

**A COUNTRYSIDE CARNIVORE: ASPECT OF LEOPARD
ECOLOGY AT JAWAI, RAJASTHAN**

Dissertation Submitted to

Saurashtra University, Rajkot

in partial fulfillment of Master's Degree in Wildlife Science

By

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Under the Supervision of

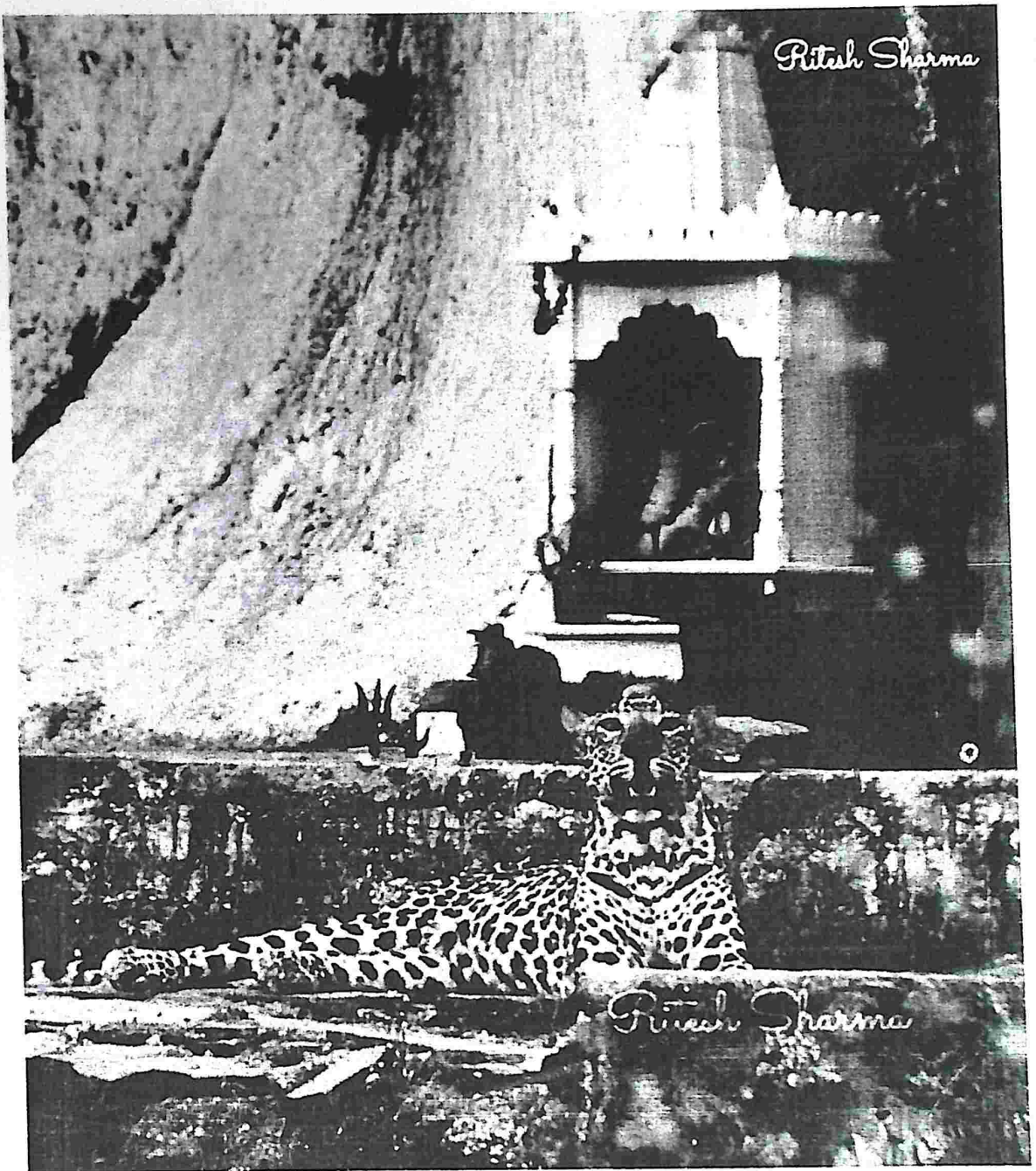
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**भारतीय वन्यजीव संस्थान
Wildlife Institute of India**

June 2017



“When my ancestors talk about the Creator they say: He is with us... We sleep with him. We hunt with him. We dance with him”.

Francis Nnaggenda



भारतीय वन्यजीव संस्थान
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CERTIFICATE

This is to certify that Mr. Ravi kr. Sharma, student of Wildlife Institute of India has carried out an original piece of research work entitled "A countryside carnivore-Aspect of leopard ecology at Jawai Dam, Rajasthan" for the partial fulfillment of M.Sc. Degree in Wildlife Science from the Saurashtra University, Rajkot, India. These investigations were carried out under our supervision from December 2016 to June 2017. We also clarify that this research has not been submitted for any other degree to any university.

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Summary

1. Increasing human population and habitat fragmentation has impacted the large carnivore population across India. Leopard among pantherine is more tolerant to human disturbance and co-occur with humans in the wide variety of habitats.
2. Study was undertaken to understand status of leopard and factors responsible for its survival in human-dominated landscape.
3. Study was conducted in Jawai Dam Community Conservation Reserve from December 2016 to April 2017 in a semi-arid region of Pali, Rajasthan, India.
4. Abundance estimation of prey was done using vehicle transect ($n=27$ and total length=98.66 Km's). Leopard abundance was estimated in 217 sq km area, using camera traps (98 days with 26 paired cameras). Data was analyzed using Distance and SECR softwares. To understand local people's perception social survey was conducted in 16 villages and interviewing 78 individuals.
5. In all the prey species domestic prey (Goat (895.91/100 km²), Sheep (157.9/100km²), Buffalo (70.14/100 km²) and Cow (54.16/100 km²)) density was higher than wild prey (Nilgai (0.89/100km²), Peafowl (10.3/100 km²)).
6. Total 11 prey species were found in diet of leopards through scat analysis and consumption of domestic was higher than wild prey (Cow (39.07%) >Langur (16.72%) >Peafowl (15.24%) >Buffalo (8.54%) > Rodent (5.72%) >Goat (4.07%) >Nilgai (3.32%) =Dog (3.46%) >Pig (2.89%) >Chinkara (0.58%) =Porcupine (0.40%)). Density of leopards was estimated 6.38 per 100km² by SECR method.
7. We examined villager's perception towards leopard by taking out the percentage of each response of respondents. Tolerance and religious view toward leopards was found significantly similar with each other, villagers has higher economic losses (livestock loss by leopards) than benefits (tourism activities) generated by hotel lobby. Villagers were examined to have minimal loss of human life and injuries by leopards, so it's easy to say about existence than co-existence or co-occurrence of both leopard and human in Proposed Jawai Leopard Community Conservation Reserve.

1. Introduction

Leopard (*Panthera pardus*) is one of the most widely distributed large felid in Africa and Asia. As the leopard lives in human-dominated landscape (Singh, 2005, Athreya, et al. 2013), it is listed in Schedule I of Wildlife Protection-1972 with the highest level of protection and at the same time leopard is categorized as vulnerable in IUCN Red list (IUCN Red List of Threatened Species 2016).

The adult leopard weighs between 20 kg and 90 kg (Stuart and Stuart, 2000). Head plus body length of male and female leopard recorded is 203-243 cm and 180-208 cm respectively (Menon V., 2014). Leopards have been seen breeding without being season specific all over the year. The gestation period of leopards has been reported for three months (Daniel, 1999). One of the findings from occupancy survey resulted that leopards occupied 174,066 km² of forest habitat in India (Jhala, et al. 2015).

Focusing on threats to leopard survival includes habitat degradation and destruction, poaching and shrinking prey base (Nowell and Jackson, 1996; Ray, et al. 2005). Increasing human population has increased the chances of interaction between human and leopard. These interactions produce negative and positive which resulted into loss of both human and leopard. Demand for skin, teeth, bones and other parts of body is one of the major threats from several countries worldwide for leopard (IUCN Red List of Threatened Species 2016)

Though most places exhibit retaliation of humans to conflict animals, certain areas do pose conservation success stories with the harmonious existence of wildlife and humans. Conflict is biggest threat to livestock, attacks on humans, with the animal intending to keep away or even kill, fall in the extreme end of the direct contact category (Thirgood, et al. 1986). Attacks on humans by wildlife are not new. It is important to note that humans have been preyed upon wild animals from the earliest times in human history (Kruuk, 2002).

2. Rationale of the project

Understanding ecology, behavior, biology, population dynamics are key to conservation of large feline species. In recent years few studies have been done solely on leopards in India focusing in both human-centric and protected areas (Athreya, et al 2004, 2006, 2011, 2013, 2014, 2016; Chauhan, et al. 2005; Edgaonkar, 2008; Sankar, et al. 2008; Harihar, et al. 2009; Kalle, et al. 2011 and Mondal, et al. 2012).

In protected areas, increase in tiger numbers often correspond to lower leopard numbers (Harihar, et al. 2011, Mondal, et al. 2012), as Tigers are known to kill and displace Leopards (McDougal, 1988, Odden, et al. 2010). On the other hand, leopard found to outnumber any big cats when it comes to survival in marginal and fringe habitats (Athreya, et al. 2013). “High conflict is reported in some areas resulting in lethal control of problem individuals” (Athreya, et al. 2013). Leopards become accustomed near human-dominated landscape based on accessibility of easy prey as in domestic and feral animals.

The current study was prepared to evaluate how leopards are coexisting with humans in proposed Jawai Dam Leopard Community Conservation Reserve.

3. Study area:

Jawai dam leopard conservation reserve is situated in southern parts of Aravallis, (73°8'48.64"E latitude and 25°6'6.26"N longitude) which is surrounded by Pali Division and the southern end of Kumbalgarh Wildlife Sanctuary(Annual Report, 2014). Geographically the area of this reserve falls within revenue limits of Pali District of Rajasthan. Historically five sq.km catchment area of Jawai Dam was declared as closed area in May 1983. After the closed area lost its legal status due to amendment 2002 in Wildlife Protection Act, 1972, area was established as Jawai Dam Conservation Reserve in the year 2013. The Dam which forms the major source of drinking water for western Rajasthan is constructed on Jawai River which is one of the western-flowing rivers of Rajasthan and also joins Luni River, which empties in Rann of Kutch.

The Conservation Reserve covers 19.78 sq. km. with the catchment area of Jawai dam and five villages Doodni, Balwana, Bisalpur, Sena, Jeewda at the fringes of established reserve area (Anon, 2012). Looking at the status of its unique floral, faunal, avifaunal diversity, including globally vulnerable apex predator present in the area, a proposal was developed by the forest department to enlarge the established reserve area to cover and conserve the leopard occupied area (mostly falls outside reserve area) of about 309 sq. km. The proposed area is planned to keep conservation reserve with an addition of community reserve i.e. Jawai Leopard Community Conservation Reserve (Figure 3). Proposed area includes 21 villages with catchment area of Jawai Dam.

