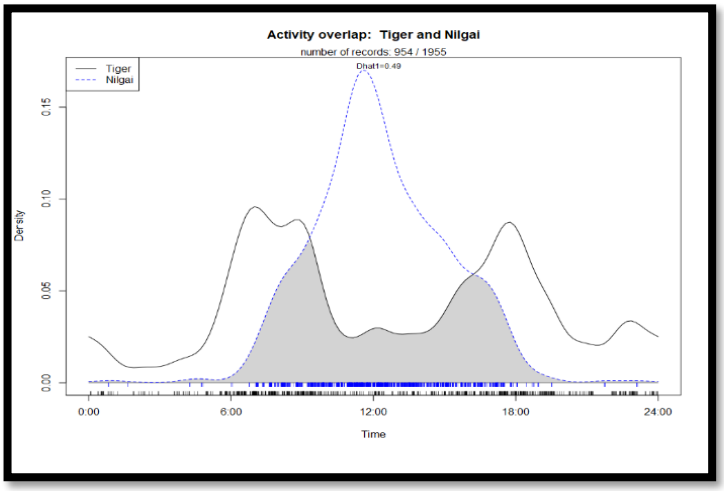

Figure 16 Visitation overlap between Tiger and Nilgai

Leopard

Leopard's temporal visitation pattern was different from that of Tiger as the slope of the peak is gradual and visits waterholes during night. Activity goes down during the afternoon. All the major prey species seems to be avoiding the peak visitation times of Leopard. Highest percentage of overlap is between Leopard and Barking Deer with 52%, followed by Spotted Deer with 40% overlap. Four-horned Antelope, Grey Langur and Wild Pig avoids the peak activity times of Leopard with overlaps of 29%, 30% and 36% respectively (Figure 17-21).

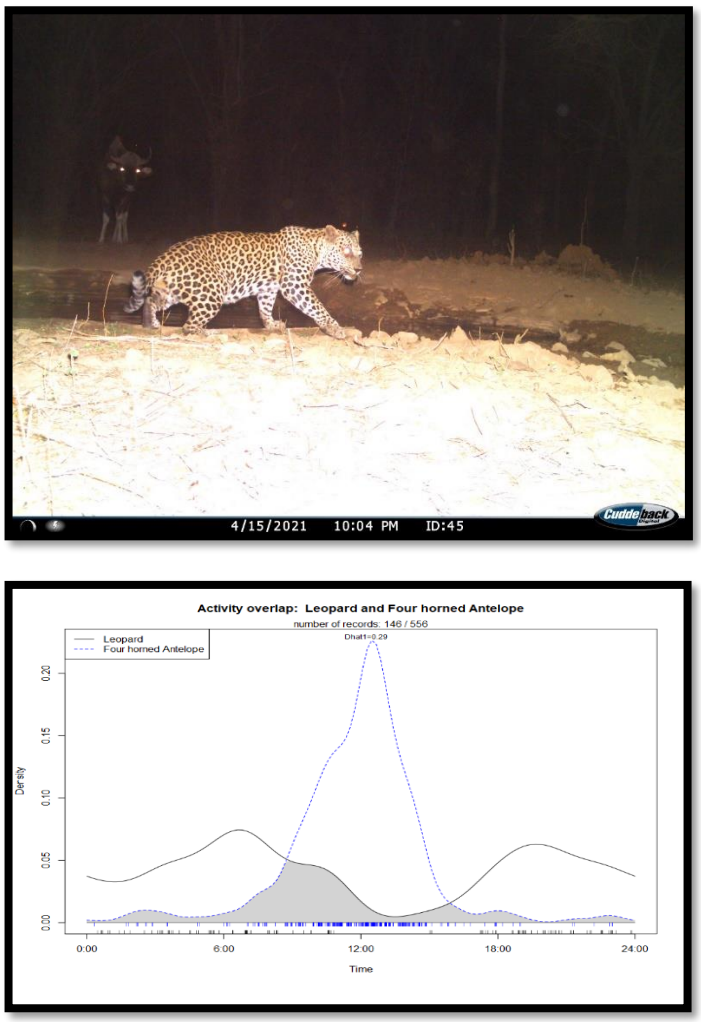

Figure 17 Visitation overlap between Leopard and Four-horned Antelope

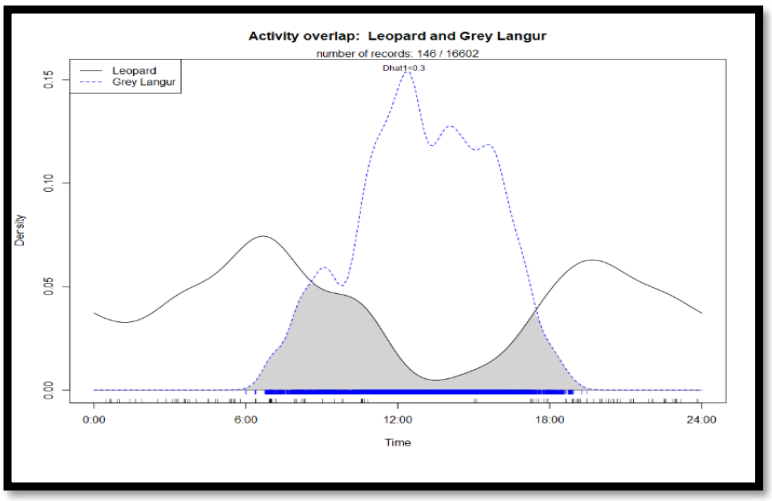

Figure 18 Visitation overlap between Leopard and Grey Langur

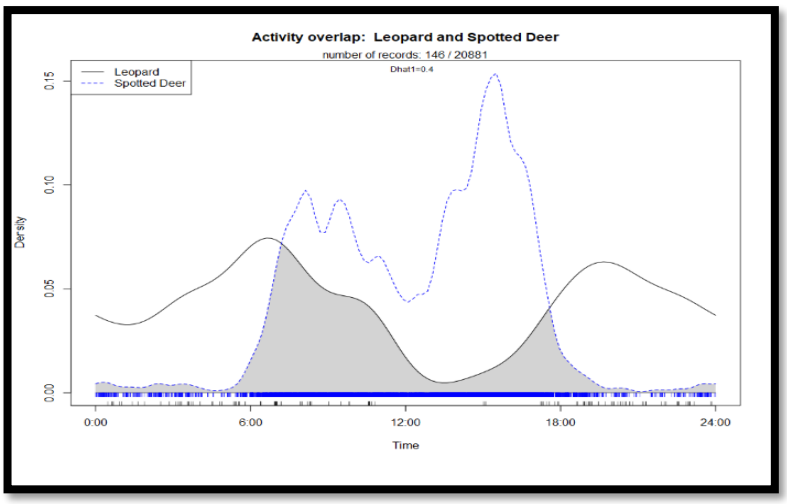

Figure 19 Visitation overlap between Leopard and Spotted Deer

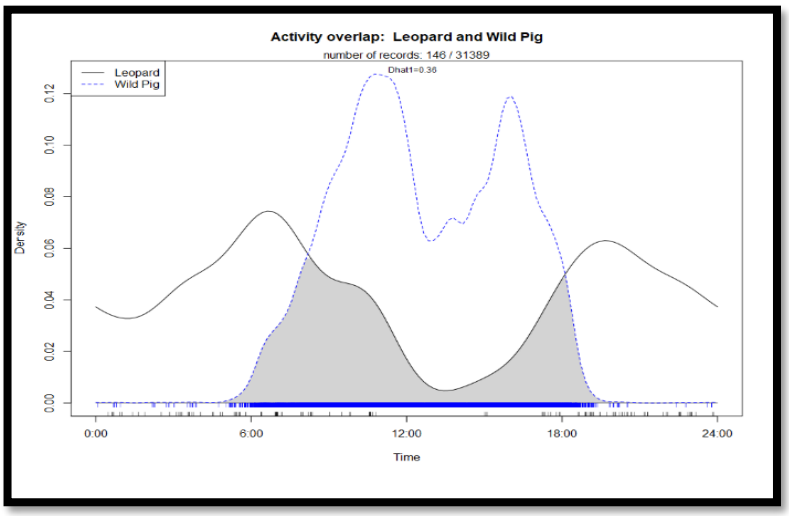

Figure 20 Visitation overlap between Leopard and Wild Pig

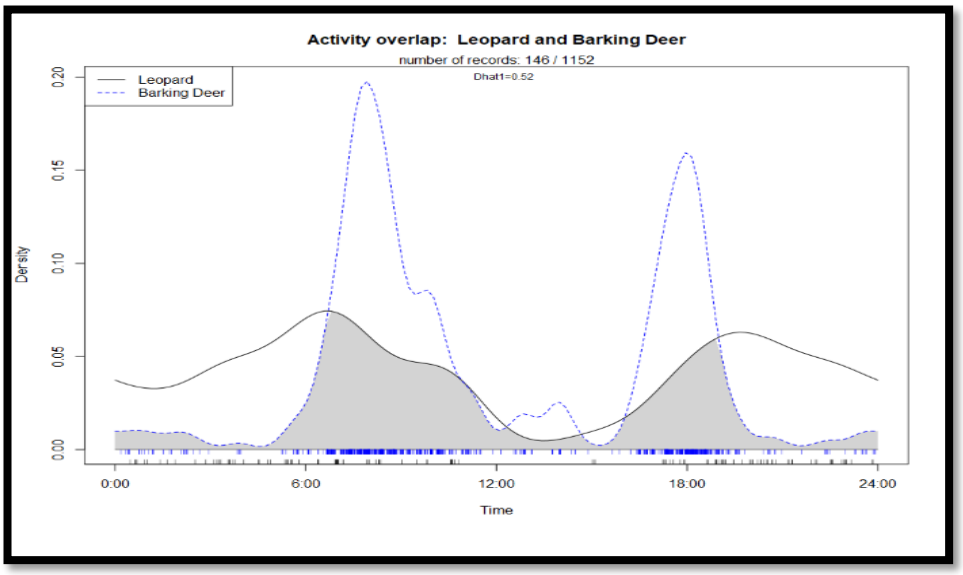

Figure 21 Visitation overlap between Leopard and Barking Deer

Wild Dog

Wild Dog was mostly diurnal with a peak in the waterhole visitation in the morning and evening. Activity peaks with a steep slope in the morning and goes down with steep slope after the evening peak. They show high overlap of more than 70% with four of the seven major prey species. Spotted Deer, Barking Deer, Wild Pig, Sambar, Nilgai and Gaur have 73%, 715, 71%, 67%, 63% and 73% of overlap respectively in their waterhole visitation timings with that of the Wild Dog. Four-horned Antelope have least overlap among major prey species with 50% of overlap (Figure 22-28).