Figure 1: Jawai Dam

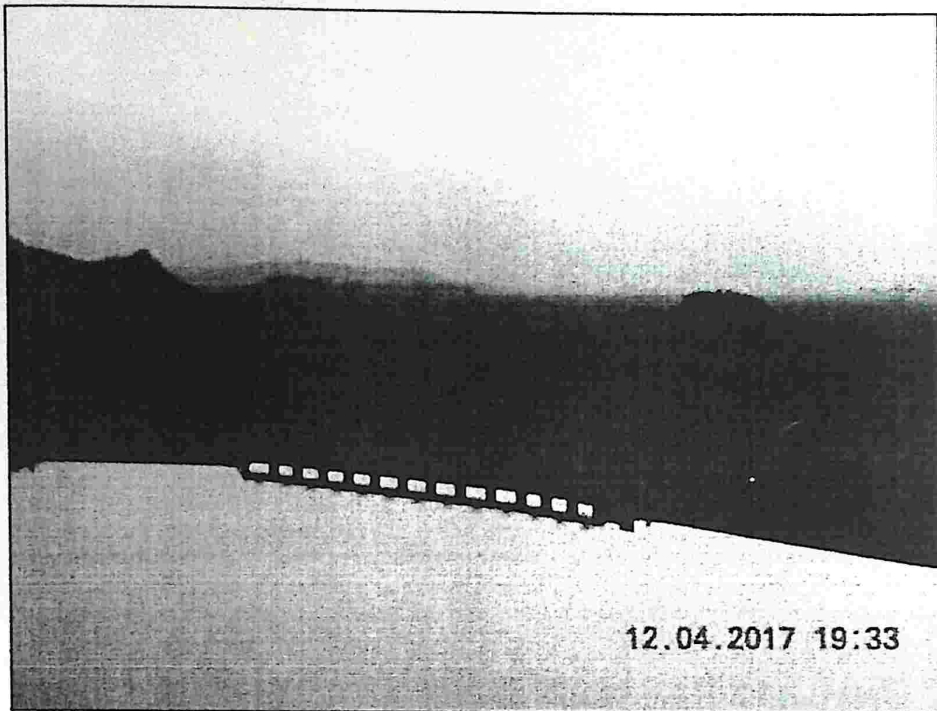


Figure 2: Agricultural settlement close to hills

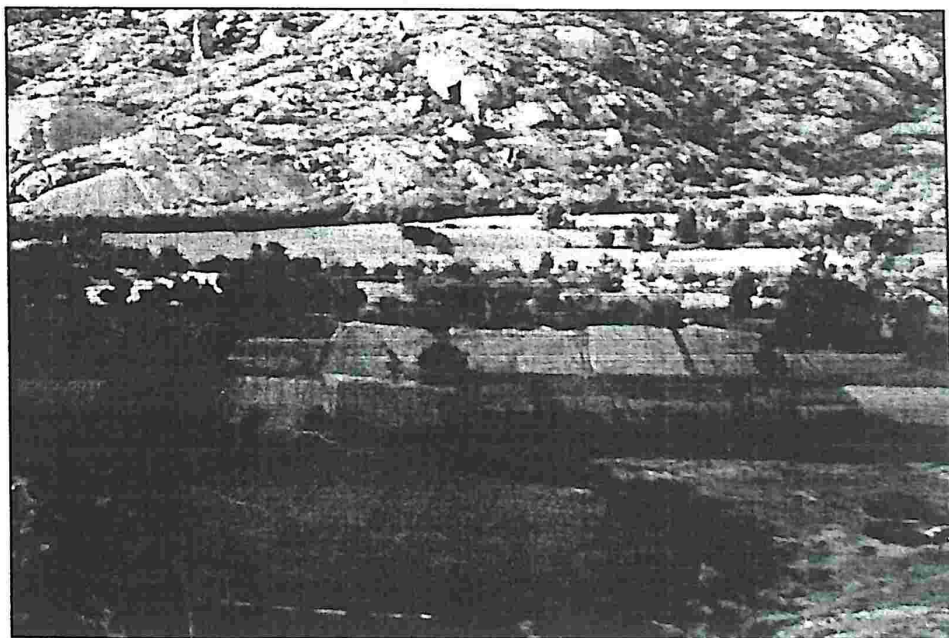
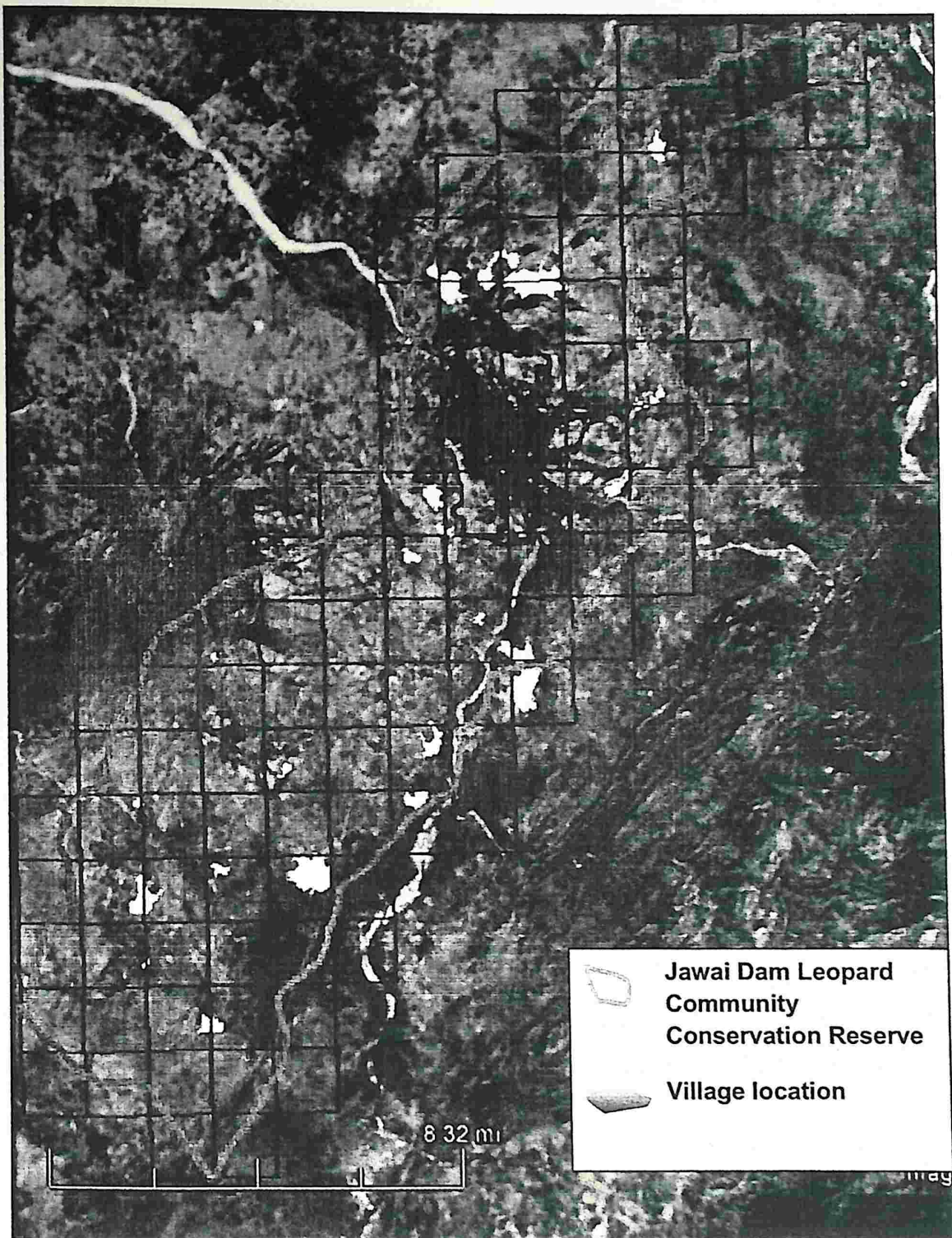


Figure3: Map showing village locations in the study area



3.1. Vegetation:

The area falls under the forest type category II Tropical Dry Deciduous forests (Champion & Seth, 1968). The dominant trees are *Anogeissus pendula*, *Mitragyana parviflora*, *Bauhinia racemosa*, *Acacia catechu*, *Acacia Senegal*, *Greweia flewecence* and *Wrightia tinctoria*, etc. (Proposal for JLCR, Annual plan, 2014).

3.2.Mammals:

Leopard (*Panthera pardus*), top predator of the study area is the key point of attraction for everyone in the speckled rocky outcrops, other mammalian fauna includes Common langur (*Semnopithecus entellus*), Striped hyena (*Hyaena hyaena*), Golden jackal (*Canis aureus*), Jungle cat (*Felis chaus*), Rusty spotted cat (*Prionailurus rubiginosus*) Sloth bear (*Melurus ursinus*), Honey badger (*Mellivora capensis*), Small Indian civet (*Viverricula indica*), Ruddy mongoose (*Herpestes smithii*), Grey mongoose (*Herpestes edwardsii*), Indian crested porcupine (*Hystrix indica*), Chinkara (*Gazella bennettii*), Bluebull (*Boselaphus tragocamelus*), Wild pig (*Sus scrofa*) and Five-striped palm squirrel (*Funambulus pennantii*).

3.3.Avi-fauna:

Catchment area of Jawai Dam and other Dams present in the study area is home to several, residential and migratory birds which provide them breeding, feeding, perching, etc. sites. Greater flamingo, Pelicans, Storks, numerous species of Ducks, Cormorants, Herons, Egrets, Lapwing etc along with several shore birds Eurasian curlew, Godwit, Painted snipe, Black winged stilt, Sandpipers etc, and arboreal birds like Grey hornbill, barbet, Eurasian wryneck, Woodpeckers etc. Numerous species of Warbler, Munia, Flycatcher, Shrikes, and wheatear, Raptors like Falcon, Osprey, Black kite, Eurasian Eagle Owl, Buzzards etc. have been reported from the study area.

3.4.Reptiles:

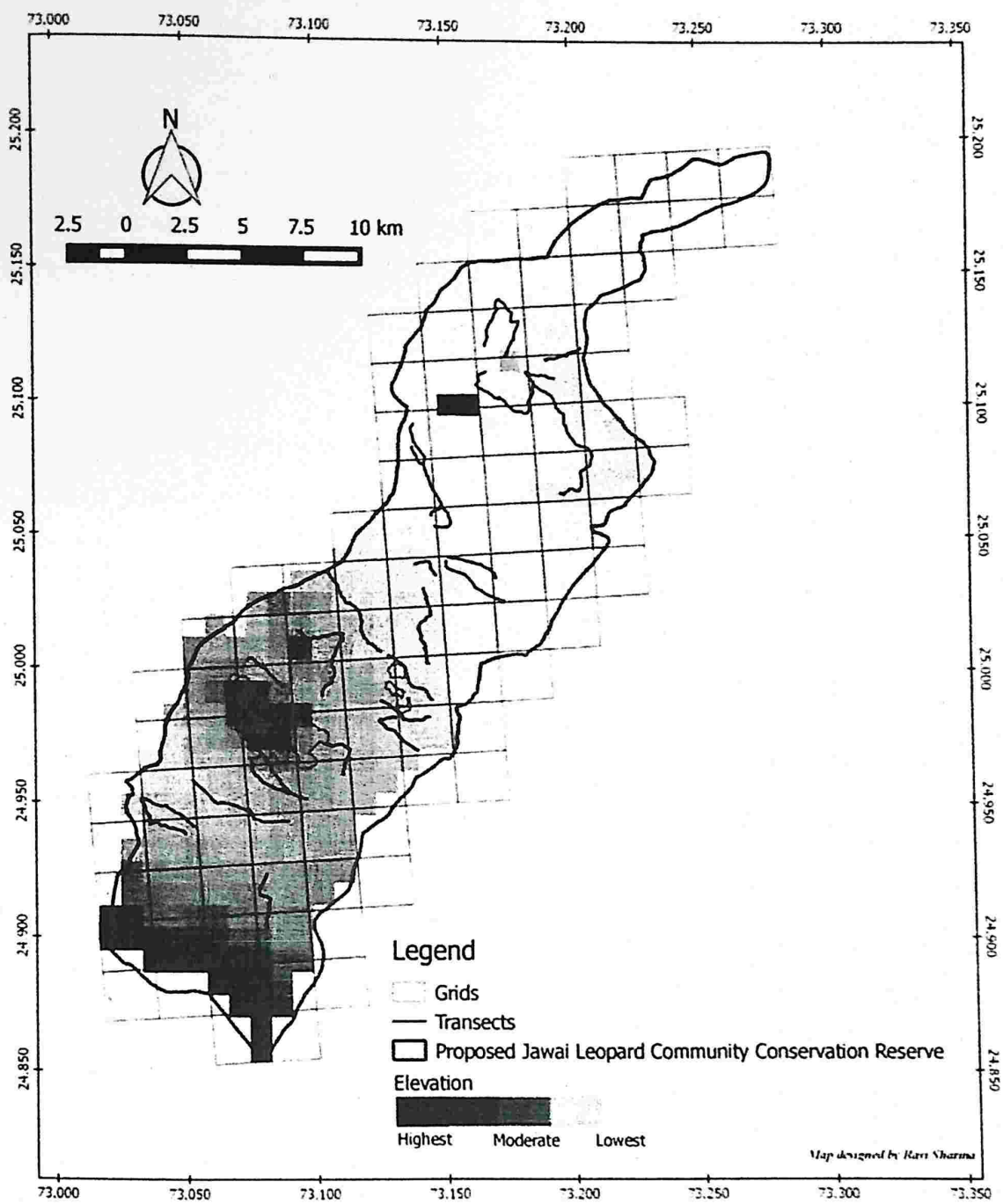
Reptilian diversity also makes the area a complete food chain of ecosystem. Marsh crocodile, Indian rock python, Wolf snake, Common trinket, Saw-scaled viper, Rat snake, etc. Star tortoise can be seen on the hillocks very easily, Flapshell turtle is also recorded from study area.