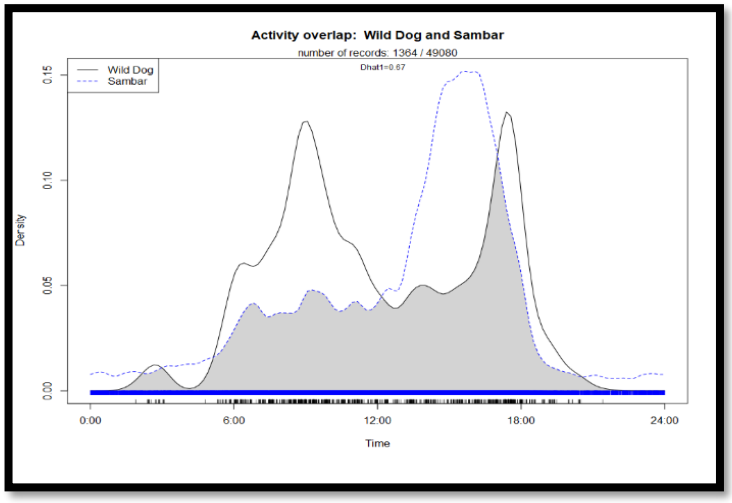

Figure 22 Visitation overlap between Wild Dog and Sambar

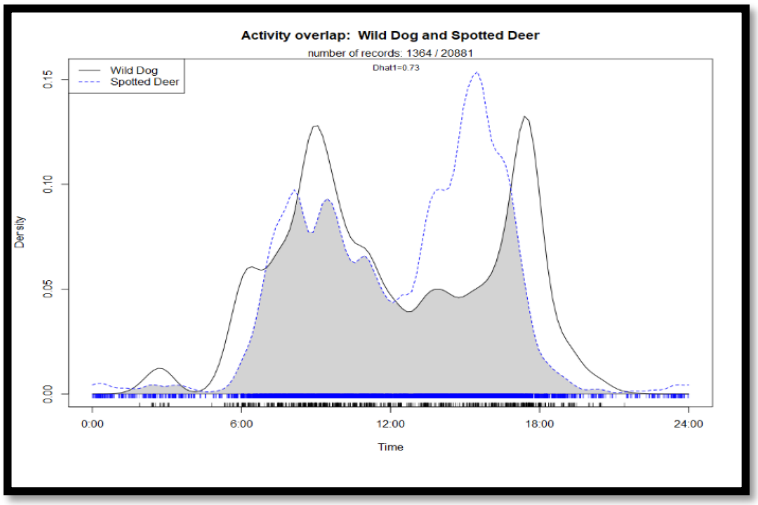

Figure 23 Visitation overlap between Wild Dog and Spotted Deer

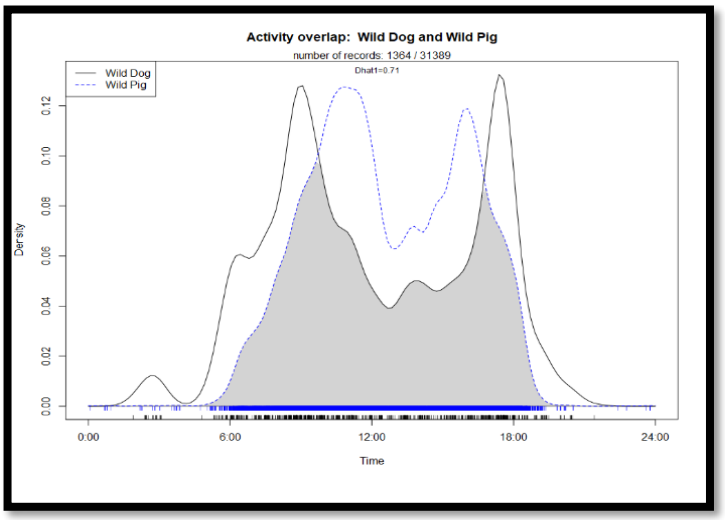

Figure 24 Visitation overlap between Wild Dog and Wild Pig

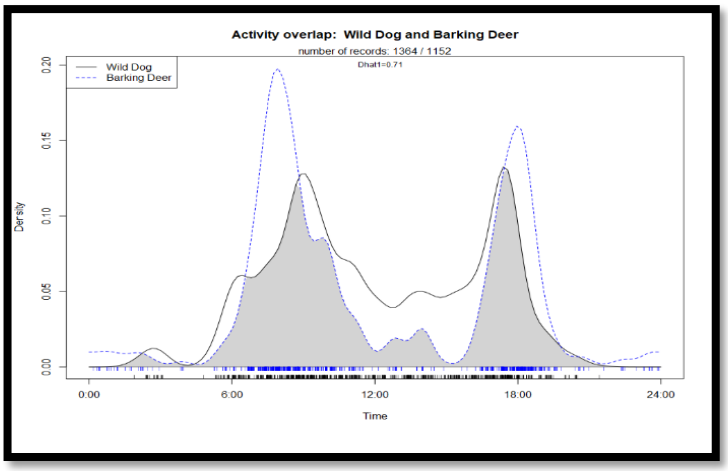

Figure 25 Visitation overlap between Wild Dog and Barking Deer

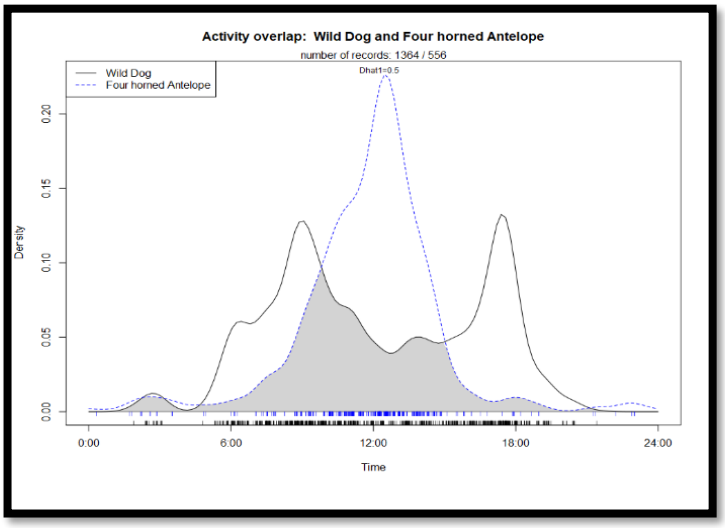

Figure 26 Visitation overlap between Wild Dog and Four-horned Antelope

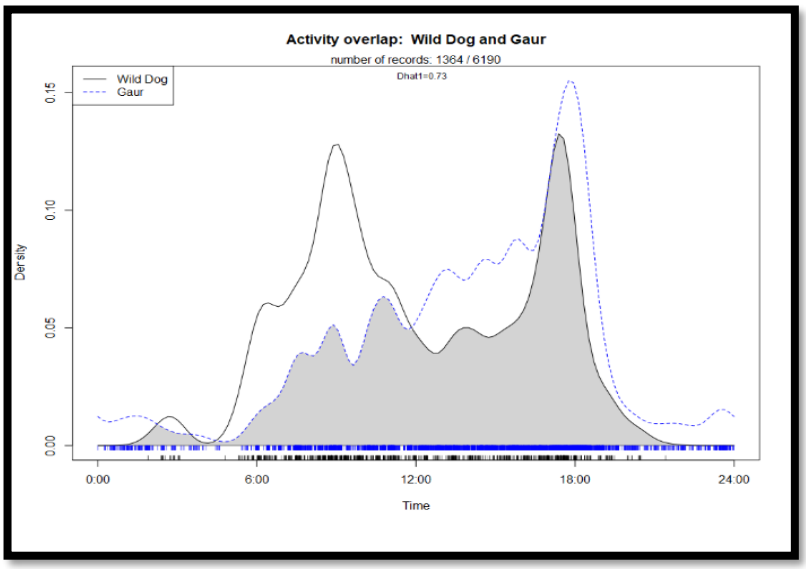

Figure 27 Visitation overlap between Wild Dog and Gaur

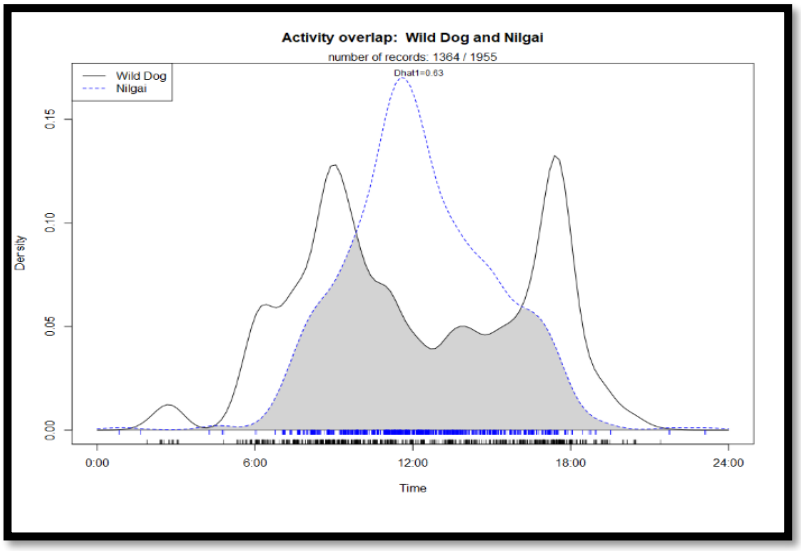

Figure 28 Visitation overlap between Wild Dog and Nilgai

Overlap in the temporal visitation pattern of three major predator species

All three predator species have two peak time for waterhole visitation in a day - morning and evening. So all of them have more than 50 overlap with each other. Tiger and Leopard overlap 70 percent in each other's waterhole visitation timings. Tiger and Wild Dogs have similar visitation pattern except that the Tiger shows good nocturnal

activity where as Wild Dog is mostly diurnal. Still they have 75% overlap in their visitation timings. Leopard and Wild Dog have an overlap in their morning and evening activity. But the peaks don't overlap with each other's. Percentage of overlap between Leopard and Wild Dog is 51 % (Figure 29-30).

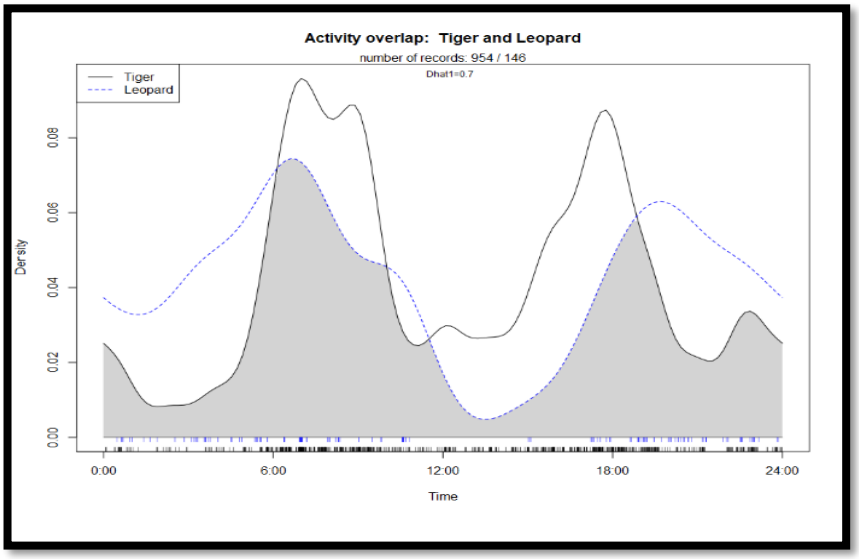

Figure 29 Visitation overlap between Tiger and Leopard

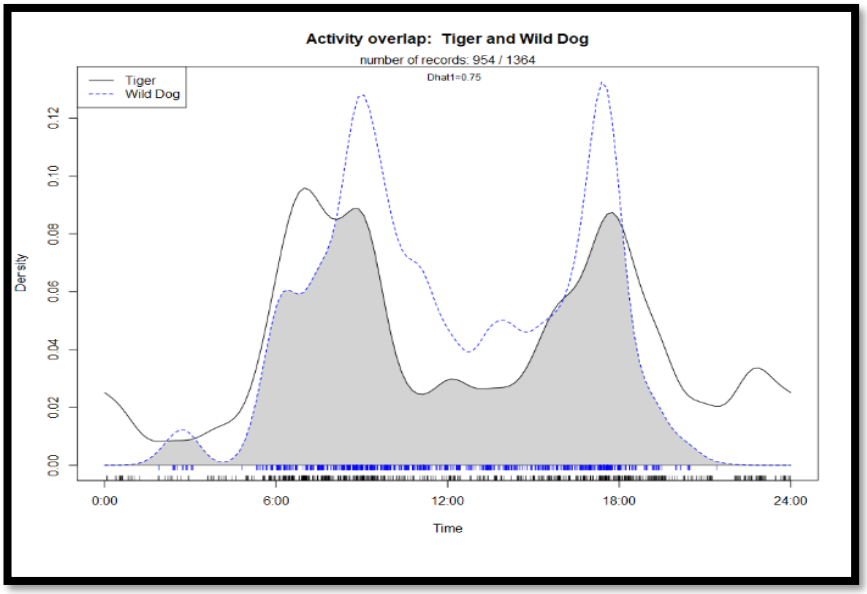

Figure 30 Visitation overlap between Tiger and Wild Dog

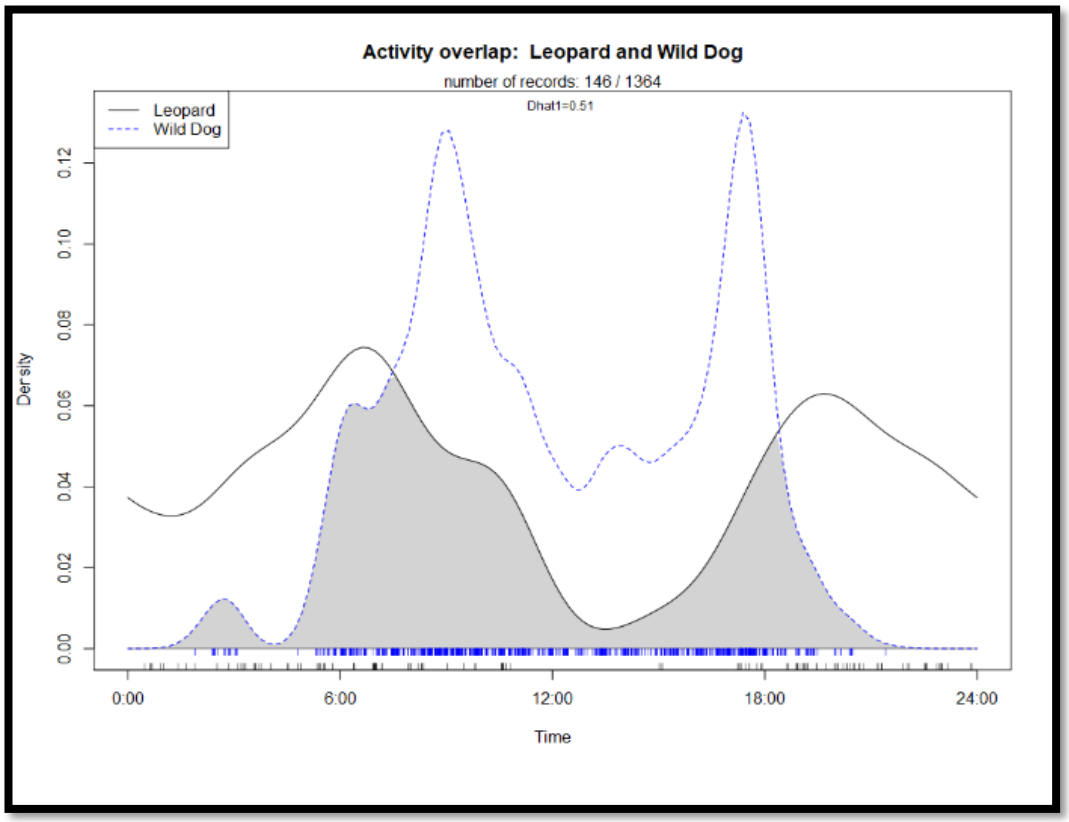

Figure 31 Visitation overlap between Leopard and Wild Dog

5. Discussion

Objective 1

Visitation frequencies of mammals at waterholes

Five highest water dependant species are Sambar, Wild pig, Spotted deer, Grey langur and gaur in deceasing order of their total time spent in waterholes. In the order of number of visitations also, Sambar is followed by Wild pig, Spotted deer, Grey langur and gaur respectively. Average Time spent/ visitation is highest for Grey langur, followed by Wild pig, sambar, Spotted deer, gaur etc. Sambar and Wild pig do allowing in the water and mud (Gray *et al.* 2019, Watter *et al.* 2020).

Seasonal differences in the visitation pattern of mammals at waterholes:

The study covered two months of both winter and summer seasons. The number of visitations of mammals at waterhole increased in summer by 153%. This can be explained by the increased requirement of water during dry weather conditions. Studies from the other parts of the world also suggests such seasonal variation in the waterhole use (Valeix 2011, Sutherland *et al.* 2018).

Two species had significant decrease in the average time spent/visitation at waterholes during summer – gaur and tiger. But their number of visitations were increased. Tiger is evolutionary adapted for cold conditions. They spend more time in water for cooling down their body (Prater 1965). A possible explanation for the decrease in the average time spent and increase in the visitation frequency is that they'll be seeking some shady areas close to the waterhole and visit the waterhole multiple times in intervals, avoiding hot and humid conditions in the open areas of waterholes.