4. Methods

4.1. Estimation of wild and domestic prey abundance in the study area:

Distance sampling was done using transect. Twenty seven transects covering 98.66 km were traversed area a period of ninety days. GPS, SUNTO compass and Hawk range finder was used for reading position, angular distance and angle. LOCUS MAP Application was used for mapping transects (Figure 4). Program DISTANCE (Buckland, 1993) was used to calculate densities of individual prey species.

Figure 4: Map showing transects



4.2. Dietary composition of leopard in the study area

Scat analysis was carried out using prey remains from leopard scats. Confirmed leopard scats were collected from identified leopard occupied hillocks and dens. Only a few scats (n=5) were collected from trails after being confirmed. Storage of scats was done in zip lock bags after putting scats to be dried in sun light for 72 hours. Undigested materials like nails, claws, quills, hairs were collected from scats during analysis. Scats were not washed under running water to get appropriate frequencies of prey remains to compute whole scat equivalence during analysis. Identification of prey remains was done following (Mukherjee et. al., 1994). Analysis of data obtained was computed for relative frequencies of occurrence of individual prey and preferences of prey were appraised software SCATMAN.

4.3. Estimation of leopard population in the study area

Study was conducted out in 309 Km² area of proposed community conservation reserve from January 2017 to April 2017. The entire study area was divided into two blocks and sub-divided into cells of 2x2 Km². Initially, 41 cells were identified for camera placements of which only 26 cells were used due to logistics difficulties. Hotel owners and crop field owners did not allow cameras to be operated on their property. Cameras were operated for a period of 54 days in block first and 44 days in block second.(Figure 5) Individual leopard were identified by a combination of unique character such as shape and position of rosettes on flanks, limbs, and forequarter (Karanth, 1995). 15 images of leopards were not used for identification due to over-exposed. SECR matrix format was chosen to design capture history of each individual. All the analysis was done in Mark & SECR framework. Meanwhile, other captured animals during camera trap session were utilized to compare the temporal overlap with leopards. CamTrap R program was used to analyze the data.

Figure 5: Map showing camera trap locations in study area

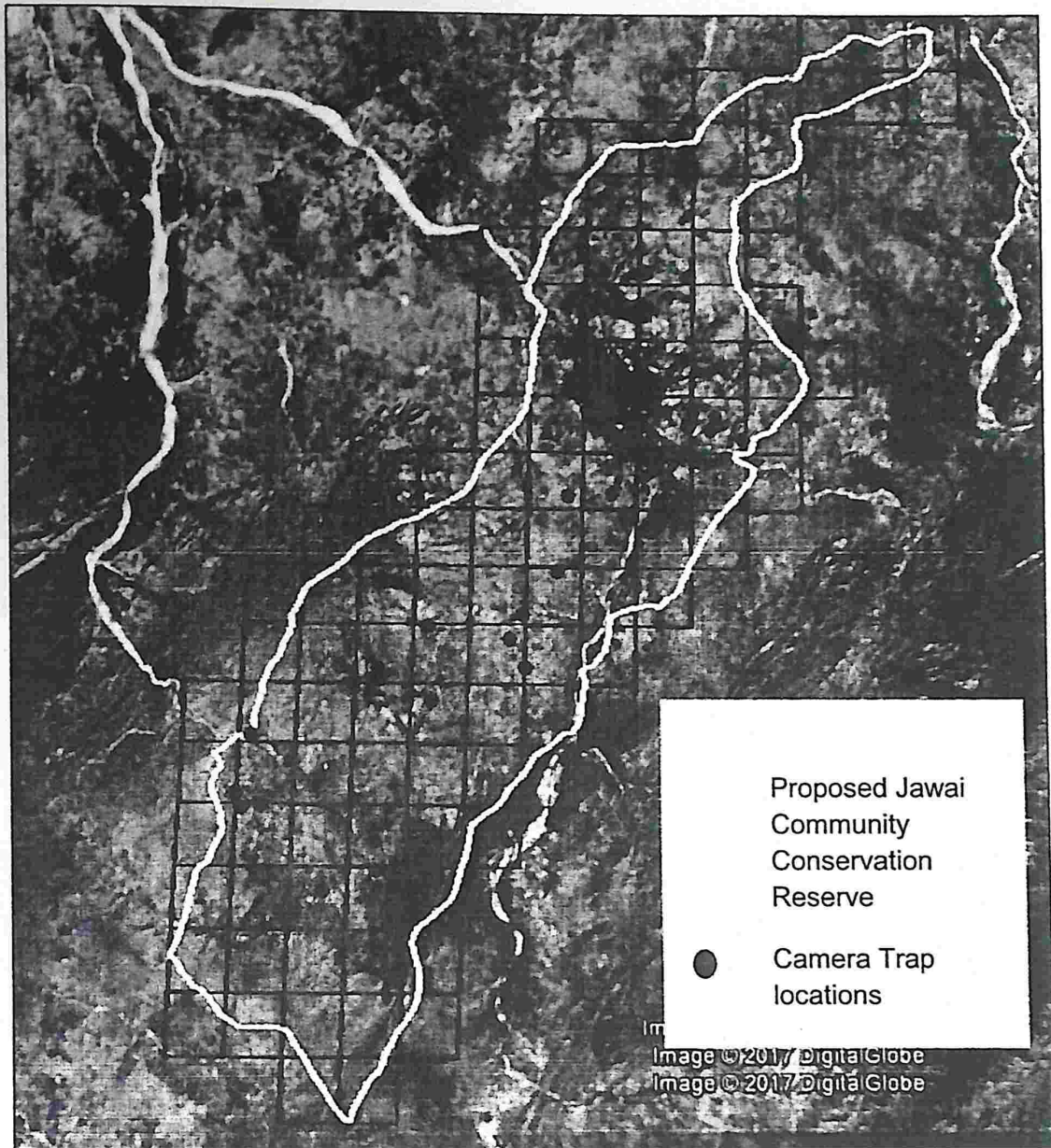


Figure 6: Confirming the leopard signs



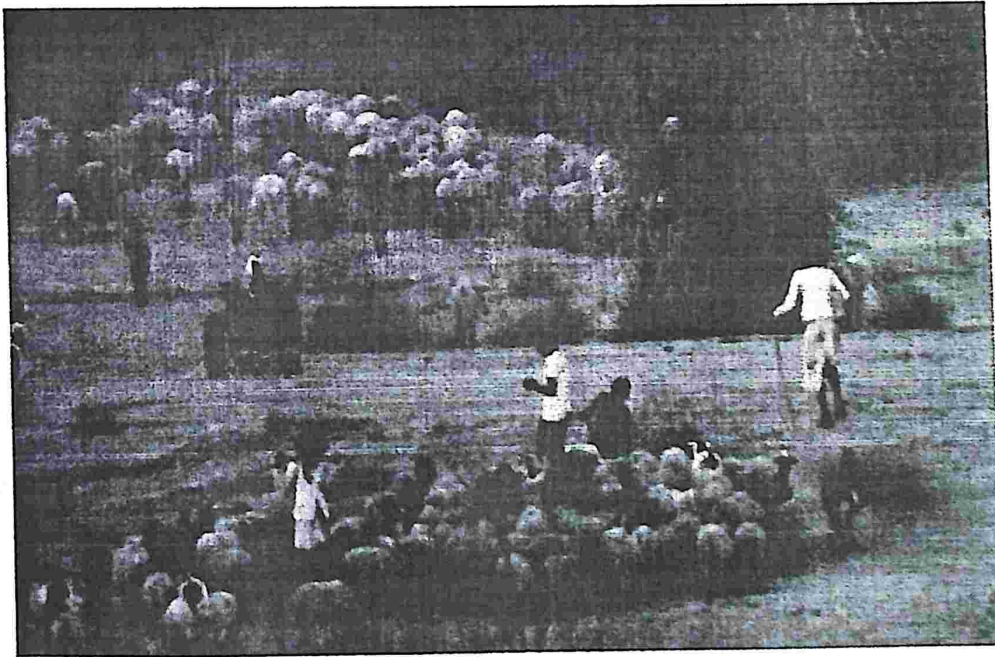
Figure 7: Camera trap placement



4.4. The people's perception towards leopards

To understand people's perception towards leopards present in the study area fixed and open-ended questionnaire survey was conducted out. Initially, all the villages were supposed to cover in the interview but most of the villagers from five villages denied to interview as they were not in support of proposed community reserve. Selection of respondents was random by focusing mostly on local shepherd community Rabari. A total of 78 respondents were interviewed from sixteen villages of proposed Jawai Leopard Community Conservation Reserve. Socio-economic structure of the local people, their respective occupation, pastoral lifestyle changes and attitude towards wildlife was the main focus to understand during the interview. All the respondents were above 20 years. Interviews were carried out in local dialect belongs to the study area i.e. 'Marwadi' by hiring local assistant and volunteer to get more robust and mutual understanding.

Figure 8: Interviewing the local herder



5. Results

5.1. Estimation of wild and domestic prey abundance in the study area:

Thirteen likely prey species were recorded on the transect. Most encountered prey species were livestock (Buffalo, Cow, Goat, Sheep, Pig, Horse, Camel, and Donkey) followed by the feral dog, Common langur, Peafowl and squirrel. Langur and wild pig encounters were low.

Table 1: Models selection and effective strip width based on global model fitted for each group

Category	Prey species
I. Large prey	Cow
	Buffalo
	Nilgai
	Camel
II. Medium prey	Goat
	Sheep
	Pig
III. Small prey	Squirrel
IV. Feral	Dog
V. Avian	Peafowl

Table 2: Density estimation of individual prey species

Group	Species	No. of groups (n)	n/l	SE	DS	SE	D	SE
I	Buffalo	52	0.52	0.19	5.48	18.42	70.14	18.42
	Cow	59	0.59	0.19	6.22	1.19	54.16	15.07
	Nilgai	4	0.4	0.01	0.42	0.19	0.89	0.58
	Camel	2	0.2	0.01	0.21	0.14	3.58	3.8
II	Goat	31	0.48	0.12	8.74	2.18	895.91	390.79
	Sheep	16	0.25	0.01	4.51	1.46	157.9	100.15
	Pig	3	0.46	0.02	0.84	0.46	7.16	4.75
III	Squirrel	49	0.601	0.22	79.885	55.86	139.65	98.27
IV	Dog	36	0.51	0.14	17.87	4.3	50.5	13.7
V	Peafowl	20	0.20	0.004	2.74	1.07	10.3	4.6

Min AIC: Minimum Akaike Information Criteria value

ESW: Effective Strip Width

n: Number of group

D: Estimate of density of animals

DS: Estimate of density of clusters

n/l: Encounter rate of number of animals per kilometre, transect walk

SE: Standard error

In the study area sightings of animals were low so they were divided into five groups and global detection model was fitted for estimation on effective strip width (Table 1) and to calculate density (Table 2). Species wise density estimate was derived from the global model fitted for each group. Chinkara was not captured, encountered on camera trap or transect respectively but they were seen in southern part of study area.