Objective 2

Visitation frequencies of Grey langur and gaur were influenced by the water supplementation being carried out using solar pumps. Langurs strongly depend on water availability in the area and influence their distribution (Newton 1992). In TATR, year-round water availability is ensured by solar water pumps in many waterholes. Other waterholes dries up during summer. The correlation of water supplementation and visitation of Langurs is potentially caused due to this. Size of the waterhole has an effect on the visitation frequencies of Wild pig and Spotted deer. Spotted deer and Wild pig being group living animals, visits waterholes in large groups and hence require larger waterholes for visitations. That is why, the size (length and breadth) of waterholes is correlated with the visitations of Spotted deer. Presence of tourism in the nearest road from waterholes didn't influence the visitations of mammals at the waterholes.

Objective 3

Prey species avoid the peak time of waterhole visitation by tiger and leopard. But their peak visitation time overlapped with that of the Wild dog. Tiger and leopard are ambush predators and Wild dog isn't. Prey species are more vigilant towards the ambush predators and avoids their peak activity time. This could be a reason for the temporal separation in visitation between prey and Ambush predators and overlapping visitation pattern with Wild dog

6. Conclusion

Visitation pattern of mammalian communities at waterholes were monitored at 54 waterholes in Tadoba-Andhari Tiger Reserve for four months (February – May) and it was analysed with respect to the physical characters of waterholes (size, shape, depth, ease of access), distance from adjacent permanent water sources, distance from road, presence of tourism in the nearby road and artificial water supplementation. Among the mammals, it was found that the Sambar visited the waterholes highest number of times and spent highest total duration, followed by wild pig, spotted deer, grey langur and gaur. There was 80.2% increase in the total time spent by mammalian communities at waterholes in summer season compared to winter.

Artificial water supplementation at waterholes had positive influences in the visitations of gaur and grey langur. Length and breadth of waterholes influence the visitations of spotted deer and wild pig. Presence of tourism in the nearest road didn't influence the visitations of mammals at waterholes significantly.

When temporal overlap in the visitation pattern of predator species and prey species at waterholes were compared, visitation pattern of wild dog, a pursuit predator had higher overlap with the prey species compared to that of the tiger and leopard which are ambush predators.

7. References

Champion, H.G. & Seth, S.K. 1968. A revised survey of the forest types of India. Manager of publications.

Climate-Data.org Chandrapur climate: Average Temperature, weather by month, Chandrapur weather averages - Climate-Data.org.

Epaphras, A., Gereta, E., Lejora, I., Meing'ataki, G.O., Ng'umbi, G., Kiwango, Y., Mwangomo, E., Semanini, F., Vitalis, L. & Balozi, J. 2008. Wildlife water utilization and importance of artificial waterholes during dry season at Ruaha National Park, Tanzania. *Wetlands ecology and management* 16: 183–188.

Gray, S.M., Roloff, G.J., Montgomery, R.A., Beasley, J.C. & Pepin, K.M. 2019. Wild pig spatial ecology and behavior. In: *Invasive wild pigs in North America: ecology, impacts, and management*, pp. 33–56. CRC.

Jhala, Y., Qureshi, Q. & Nayak, AK. 2018. Status of tigers, co-predators, and prey in India.

Juergen & Niedballa. 2020. *camtrapR*.

Habib, B., Nigam, P., Pallavi, G., Gomes, L., Praveen, N., Sinha, V., Ladkat, N., Guruprasad, G. & Bhagwat, S. 2019. Status of Tigers, Co-Predator and Prey in Tadoba Andhari Tiger Reserve (TATR) 2019. Wildlife Institute of India & Maharashtra Forest Department.

Kamanda, M., Ndiweni, V., Imbayarwo-Chikosi, V., Muvengwi, J. & Musakwa, A. 2008. The impact of tourism on sable antelope (Hippotragus niger) vigilance behaviour at artificial waterholes during the dry season in Hwange National Park. *Journal of Sustainable Development in Africa* 10: 299–314.

Microsoft Corporation. 2020. *Microsoft Excel*.

Newton, P. 1992. Feeding and ranging patterns of forest hanuman langurs (Presbytis entellus). *International Journal of Primatology* 13: 245–285.

Parker, A.H. & Witkowski, E.T.F. 1999. Long-term impacts of abundant perennial water provision for game on herbaceous vegetation in a semi-arid African savanna woodland. *Journal of Arid Environments* 41: 309–321.

Prater, S.H. 1965. *The book of Indian animals*. Bombay natural history society.

QGIS.org. 2020. *QGIS 3.18.2*. QGIS Geographic Information System. QGIS Association.

R Core Team. 2021. *R 4.0.5*.

Rosenstock, S.S., Ballard, W.B. & DeVos, J.C. 1999. Viewpoint: benefits and impacts of wildlife water developments. *Rangeland Ecology & Management / Journal of Range Management Archives* 52: 302–311.

Smit, I. & Grant, C. 2009. Managing surface-water in a large semi-arid savanna park: effects on grazer distribution patterns. *Journal for Nature Conservation* 17: 61–71.

Sutherland, K., Ndlovu, M. & Pérez-Rodríguez, A. 2018. Use of Artificial Waterholes by Animals in the Southern Region of the Kruger National Park, South Africa. *sawr.1* 48.

Udaya Sekhar, N. 2003. Local people's attitudes towards conservation and wildlife tourism around Sariska Tiger Reserve, India. *Journal of Environmental Management* 69: 339–347.

Valeix, M. 2011. Temporal dynamics of dry-season water-hole use by large African herbivores in two years of contrasting rainfall in Hwange National Park, Zimbabwe. *Journal of Tropical Ecology* 27: 163–170.

Valeix, M., Fritz, H., Loveridge, A.J., Davidson, Z., Hunt, J.E., Murindagomo, F. & Macdonald, D.W. 2009. Does the risk of encountering lions influence African herbivore behaviour at waterholes? *Behav Ecol Sociobiol* 63: 1483–1494.

Valeix, M., Loveridge, A.J., Davidson, Z., Madzikanda, H., Fritz, H. & Macdonald, D.W. 2010. How key habitat features influence large terrestrial carnivore movements: waterholes and African lions in a semi-arid savanna of north-western Zimbabwe. *Landscape Ecol* 25: 337–351.

Watter, K., Thomas, E., White, N., Finch, N. & Murray, P.J. 2020. Reproductive seasonality and rate of increase of wild sambar deer (Rusa unicolor) in a new environment, Victoria, Australia. *Animal Reproduction Science* 223: 106630.

8. Appendices

Appendix A

Number of visitations of mammal species at each of the waterholes in TATR across two seasons

Waterhole ID	Asian Palm Civet	Barking Deer	Bat	Black naped Hare	Four horned	Gaur	Grey Langur	Grey Mongoose	Honey Badger	Jungle Cat	Leopard	Nilgai	People	Porcupine	Rhesus Macaque	Ruddy Mongoose	Rusty Spotted Cat	Sambar	Sloth Bear	Small Indian Civet	Spotted Deer	Tiger	Wild Dog	Wild Pig	All Species
1	0	11	0	4	0	14	5	0	0	0	2	0	4	4	0	0	0	61	9	0	34	4	4	11	164
01 2	0	4	0	0	0	20	20	0	0	0	0	0	8	0	0	0	0	79	8	0	43	0	4	106	291
2	0	19	0	13	2	80	23	0	1	0	4	0	4	17	0	1	0	177	25	0	4	0	6	165	543
02 2	0	0	0	0	0	11	76	0	0	0	11	0	48	3	0	3	0	28	8	0	0	0	6	37	230
3	0	0	0	0	0	0	30	0	0	0	0	0	8	4	0	0	0	72	8	0	0	0	0	13	135
4	0	51	0	0	0	46	17	0	0	0	0	17	38	8	0	0	0	34	8	0	0	25	4	30	278
04 2	0	287	0	0	0	84	17	0	0	0	0	0	59	51	0	8	0	126	17	8	0	25	8	169	860
5	0	48	0	0	4	85	27	0	0	0	1	0	6	0	0	0	0	284	13	0	1	5	4	116	595
6	7	16	0	0	0	1	35	2	0	0	0	5	5	30	0	1	0	222	4	1	41	1	21	74	467
7	0	12	0	0	41	35	80	1	0	0	8	37	11	3	0	0	0	370	0	0	0	1	11	139	749
8	1	45	0	7	3	62	111	3	0	0	8	7	14	3	1	1	0	145	8	4	0	11	14	196	645
9	0	2	0	0	4	37	11	0	1	0	1	6	45	0	0	0	0	42	8	0	5	50	0	6	217
10	0	2	0	0	0	0	15	0	2	0	3	29	17	0	0	2	0	56	5	2	10	3	2	29	175

25	24	23	22	21	20	19	18	17	16	15	14	13_2	13	11	Waterhole ID
0	0	1	0	0	1	3	0	0	18	0	2	0	11	0	**Asian Palm Civet**
0	0	7	0	0	0	28	18	7	13	0	0	8	3	0	**Barking Deer**
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**Bat**
5	0	0	0	0	0	0	0	0	0	1	8	0	3	0	**Black naped Hare**
2	0	0	0	0	0	0	0	0	0	0	1	0	3	0	**Four horned**
10	10	6	16	6	16	1	12	30	23	27	61	59	60	5	**Gaur**
43	22	33	9	9	36	45	0	89	3	51	16	24	11	18	**Grey Langur**
0	0	4	0	0	0	0	6	0	0	2	0	0	1	0	**Grey Mongoose**
0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	**Honey Badger**
0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	**Jungle Cat**
2	3	0	0	3	0	10	0	0	5	1	0	0	1	0	**Leopard**
42	6	0	3	0	3	0	0	0	0	2	0	0	0	0	**Nilgai**
5	20	7	7	3	7	15	18	15	5	29	7	0	4	10	**People**
0	0	17	0	0	1	13	0	7	8	1	0	0	23	1	**Porcupine**
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**Rhesus Macaque**
2	0	9	0	6	0	7	12	0	67	0	1	0	1	0	**Ruddy Mongoose**
0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	**Rusty Spotted Cat**
93	66	214	308	407	273	291	118	266	203	86	127	484	221	51	**Sambar**
3	9	30	0	3	4	7	12	0	3	0	7	0	0	1	**Sloth Bear**
1	0	1	0	0	0	1	0	0	13	12	0	0	5	1	**Small Indian Civet**
35	7	3	217	19	119	3	12	162	64	172	83	138	48	169	**Spotted Deer**
8	12	29	17	3	7	15	12	7	3	13	3	4	1	0	**Tiger**
2	3	0	0	0	0	3	6	0	0	17	1	4	5	20	**Wild Dog**
27	26	7	83	84	93	41	18	148	5	30	148	114	95	22	**Wild Pig**
280	183	370	661	543	561	485	242	730	431	447	469	834	497	299	**All Species**

38	37	36	35	34	33	32	30_3	30_2	30	29_2	29	28	27	26	Waterhole ID
0	0	0	135	2	8	2	0	0	0	10	0	1	0	45	**Asian Palm Civet**
7	0	0	0	0	3	0	52	71	5	0	2	0	0	0	**Barking Deer**
0	0	0	0	3	0	0	0	0	19	0	0	0	0	0	**Bat**
2	1	21	53	0	1	0	0	2	0	0	0	1	3	0	**Black naped Hare**
14	6	4	0	45	0	0	0	2	0	5	0	1	0	0	**Four horned**
9	4	13	4	8	65	23	0	10	0	3	7	0	0	0	**Gaur**
79	7	21	27	14	91	16	13	6	0	26	15	9	96	14	**Grey Langur**
0	0	0	0	0	0	0	0	2	0	1	0	0	0	4	**Grey Mongoose**
0	0	0	4	0	5	1	0	0	0	3	0	0	6	4	**Honey Badger**
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**Jungle Cat**
2	0	0	6	3	8	4	0	2	2	0	0	0	0	0	**Leopard**
0	0	0	49	11	0	65	0	0	0	3	0	0	31	0	**Nilgai**
14	9	13	24	14	12	6	20	4	14	5	5	5	12	13	**People**
2	3	4	11	8	32	1	7	16	2	13	27	6	0	4	**Porcupine**
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**Rhesus Macaque**
0	0	4	0	0	3	0	0	12	0	16	0	3	0	91	**Ruddy Mongoose**
0	0	0	1	0	0	0	0	0	0	3	0	0	0	0	**Rusty Spotted Cat**
456	341	219	48	169	132	56	203	301	191	113	523	143	174	13	**Sambar**
7	1	13	3	6	5	1	0	18	0	1	2	3	3	16	**Sloth Bear**
2	1	8	22	0	0	0	0	8	0	7	0	3	0	9	**Small Indian Civet**
14	38	0	101	16	97	136	13	8	0	0	0	90	410	41	**Spotted Deer**
32	0	0	3	5	74	7	0	2	0	7	0	31	84	5	**Tiger**
14	3	46	31	0	12	4	0	69	0	14	0	3	0	0	**Wild Dog**
286	192	143	18	28	51	4	52	234	0	4	248	13	93	0	**Wild Pig**
939	608	510	541	331	599	326	361	769	234	233	828	311	913	257	**All Species**