5.2. Dietary composition of leopard in the study area

A total of sixty leopard scats were analyzed. Eleven species of prey including wild, domestic and feral were categorised. The contribution of domestic prey (47.2%) was not much higher than wild prey (44.7%) in leopard's diet. Relative biomass consumed was calculated using leopard specific model by Chakrabarti's equation (Chakrabarti et. al., 2016). A curve for species number with respect to scat was generated to find out adequacy of sampling (Fig 9). Thirty-three leopard scat sample reached an asymptote and can be believed to represent the food spectrum of leopards in Proposed Jawai Dam Leopard Community Conservation Reserve.

Figure 9: Adequacy curve of sample size of leopard food spectrum by scat analysis

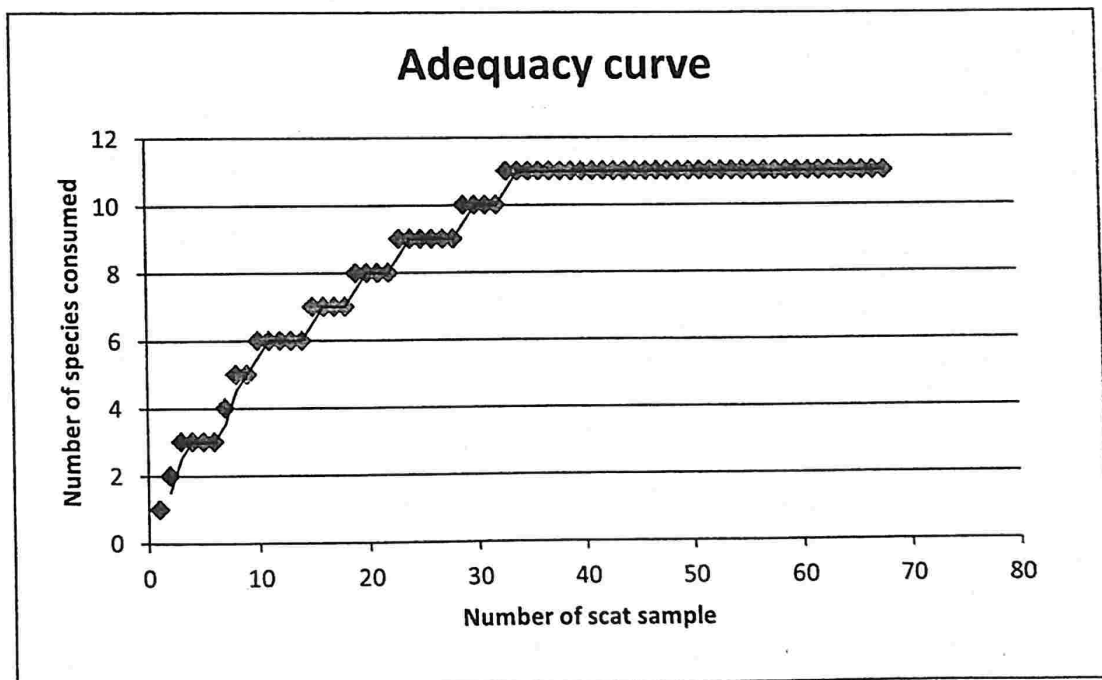
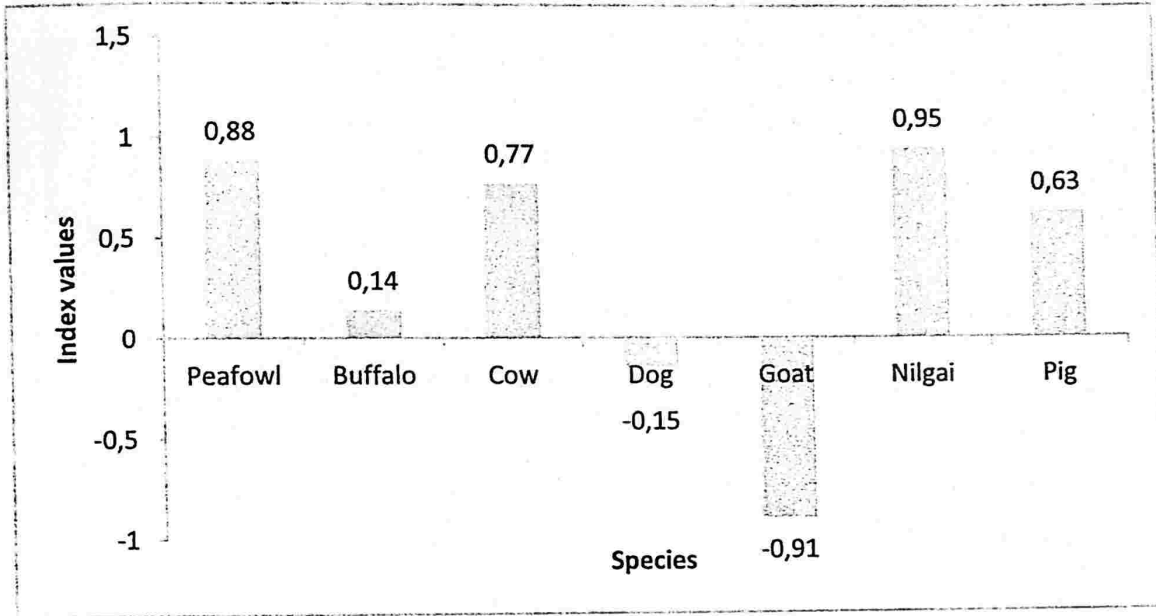


Table 3: Total biomass consumed for each prey remains in leopard scat from the study area.

Species	Biomass consumed per collectable scat $Y=2.171-1.671*EXP(-0.056*X)$ (gms)	Average body weight (kg)	Whole scat equivalence	Prey biomass consumed (kg)	Relative biomass consumed (%)
Cow	1.54	136	17.4	26.80	39.07
Langur	1.19	14	9.6	11.47	16.72
Peafowl	1.16	4	9	10.45	15.24
Buffalo	0.98	150	6	5.86	8.54
Rodent	0.87	0.25	4.5	3.93	5.72
Goat	0.80	27	3.5	2.79	4.07
Dog	0.77	18	3.1	2.38	3.46
Nilgai	0.76	136	3	2.28	3.32
Pig	0.73	38	2.7	1.98	2.89
Chinkara	0.56	20	0.7	0.39	0.58
Porcupine	0.55	14	0.5	0.27	0.40

Cow, langur, peafowl and buffalo were found to be commonest item followed by rodent goat and dog in leopard's diet. Cow (39.07%) >Langur (16.72%) >Peafowl (15.24%) >Buffalo (8.54%) > Rodent (5.72%) >Goat (4.07%) >Nilgai (3.32%) =Dog (3.46%) >Pig (2.89%) >Chinkara (0.58%) =Porcupine (0.40%) (Table 3).

Figure 10: Ivlev's Index for major prey species of leopard in study area



While looking at the proportion of availability and consumed of both domestic and wild prey by the leopard in the study area resulted in the usage of Cow, Peafowl, Nilgai, Pig, and Buffalo was more consumed than their availability but Goat and Dog were less consumed than their availability.

After incorporating the uncertainty in prey available estimates using simulation software SCATMAN prey selection did not significantly differ from what has been reported above using Ivlev's Index (Fig. 10). However, although buffalo and dog show selection and nonselection respectively through Ivlev's Index, such estimates were found to be insignificant using SCATMAN (Table 4). This might be owing to the high variability of density estimates on buffalo and dog.



Table 4: Prey selection in leopard's diet through SCATMAN (with 20% CV)

Species	Observed	Expected	Adjusted p-value
Peafowl	9	0.01	0.00
Buffalo	6	6.62	0.80
Cow	17	6.25	0.00
Dog	3.1	1.19	0.07
Goat	3.5	27.4	0.00
Nilgai	3	0.13	0.00

5.3. Estimation of leopard population in the study area

Fourteen leopards were identified from a total of 117 photographs. The conventional method and spatially explicit capture-recapture maximum likelihood approach (Efford, 2004) was used to estimate the abundance and density of leopard. Abundance was estimated using program Mark (Table 5) (Burman & White, 1999) and SECR (Table 6) were fitted using SECR (R version 3.4.0).

Table 5: Model selection and tests for Models Mo, Mb, Mt and Mtb in the mark-recapture framework

Leopard population		
Full likelihood		
Model	AIC	Estimated population (SE)
Mo	232.8	15.0 (1.5)
Mb	234.5	16.2 (3.8)
Mt	270.6	14.7 (1.4)
Mtb	319.0	14.0 (0.4)

5.4. Leopard density estimation

Table 6: Density estimation for leopards using different model in MLSECR

Model	AIC	Density/100 km² (SE)
g0[.]s[.]	137.7	6.38 (2.2)
g0[b]s[b]	153.9	1.68 (0.04)
g0[h2]s[h2]	148.0	3.65 (0.37)

g0[.]s[.]: Null model

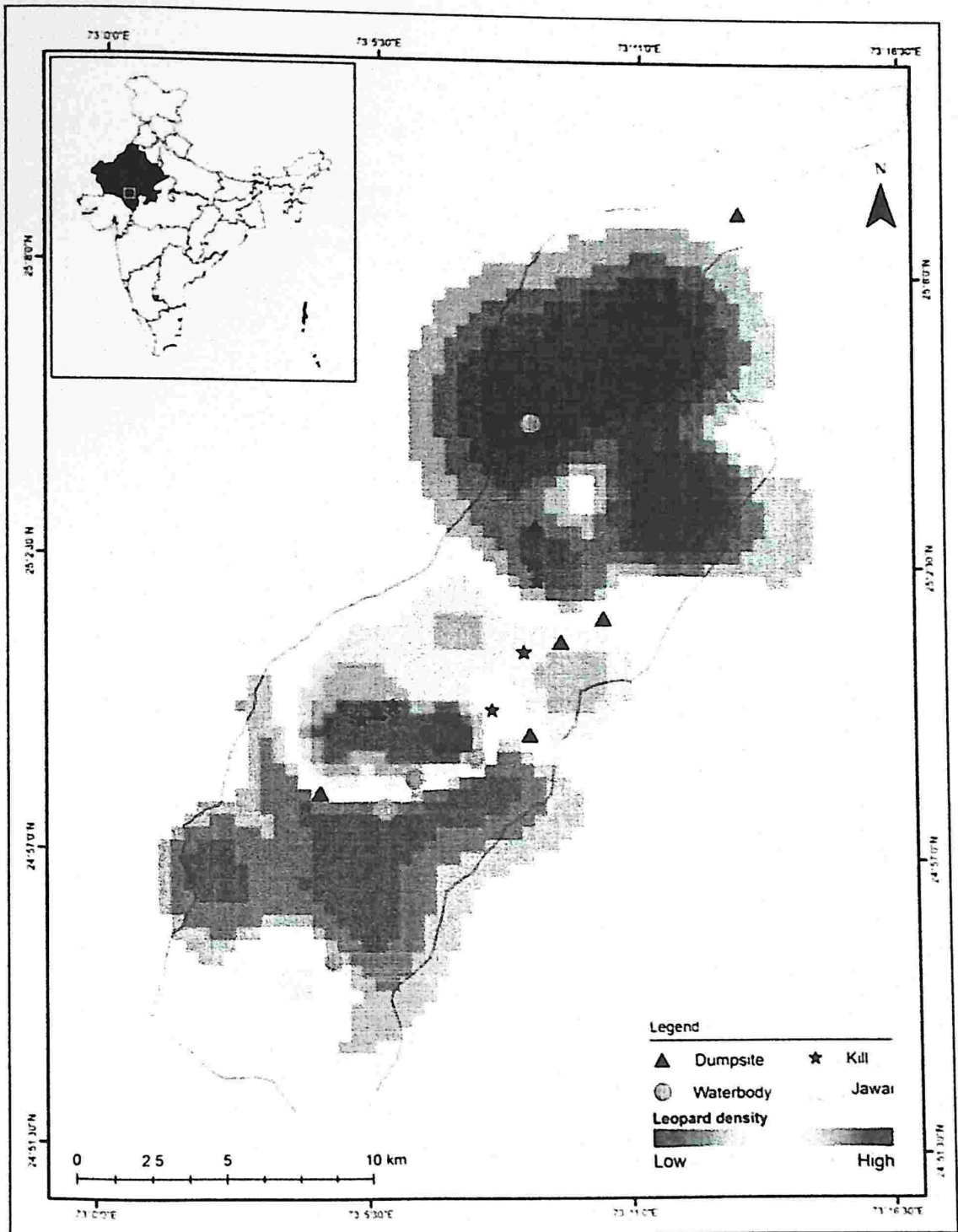
g0[b]s[b]: Behavior model

g0[h2]s[h2]: Heterogeneity model

AIC: Aikaike information criteria value.