Total	53	52	51_2	48	46	45	44	43	42	40_2	40	Waterhole ID
300	0	0	0	0	0	2	6	0	0	35	10	**Asian Palm Civet**
780	4	0	0	28	0	27	0	0	0	0	0	**Barking Deer**
22	0	0	0	0	0	0	0	0	0	0	0	**Bat**
154	0	0	0	0	8	16	0	0	0	0	5	**Black naped Hare**
340	17	0	55	12	8	36	47	28	0	0	0	**Four horned**
1289	4	37	0	79	0	98	12	76	5	5	10	**Gaur**
2147	34	7	4	75	93	61	124	153	146	17	123	**Grey Langur**
35	0	0	0	0	0	0	0	0	0	9	0	**Grey Mongoose**
31	0	0	0	0	0	0	0	0	0	2	0	**Honey Badger**
7	0	0	0	0	0	0	0	0	0	0	5	**Jungle Cat**
110	0	0	0	0	0	20	0	0	0	0	0	**Leopard**
673	0	37	114	20	17	48	35	42	5	0	39	**Nilgai**
872	38	22	0	0	51	16	24	19	111	2	0	**People**
445	21	7	0	0	0	30	30	2	0	5	20	**Porcupine**
1	0	0	0	0	0	0	0	0	0	0	0	**Rhesus Macaque**
281	0	0	0	0	0	16	6	0	0	9	0	**Ruddy Mongoose**
5	0	0	0	0	0	0	0	0	0	0	0	**Rusty Spotted Cat**
10227	0	192	16	618	160	545	100	337	26	21	226	**Sambar**
431	4	0	0	59	34	11	6	2	0	2	34	**Sloth Bear**
130	4	0	0	0	0	2	6	0	0	9	0	**Small Indian Civet**
3425	0	59	98	326	42	5	24	28	50	101	339	**Spotted Deer**
676	17	0	4	8	34	23	18	14	3	31	15	**Tiger**
532	185	0	4	0	0	2	0	0	0	0	0	**Wild Dog**
4757	13	52	134	366	51	166	159	227	0	24	167	**Wild Pig**
27673	341	413	429	1589	497	1123	596	930	347	274	993	**All Species**

Average time spent/ visitation by all species from 54 waterholes across two seasons.

Appendix B

Waterhole ID	Asian Palm Civet	Barking Deer	Bat	Black naped Hare	Four horned	Gaur	Grey Langur	Grey Mongoose	Honey Badger	Jungle Cat	Leopard	Nilgai	People	Porcupine	Rhesus Macaque	Ruddy Mongoose	Rusty Spotted Cat	Sambar	Sloth Bear	Small Indian Civet	Spotted Deer	Tiger	Wild Dog	Wild Pig	All Species
1	0	10.6	0	0.17	0	21.85	0.95	0	0	0	0.08	0	2.58	8.03	0	0	0	124.7	4.48	0	32.92	0.17	1.45	14.43	222.4
01_2	0	0.08	0	0	0	3.83	61	0	0	0	0	0	2.57	0	0	0	0	55.9	1.97	0	22.4	0	0.08	88.3	236
2	0	22.15	0	5.32	2.37	360.95	125.1	0	0.08	0	3.8	0	13.92	11.23	0	0.08	0	645.2	32.83	0	5.4	0	10.8	1114.9	2354.1
02_2	0	0	0	0	0	15.8	214	0	0	0	3.53	0	30.03	0.08	0	0.08	0	14.52	4.43	0	0	0	0.48	19.82	302.7
3	0	0	0	0	0	0	18.2	0	0	0	0	0	0.95	7.15	0	0	0	67.2	0.33	0	0	0	0	2.97	96.8
4	0	18.9	0	0	0	91.83	51.38	0	0	0	0	3.27	175.4	5.12	0	0	0	26.92	0.25	0	0	65.57	0.08	14.92	453.7
04_2	0	101.3	0	0	0	59.27	18.57	0	0	0	0	0	54.9	1.2	0	0.1	0	125	7.2	0.08	0	1.5	0.95	130.4	500.5
5	0	70.9	0	0	2.43	615.02	125.7	0	0	0	3.13	0	18.53	0	0	0	0	1846.2	14.67	0	0.08	4.32	16.43	481.45	3198.9
6	8.72	17.65	0	0	0	0.08	246.18	1.43	0	0	0	12.65	8.2	38.55	0	0.08	0	889.58	10.9	0.08	107.2	0.55	43.2	387.13	1772.3
7	0	24.27	0	0	54.5	176.25	671.48	0.08	0	0	16.08	80.6	11	3.47	0	0	0	2271.1	0	0	0	0.08	31.12	729.42	4069.5
8	0.08	44.17	0	0.42	5.48	224.3	720.4	11.2	0	0	13.95	4.35	21.95	3.47	0.08	0.08	0	332.25	2.27	0.25	0	12.18	24.85	1024.1	2445.8
9	0	1.78	0	0	4.48	104.8	74.27	0	0.08	0	0.08	11.02	152	0	0	0	0	153.4	1.15	0	6.92	53.03	0	4.8	567.8
10	0	0.08	0	0	0	0	119.7	0	0.08	0	9.97	42.67	22.55	0	0	0.08	0	112.1	0.87	0.08	8.85	9.9	0.08	74.22	401.2
11	0	0	0	0	0	13.7	37.32	0	0	0.08	0	0	6.73	0.08	0	0	0	204.4	0.08	0.08	459.5	0	43.78	25.65	791.4

26	25	24	23	22	21	20	19	18	17	16	15	14	13_2	13	Waterhole ID
14.87	0	0	0.52	0	0	0.08	0.17	0	0	3.85	0	0.17	0	0.67	**Asian Palm Civet**
0	0	0	6.83	0	0	0	26.02	3	0.08	1.17	0	0	0.32	1.07	**Barking Deer**
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**Bat**
0	1.63	0	0	0	0	0	0	0	0	0	0.08	9.03	0	0.17	**Black naped Hare**
0	0.42	0	0	0	0	0	0	0	0	0	0	0.08	0	4.5	**Four horned**
0	40.75	50.88	1.43	31.3	14.42	28.47	0.08	0.78	20.28	20.5	102.33	277.87	89.73	210.35	**Gaur**
86.3	338.9	97.82	207	48.9	11.8	178.93	432.3	0	40.52	0.08	352	143	18.42	28.4	**Grey Langur**
0.17	0	0	0.25	0	0	0	0	0.08	0	0	0.17	0	0	0.08	**Grey Mongoose**
2.85	0	0	0	0	0	0	0.08	0	0	0	0.48	0	0	0	**Honey Badger**
0	0	0	0	0	0	0	0	0	0	0	0.08	0	0	0	**Jungle Cat**
0	8.27	11.12	0	0	7.23	0	4.47	0	0	13.2	5	0	0	0.08	**Leopard**
0	88.93	2.65	0	2.72	0	4.57	0	0	0	0	4.28	0	0	0	**Nilgai**
5.57	13.55	20.37	4.25	13.68	0.08	14.9	16.17	5.62	1.35	0.17	69.35	11.12	0	13.1	**People**
0.53	0	0	1.75	0	0	0.08	6.08	0	0.08	4.43	0.08	0	0	25.02	**Porcupine**
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**Rhesus Macaque**
11.8	0.5	0	2.27	0	0.5	0	2.53	0.17	0	7.62	0	0.08	0	0.08	**Ruddy Mongoose**
0	0	0	0	0	0	0	0	0	0	0	0	0.08	0	0	**Rusty Spotted Cat**
8.43	211.4	166.5	761.8	1341.9	573	1369.5	1476	92.92	319.4	432	269.85	513.88	391.7	696.83	**Sambar**
25.72	1.85	0.93	11.17	0	0.08	7.17	2.5	1.92	0	0.08	0	12.63	0	0	**Sloth Bear**
2.22	0.08	0	0.08	0	0	0	0.08	0	0	1.15	2.62	0	0	0.33	**Small Indian Civet**
122.2	60.37	19.2	0.45	1275	7.85	331.72	1.75	10.43	130.4	128	616.1	207.95	71.9	63	**Spotted Deer**
3.03	4.4	6.55	11.12	49.2	0.08	4.58	26.77	0.17	0.08	0.08	36.17	8.98	0.08	0.08	**Tiger**
0	2.35	3.13	0	0	0	0	0.7	0.08	0	0	40.37	0.08	0.85	4.28	**Wild Dog**
0	25.25	50.82	20.38	205.13	83.57	305.23	156.83	27.62	120.1	4.03	93.65	906.65	117.1	225	**Wild Pig**
283.7	798.6	429.9	1029	2967.8	698.6	2245.2	2152.5	142.8	632.3	616	1592.6	2091.6	690.1	1273.1	**All Species**

38	37	36	35	34	33	32	30_3	30_2	30	29_2	29	28	27	Waterhole ID
0	0	0	108.18	0.08	21.53	2.35	0	0	0	7.03	0	0.52	0	**Asian Palm Civet**
7.12	0	0	0	0	7	0	30.13	55.72	0.25	0	3.33	0	0	**Barking Deer**
0	0	0	0	0.17	0	0	0	0	1.77	0	0	0	0	**Bat**
0.08	0.08	3.6	35.32	0	0.08	0	0	0.08	0	0	0	0.08	0.08	**Black naped Hare**
5.5	1.5	0.08	0	33.6	0	0	0	1.53	0	4.47	0	1.6	0	**Four horned**
8.63	5.5	4.32	1.55	28.7	268.98	68.18	0	4.65	0	8.7	9.57	0	0	**Gaur**
128.55	33.65	26.97	165.02	51.03	1390.4	50.43	15.2	10.82	0	102.6	38.02	23.88	592.8	**Grey Langur**
0	0	0	0	0	0	0	0	0.08	0	0.08	0	0	0	**Grey Mongoose**
0	0	0	10.82	0	1.03	0.08	0	0	0	0.92	0	0	0.67	**Honey Badger**
0	0	0	0	0	0	0	0	0	0	0	0	0	0	**Jungle Cat**
8.98	0	0	7.55	5.22	9.6	2.97	0	0.08	0.08	0	0	0	0	**Leopard**
0	0	0	64.2	7.63	0	218.65	0	0	0	2.7	0	0	29.75	**Nilgai**
13	14.47	4.8	57.25	10.17	27.98	10.4	2.1	4.98	5.62	10.6	8.27	3.67	0.67	**People**
0.08	1.68	0.08	15.97	26.85	3.13	0.08	0.08	13.28	0.08	10.15	23.03	2.87	0	**Porcupine**
0	0	0	0	0	0	0	0	0	0	0	0	0	0	**Rhesus Macaque**
0	0	0.08	0	0	11.62	0	0	1.48	0	3.42	0	0.33	0	**Ruddy Mongoose**
0	0	0	0.08	0	0	0	0	0	0	3.93	0	0	0	**Rusty Spotted Cat**
1524.9	1362.8	220.5	113.25	514.9	629.77	295.98	62.65	920.8	284.5	415.5	2129	624.67	399.27	**Sambar**
1.03	0.08	8.35	0.5	4.78	6.27	0.08	0	7.15	0	0.08	0.08	0.17	0.6	**Sloth Bear**
0.08	0.08	0.17	9.42	0	0	0	0	0.33	0	3.9	0	6.9	0	**Small Indian Civet**
3.7	131.7	0	285.28	24.02	576.02	533.7	0.17	1.9	0	0	0	575.37	1647.8	**Spotted Deer**
18	0	0	6.12	10.1	86.65	2.23	0	5.1	0	0.42	0	50.68	121.82	**Tiger**
49.5	1.78	40.1	116.43	0	2.52	33.82	0	190.08	0	39.67	0	1.63	0	**Wild Dog**
1628.3	503.48	225.4	4.05	50.83	205.5	3.6	14.53	751.87	0	9.42	874.9	22.12	95.52	**Wild Pig**
3397.4	2056.8	534.4	1001	768.1	3248.1	1222.6	124.9	1970	292.3	623.6	3087	1314.5	2889	**All Species**

Total	53	52	51_2	48	46	45	44	43	42	40_2	40	Waterhole ID
214.58	0	0	0	0	0	0.08	0.08	0	0	40.35	5.25	**Asian Palm Civet**
492.52	0.08	0	0	13.43	0	25.05	0	0	0	0	0	**Barking Deer**
1.93	0	0	0	0	0	0	0	0	0	0	0	**Bat**
57.48	0	0	0	0	0.08	1.08	0	0	0	0	0.08	**Black naped Hare**
202.75	2.52	0	13.02	2.28	0.08	22.52	16.98	22.8	0	0	0	**Four horned**
3580.92	0.17	13.05	0	94.65	0	321.32	2.42	144.8	14.28	4	0.62	**Gaur**
9537.37	3.07	0.08	0.08	142.2	110.2	196.87	496.1	538.57	708.58	31.65	212.1	**Grey Langur**
13.97	0	0	0	0	0	0	0	0	0	0.33	0	**Grey Mongoose**
17.27	0	0	0	0	0	0	0	0	0	0.08	0	**Honey Badger**
0.25	0	0	0	0	0	0	0	0	0	0	0.08	**Jungle Cat**
147.63	0	0	0	0	0	13.13	0	0	0	0	0	**Leopard**
808.82	0	4.43	89.97	14.65	7.97	56.93	12.68	30.48	7.8	0	3.27	**Nilgai**
1077.73	38.63	10.1	0	0	13.22	21.4	8.47	23.62	77.65	0.08	0	**People**
258.18	4.65	0.08	0	0	0	25.08	3.7	0.08	0	3.93	6.82	**Porcupine**
0.08	0	0	0	0	0	0	0	0	0	0	0	**Rhesus Macaque**
46.38	0	0	0	0	0	0.58	0.08	0	0	2.72	0	**Ruddy Mongoose**
4.1	0	0	0	0	0	0	0	0	0	0	0	**Rusty Spotted Cat**
29697.4	0	71.68	10.47	1884.5	119.8	1279.9	141	754.18	119.47	30.75	294	**Sambar**
214.12	0.5	0	0	30.17	0.5	2.92	0.08	0.57	0	0.08	4.63	**Sloth Bear**
28.62	0.08	0	0	0	0	0.08	0.08	0	0	0.33	0	**Small Indian Civet**
9156.07	0	10.5	32.03	548.28	2.4	4.98	5.7	17.27	109.38	179	777.8	**Spotted Deer**
665.9	7.3	0	0.08	0.17	8.48	10.28	10.23	4.92	3.3	21.08	0.25	**Tiger**
778.57	77.7	0	0.08	0	0	0.08	0	0	0	0	0	**Wild Dog**
13419.9	1.78	11.95	150.6	509.87	46.95	467.48	262	937.48	0	13.02	175.4	**Wild Pig**
70422.6	136.5	121.9	296.4	3240.2	309.7	2449.8	959.6	2474.8	1040.5	327.4	1480	**All Species**