Based on several model shown above (Table 6) Null model calculated leopard density was, $6.38 \pm 2.24(\text{SE})$ at a confidence interval of 95%. Density surface map was also generated through SECR (Figure 11)

Figure 11: Leopard abundance map in the study area



5.5. Temporal overlap of prey species (Wild & Domestic) with leopard

Temporal activity of leopard was found highly overlapped with Peafowl but the livestock has significant segregation in temporal activity with leopards.

Figure 12: Temporal activity and overlap of leopard with peafowl

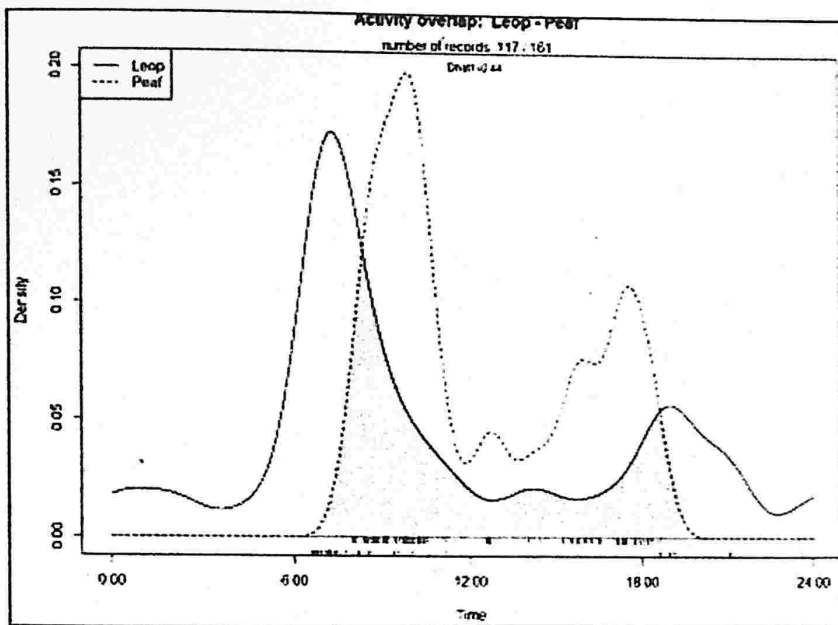


Figure 13: Temporal activity and overlap of leopard with livestock

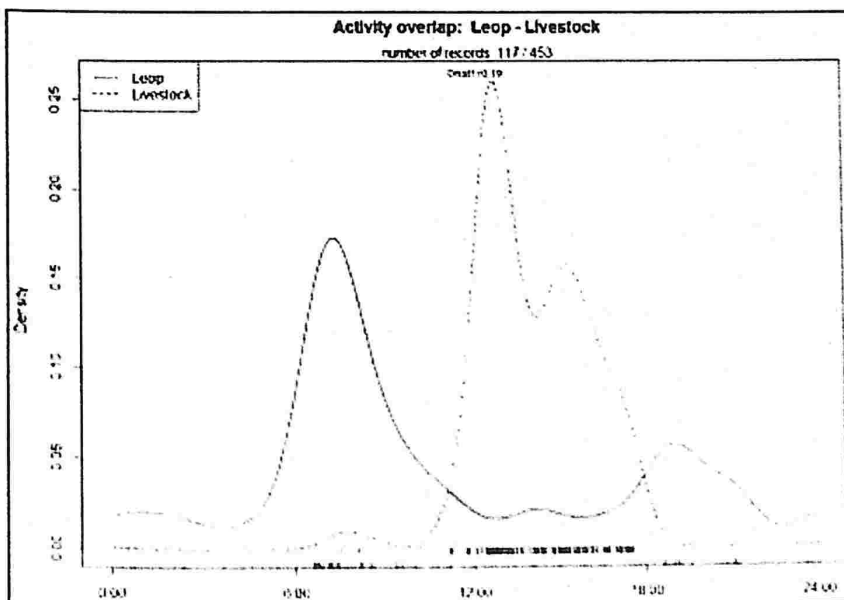


Figure 15: Leopard capture in camera trap

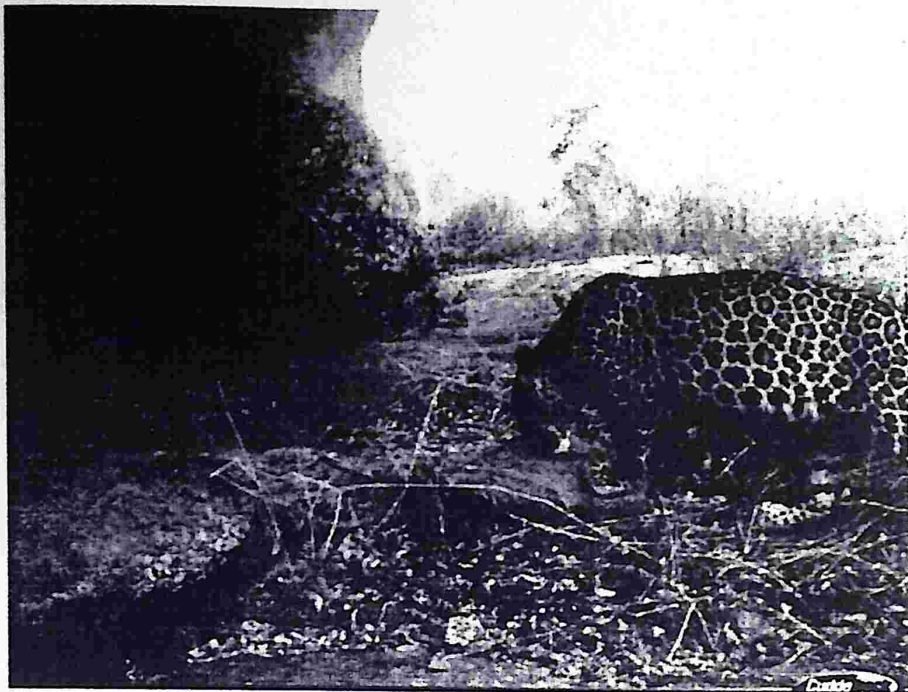


Figure 16: Female leopard with two cubs



5.6. The people's perception towards leopards

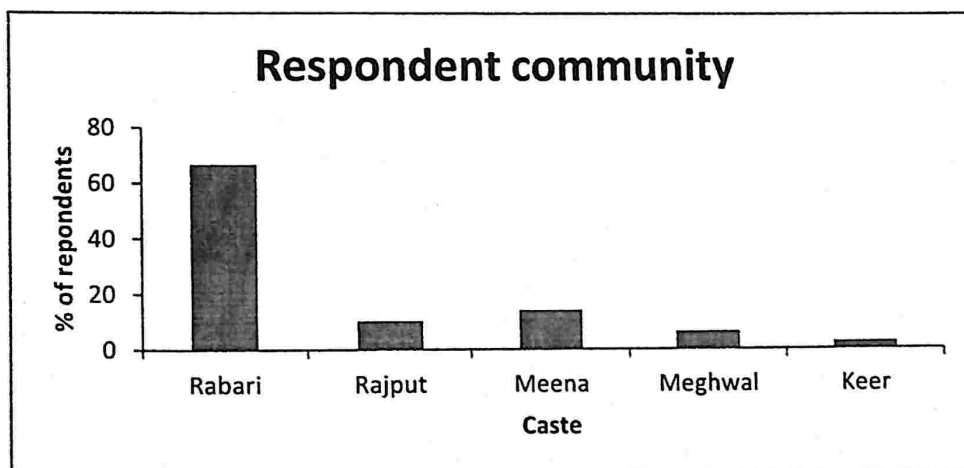
All the responses from interviews were analyzed by taking village wise proportion of answers in MS-excel to get an overview of responses to several questions. All the answers were calculated on scoring criteria. Datasheet was divided into two categories; i) economic structure of respondent their lifestyle and ii) perception toward leopards in the area (reason of coexistence with leopard, the level of acceptance of livestock loss by leopard, benefits of leopard being in the area, and religious view). The Majority of people interviewed were found with an average age of 46.9 (3.7 SE).

5.6.1. Social and economic structure

a) Respondent community

Majority of respondents (n=78) from each village attempted were Rabari (66.66%) followed by Meena (14.10%), Rajput (10.25%), Meghwal (6.4%) and Keer (2.5%) community

Figure 17: Community responded in interview



5.6. The people's perception towards leopards

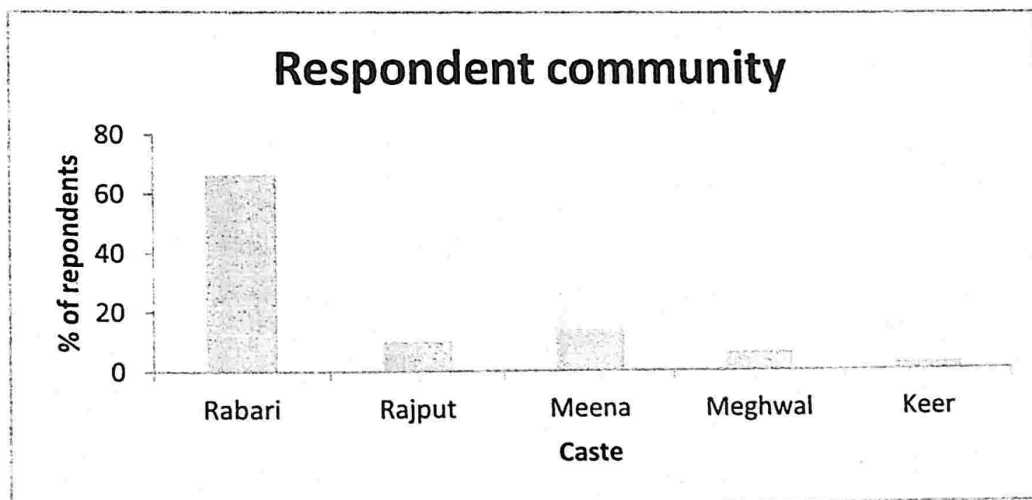
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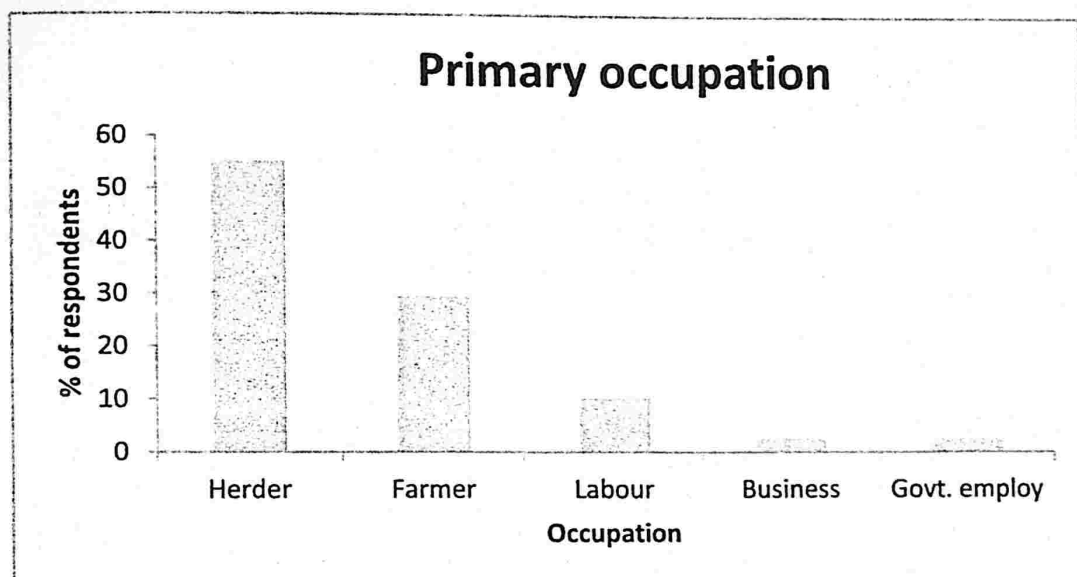
Figure 17: Community responded in interview



b) Primary occupation of respondents

As area is semi-pastoral land and dominated by Rabari community majority of the respondent (n=78) were found to be occupied as herders (55.12%), farmers (29.48%) followed by labors (10.26%), businessmen (2.5%) and government employ (2.5 %).

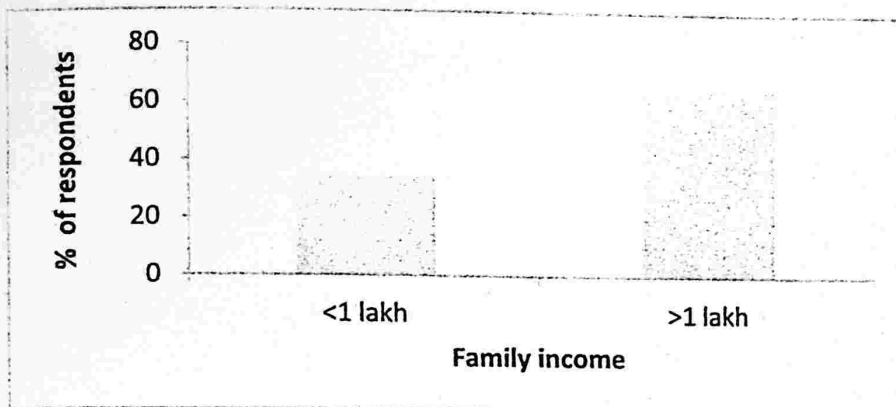
Figure 18: Responses on primary occupation in interview



c) Family income of respondents

Family income of respondents (n=78) was categorized in two groups >1 lakh/annum and <1 lakh/annum. Respondents were found >1 lakh/annum (65.38%) and <1 lakh/annum (34.61%). Income of respondents were carried out by direct asking and mostly assumed by their occupations and their living style (House structure, clothing, and footwear, etc).

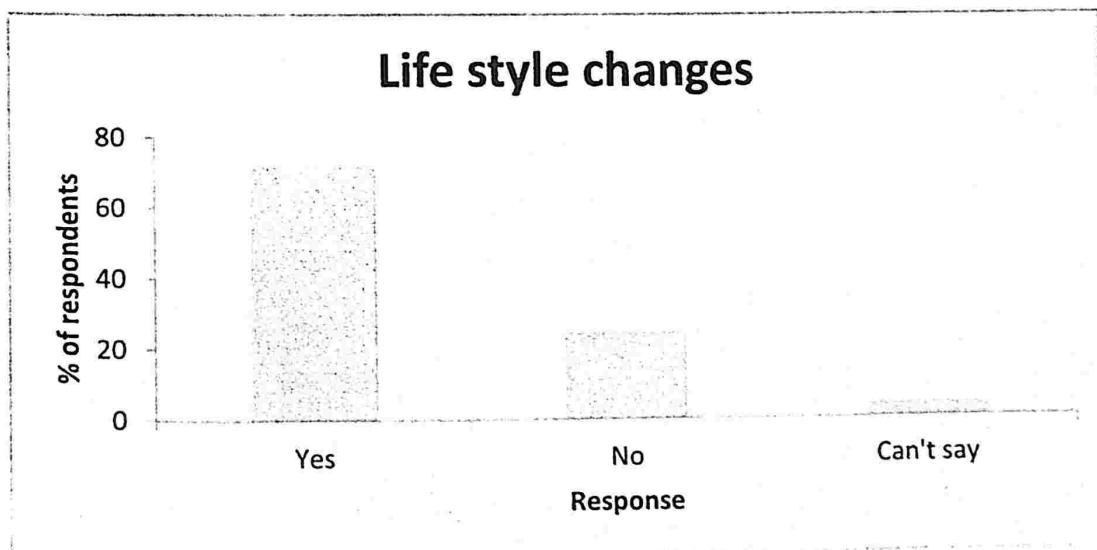
Figure 19: Responses on family income in interview



d) Changes in lifestyle over the years

The majority of respondents (n=78) agreed for Yes (71.79 %) followed by no (24.35%) and few respondents did not respond to any question (3.8 %) about change in their pastoral lifestyle over the year.

Figure 20: Responses of change in life style over the years.

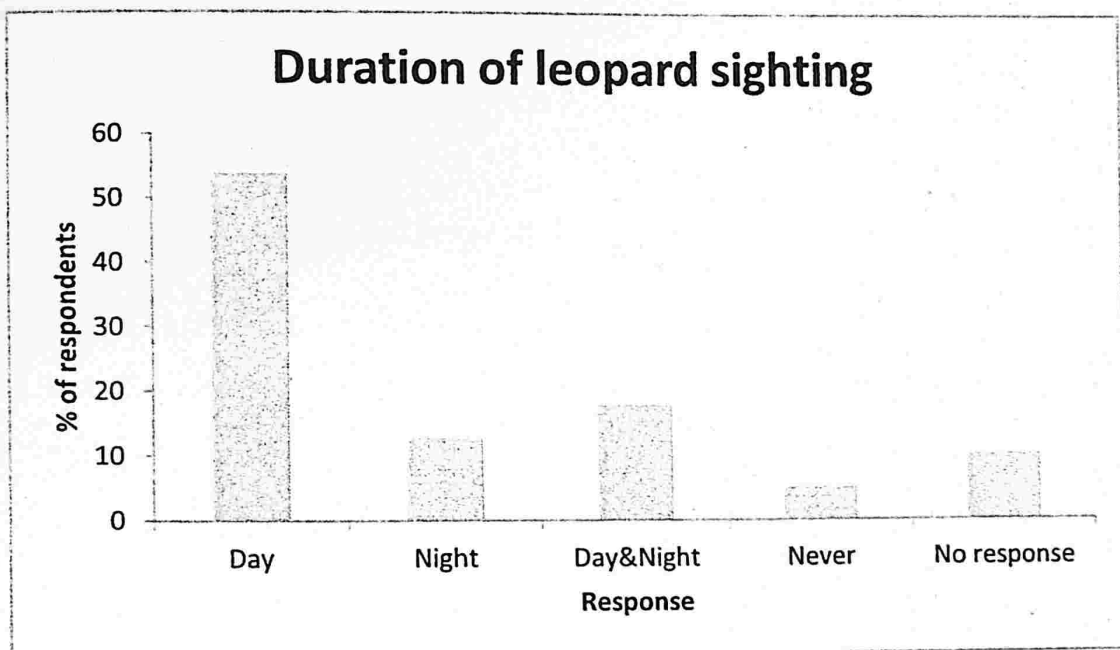


5.6.2. Perception toward leopard in the area

a. Time of leopard sighting by villagers

Frequency of leopard sighting by respondents (n=78) were Day (53.8%), Day & Night (17.9%), Night (12.8%), never sighted (5.1 %) and few respondents did not respond to the question (10.25%)

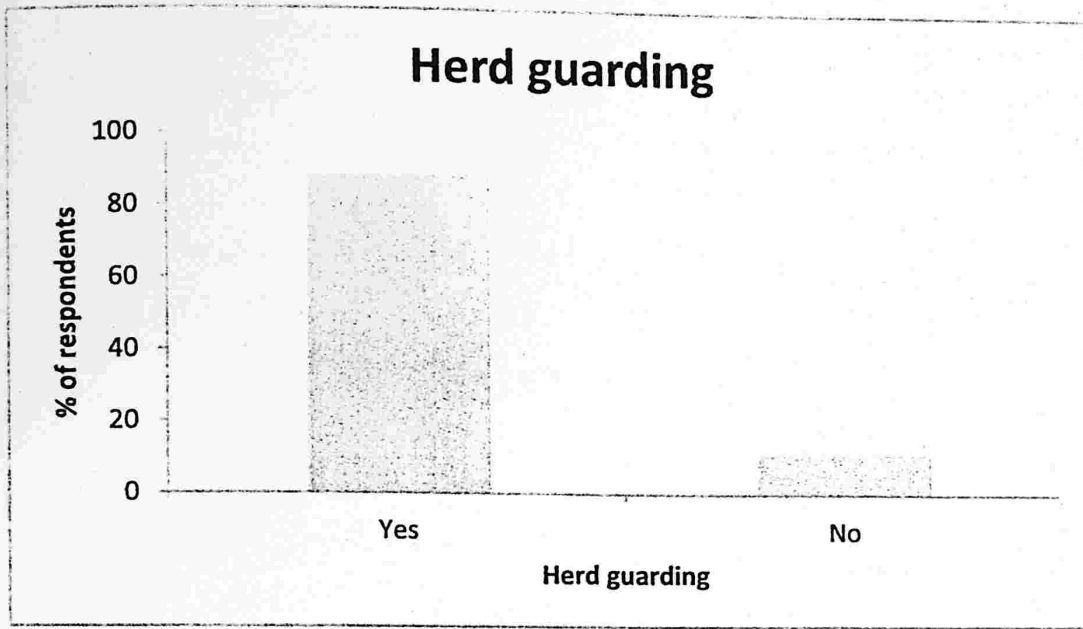
Figure 21: Responses of leopard sighting on temporal scale in interview



b. Guarding of livestock by villagers

The majority of respondents (n=78) were found to be Yes (88.46%) and No (11.54%) for guarding their grazing livestock.

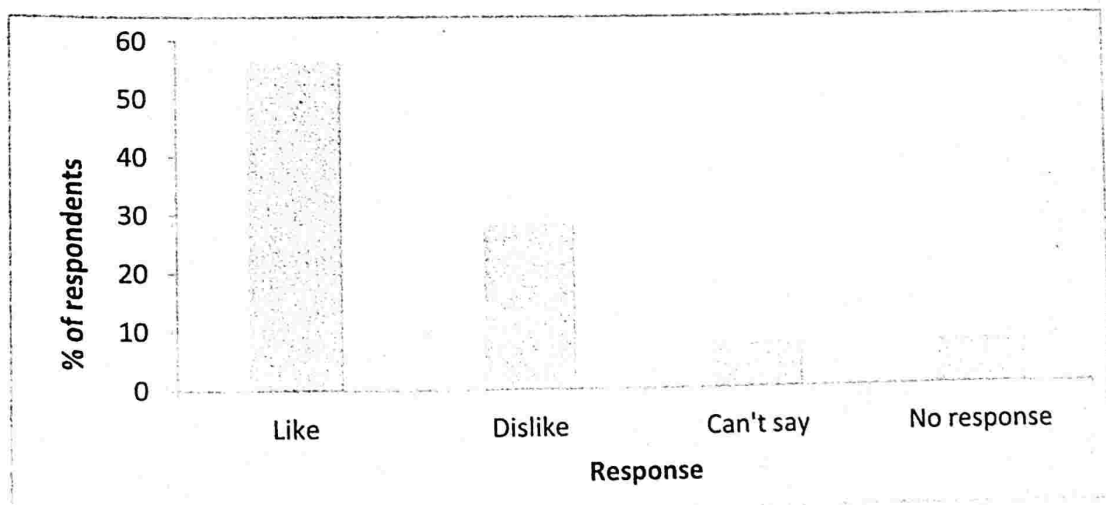
Figure 22: Responses of herd guarding by villagers



c. Perspective toward leopard

While asking about perspective toward leopards present in the area, majority of the respondent (n=78) were found they like (56.4%) the leopard followed by the responses of dislike (28.2%), can't say (8.3%), and no respondents (7.6%).

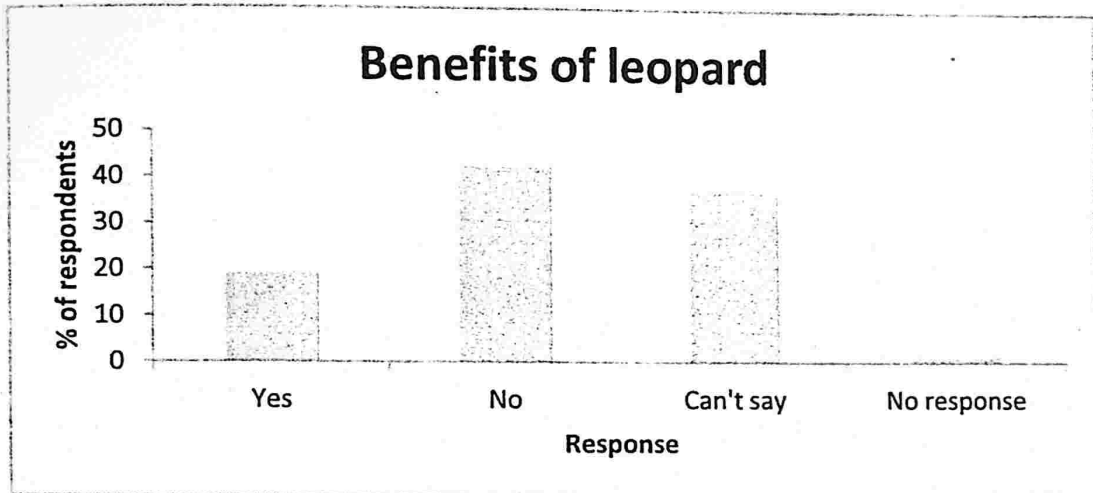
Figure 23: Responses of perspective for leopards



d. Benefits of leopards being in area

Responses from all of the Respondents (n=78) were Yes (19.2%), No (42.3%), can't say (37.1%) and no responses (1.2%) regarding benefits to them by leopards being in the area.

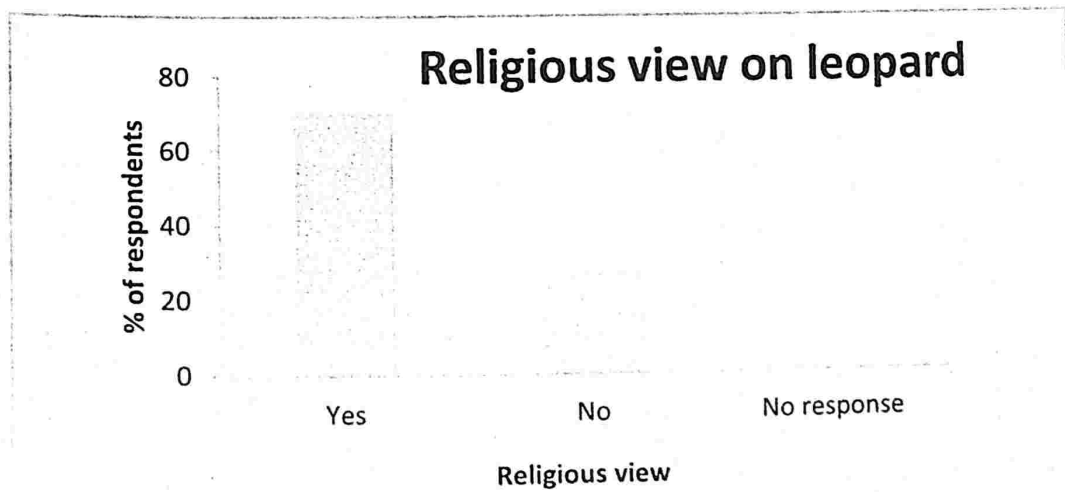
Figure 24: Responses of benefits of leopard being in the area to local villagers



d. Religious view on leopard

Responses of respondents (n=78) on religious view for leopards was mostly found Yes (70.5%) responses to No (26.9%) were less and no responses (2.5%).

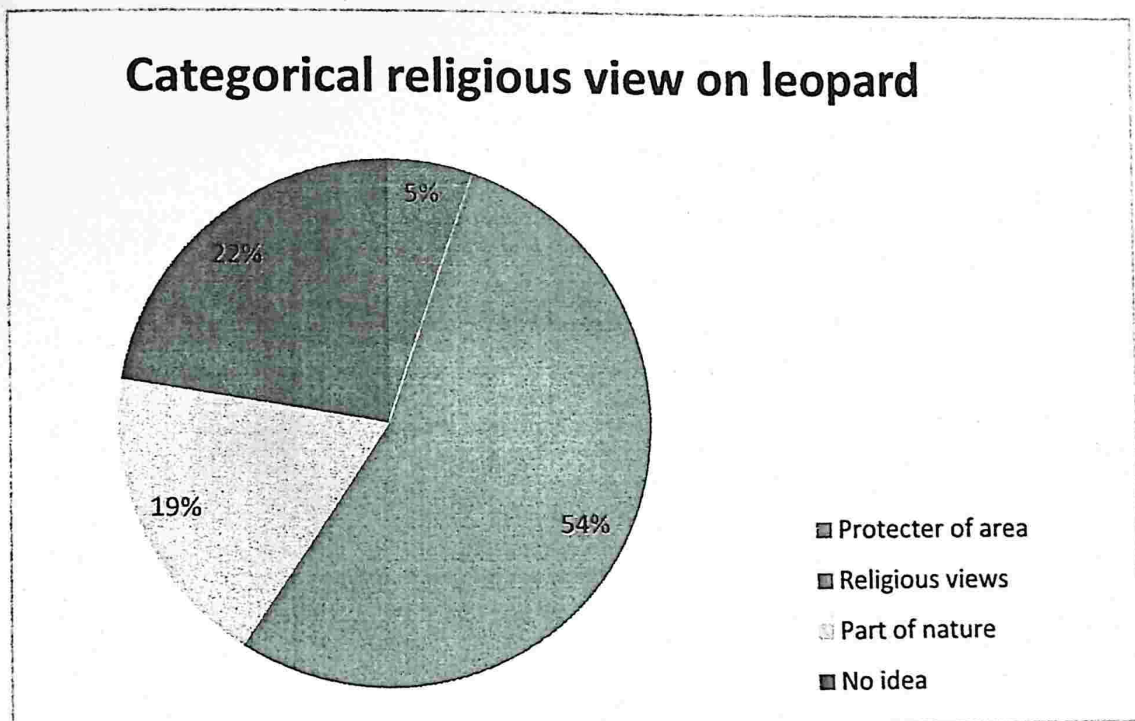
Figure 25: Responses of religious view on leopards in interview



e. Categories of religious believe for leopards

Based on responses of religious view on leopards, categorical views were as Animal of god/goddess (54%), leopards are part of nature like us (19%), leopards are worshipped as protector of area as guard (5%) and respondent agreed to have religious view but without explanation their acceptance. i.e. No idea (22%).

Figure 26: Responses on categorical religious view of people



6. Discussion

6.1. Prey estimation

Prey recorded from transects were divided into four groups based on their body size, large prey (129.1 per km²), medium prey (1061 per km²) small prey (139 per km²) dog (50.5 per km²) and peafowl (10 per km²). In wild ungulates, only Nilgai was found sightings were low.

Table 7: Densities of prey (per km²) from different studies

Location	Cow	Goat	Buffalo	Nilgai	Peafowl	Studies
Jawai, Rajasthan	54.15	895	70.14	0.89	10	Current study
Sariska Tiger Reserve, Rajasthan	28.3	0.97	NA	42.7	100	Mondal, et al., 2012
Akole, Maharashtra	162	174	7	NP	NA	Athreya, 2016

NP: Not present; NA- : Not available

Comparing at two studies one from Sariska Tiger Reserve and other from Akole, Maharashtra goat and buffalo density was quite higher in the current study area (Table7). Langur has poor observation on transects so they were not used in calculation. Nilgai being only wild ungulate present in the area with low density (Table 7), even cameras too has less captures (n=5) of Nilgai. Pig found in the study area was considered as feral as there was no evidence or confirmation of wild pig in the area. The low density of wild prey can be justified as area has high livestock pressure with demand of natural resources for fulfilment of one's need. The study area belongs to the revenue land so every place is accessible without any restriction.

6.2. Dietary composition through prey utilization

The frequency of occurrence calculated from the prey remains in scat was Wild (45%), Domestic (44.8%) and feral (9.6%) (Table 8).

Table 8: Frequency of occurrence (FO in %) in leopard scat from different sites

Prey species	Jawai, Rajasthan	Sariska Tiger Reserve, Rajasthan				Akole, Maharashtra
	Current study	Mondal, et al				Athreya, 2016
		2007	2008	2009	2010	2016
	FO	FO	FO	FO	FO	FO
Nilgai	5.2	6.6	11.5	8.9	5	NP
Pig	3.8	0	2.2	2.7	2	3.1
Langur	12.81	5.3	10.4	6.3	10.9	0.8
Cow	30.56	9.2	3.8	7.1	11.9	10.8
Porcupine	0.67	1.3	2.7	5.4	2	0
Peafowl	19.28	10.5	1.6	6.3	8.9	3.9
Dog	4.18	0	0.5	0	0	38.5
Goat	4.83	2.6	0	0	0	10
Rodents	5.7	14.5	0	0	4	6.9

NP: Not present

Comparatively, current study shows the highest frequency of occurrence for livestock, Peafowl, Langur and Dog in comparison to other studies. High consumption of livestock can be interpreted as leopards must have fed on carcasses as well as live predation.

Utilized and consumed data resulted into Cow being more consumed comparative to its availability (54 per km²) followed by peafowl (10 per km²) (Figure 3). Hares were recorded in camera trap but never been observed during transect and not found in diet analysis as well during my study period.

6.3. Leopard density estimation

The individual identification was found to be easy of leopards from the photographs except even the animal moved very close or farther away from cameras. To calculate abundance Null model (Mo) was chosen in the MARK framework based on the minimum AIC value. Since spatially explicit models are technically and biologically more robust than the traditionally used half MMDM approach, SECR density was used in this study. Total trap night (n=932) resulted into 14 adult individual leopard with cubs (n=7) and sub adults (n=2).

Another study (Akole, Maharashtra) from the similar human dominated landscape with low wild prey base shows comparatively higher density of leopard in the current study area (Table 9).

Table 9: Comparison of leopard and human densities from other study

Area	Jawai, Rajasthan (Current study)	Akole, Maharashtra (Athreya, 2013)
Leopard density (per 100 km ²)	6.28	4.8
Human density (per km ²)	236.5	>300

Density map generated through SECR shows high densities in two villages Vellar and Kothar (Figure 11). These two villages have good water resource with the largest chain of hills and work as tourism hotspot for tourists. There are evidence of food provisioning to leopard from these two villages, so all these factors can be influencing factors for high density of leopard in two villages

6.4. Temporal overlap of prey species (Wild & Domestic) with leopard

As the landscape is speckled with villages leopards have been observed to segregate themselves with humans on a temporal scale ($\Delta=0.26$). As area supports low wild prey base but langur-leopard ($\Delta=0.64$) and peafowl-leopard (0.44) were found to have significant overlap on a temporal scale. Domestic prey was found active on different time (0.19) from leopard as these are guarded by the human being to reduce the chances of predation.

6.5. Human perspective: Local people's perception

Socio economic and demographic structures are considered as major influencing factors to maintain people's attitude and perception. Even attitude can also be polarized by religion (Bhatia S., 2016). The interview conducted in the study area covered all the major concepts regarding perception, attitude, and economic loss due to leopards. It is believed that local dominant community Rabari and others are following traditional way of living with leopards even though they are in loss by losing their property (livestock).

Interview data represents Rabari the most dominant community were cooperating in my research. Most of the responses indicate villagers are changing their lifestyle and sell their livestock over the year because they are losing their property by leopards and they cannot afford these losses. Herders are shifting towards business, few responses for new generation was remarkable, according to them new generation would not follow the traditional way of herding as they are being educated and frequently learning new technologies. Few People (24.35%) thinks there is no change happened in their lifestyle. Leopards were seen mostly during day time (60%) It shows the temporal activity peak between 06:00 am to 12:15 pm. frequent sights of leopards during day can also be co-related with the domestic prey movement. Sighting was reported more during day (20%)

and night account for 14% of sightings. Pastoral movement of herders was also covered by asking seasonal movement of grazing and duration of stay in grazing land. Most of the time livestock herds were guarded (88.46%). Leopards were seen to attack on grazing livestock when the individual from the herd goes far away while grazing or left behind the herd (Injured, old individuals). Fairly large number of people (41.7%) indicated no benefits from leopard. These peoples were seen to suffer more than other respondent in terms of loss of livestock and damage to crops by safaris running across crop fields. Small proportion of population believe that they are getting benefits of leopards; as it controls the crop depredation by Nilgai, and Pigs (8.8%).Jawai is getting good number of foreign tourists for leopard safari and small population of local villages are benefitted from tourism (1.2%)and believe that this activity has got them recognition worldwide.

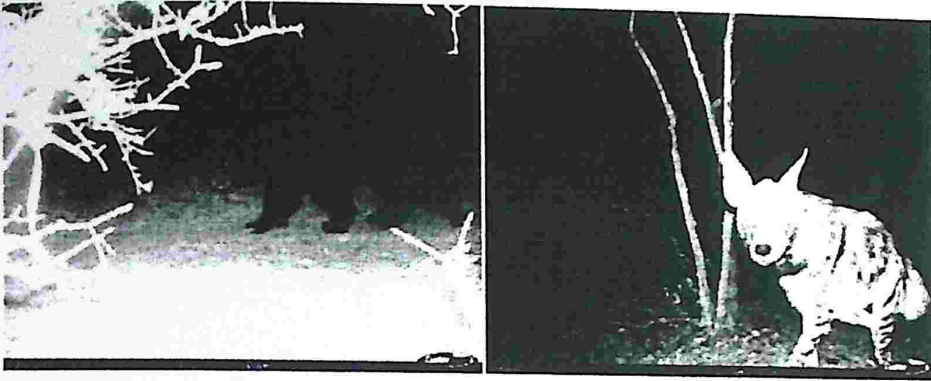
All the respondent (n=78) agreed that they have never been attacked by leopards so far. Total five leopard attack on human has been reported from study area in last 25 years. People of the area claimed that leopards have enough resources in dens in the hills, water availability (Natural and manmade waterhole), availability of easy prey (livestock). Loss of livestock is tolerable for them as they agreed their ancestors and earlier generation were engaged in game hunting and preying upon wild animals so leopards of the area are also following the same tradition by hunting on livestock. Coexistence is also aided by hoteliers as they engage in food provisioning for leopards along with several other aspects of tourism

7. Conclusion

Thus results from the study can be seen as coexistence (Co-occurrence) is possible due to an influence of hotel lobby. The loss of human life or injuries is minimal in the area. Villagers are not happy about economic losses due to leopard's depredation on livestock. It is difficult to say about the coexistence or co-occurrence of leopard with humans in this kind of short duration of study. Long-term study is needed to look at the whole scenario of the existence of leopard in Proposed Jawai Community Conservation Reserve.

Appendix I

Camera trap images of other animals from the study area



Appendix II: Checklist of birds from the study area*

Number	Species
1	Lesser Whistling-Duck - <i>Dendrocygna javanica</i>
2	Graylag Goose - <i>Anser anser</i>
3	Bar-headed Goose - <i>Anser indicus</i>
4	Comb Duck - <i>Sarkidiornis melanotos</i>
5	Ruddy Shelduck - <i>Tadorna ferruginea</i>
6	Cotton Pygmy-Goose - <i>Nettapus coromandelianus</i>
7	Gadwall - <i>Anas strepera</i>
8	Eurasian Wigeon - <i>Anas penelope</i>
9	Mallard - <i>Anas platyrhynchos</i>
10	Indian Spot-billed Duck - <i>Anas poecilorhyncha</i>
11	Northern Shoveler - <i>Anas clypeata</i>
12	Northern Pintail - <i>Anas acuta</i>
13	Garganey - <i>Anas querquedula</i>
14	Common Pochard - <i>Aythya ferina</i>
15	Indian Peafowl - <i>Pavo cristatus</i>
16	Common Quail - <i>Coturnix coturnix</i>
17	Rock Bush-Quail - <i>Perdicula argoondah</i>
18	Gray Francolin - <i>Francolinus pondicerianus</i>
19	Little Grebe - <i>Tachybaptus ruficollis</i>
20	Greater Flamingo - <i>Phoenicopterus roseus</i>
21	Asian Openbill - <i>Anastomus oscitans</i>
22	Woolly-necked Stork - <i>Ciconia episcopus</i>
23	Painted Stork - <i>Mycteria leucocephala</i>
24	Little Cormorant - <i>Microcarbo niger</i>
25	Great Cormorant - <i>Phalacrocorax carbo</i>
26	Oriental Darter - <i>Anhinga melanogaster</i>
27	Great White Pelican - <i>Pelecanus onocrotalus</i>
28	Dalmatian Pelican - <i>Pelecanus crispus</i>

29	Gray Heron - <i>Ardea cinerea</i>
30	Purple Heron - <i>Ardea purpurea</i>
31	Great Egret - <i>Ardea alba</i>
32	Intermediate Egret - <i>Mesophoyx intermedia</i>
33	Little Egret - <i>Egretta garzetta</i>
34	Cow Egret - <i>Bubulcus ibis</i>
35	Indian Pond-Heron - <i>Ardeola grayii</i>
36	Black-crowned Night-Heron - <i>Nycticorax nycticorax</i>
37	Glossy Ibis - <i>Plegadis falcinellus</i>
38	Black-headed Ibis - <i>Threskiornis melanocephalus</i>
39	Red-naped Ibis - <i>Pseudibis papillosa</i>
40	Eurasian Spoonbill - <i>Platalea leucorodia</i>
41	Osprey - <i>Pandion haliaetus</i>
42	Black-shouldered Kite - <i>Elanus caeruleus</i>
43	Egyptian Vulture - <i>Neophron percnopterus</i>
44	Oriental Honey-buzzard - <i>Pernis ptilorhynchus</i>
45	Steppe Eagle - <i>Aquila nipalensis</i>
46	Bonelli's Eagle - <i>Aquila fasciata</i>
47	White-eyed Buzzard - <i>Butastur teesa</i>
48	Eurasian Marsh-Harrier - <i>Circus aeruginosus</i>
49	Montagu's Harrier - <i>Circus pygargus</i>
50	Shikra - <i>Accipiter badius</i>
51	Black Kite - <i>Milvus migrans</i>
52	Long-legged Buzzard - <i>Buteo rufinus</i>
53	White-breasted Waterhen - <i>Amaurornis phoenicurus</i>
54	Gray-headed Swamphen - <i>Porphyrio poliocephalus</i>
55	Eurasian Moorhen - <i>Gallinula chloropus</i>
56	Eurasian Coot - <i>Fulica atra</i>
57	Demoiselle Crane - <i>Anthropoides virgo</i>
58	Sarus Crane - <i>Antigone antigone</i>
59	Common Crane - <i>Grus grus</i>
60	Eurasian Thick-knee - <i>Burhinus oedicnemus</i>
61	Great Thick-knee - <i>Esacus recurvirostris</i>

62	Black-winged Stilt - <i>Himantopus himantopus</i>
63	Pied Avocet - <i>Recurvirostra avosetta</i>
64	Yellow-wattled Lapwing - <i>Vanellus malabaricus</i>
65	Red-wattled Lapwing - <i>Vanellus indicus</i>
66	White-tailed Lapwing - <i>Vanellus leucurus</i>
67	Kentish Plover - <i>Charadrius alexandrinus</i>
68	Little Ringed Plover - <i>Charadrius dubius</i>
69	Pheasant-tailed Jacana - <i>Hydrophasianus chirurgus</i>
70	Bronze-winged Jacana - <i>Metopidius indicus</i>
71	Eurasian Curlew - <i>Numenius arquata</i>
72	Black-tailed Godwit - <i>Limosa limosa</i>
73	Ruff - <i>Calidris pugnax</i>
74	Temminck's Stint - <i>Calidris temminckii</i>
75	Little Stint - <i>Calidris minuta</i>
76	Common Snipe - <i>Gallinago gallinago</i>
77	Common Sandpiper - <i>Actitis hypoleucos</i>
78	Green Sandpiper - <i>Tringa ochropus</i>
79	Common Greenshank - <i>Tringa nebularia</i>
80	Marsh Sandpiper - <i>Tringa stagnatilis</i>
81	Wood Sandpiper - <i>Tringa glareola</i>
82	Common Redshank - <i>Tringa totanus</i>
83	Small Pratincole - <i>Glareola lactea</i>
84	Brown-headed Gull - <i>Chroicocephalus brunnicephalus</i>
85	Pallas's Gull - <i>Ichthyaetus ichthyaetus</i>
86	Whiskered Tern - <i>Chlidonias hybrida</i>
87	River Tern - <i>Sterna aurantia</i>
88	Chestnut-bellied Sandgrouse - <i>Pterocles exustus</i>
89	Rock Pigeon - <i>Columba livia</i>
90	Eurasian Collared-Dove - <i>Streptopelia decaocto</i>
91	Red Collared-Dove - <i>Streptopelia tranquebarica</i>
92	Spotted Dove - <i>Streptopelia chinensis</i>
93	Laughing Dove - <i>Streptopelia senegalensis</i>
94	Yellow-footed Pigeon - <i>Treron phoenicopterus</i>

95	Greater Coucal - <i>Centropus sinensis</i>
96	Sirkeer Malkoha - <i>Taccocua leschenaultii</i>
97	Pied Cuckoo - <i>Clamator jacobinus</i>
98	Asian Koel - <i>Eudynamys scolopaceus</i>
99	Common Hawk-Cuckoo - <i>Hierococcyx varius</i>
100	Barn Owl - <i>Tyto alba</i>
101	Eurasian Eagle-Owl - <i>Bubo bubo</i>
102	Spotted Owlet - <i>Athene brama</i>
103	Gray Nightjar - <i>Caprimulgus jotaka</i>
104	Savanna Nightjar - <i>Caprimulgus affinis</i>
105	Little Swift - <i>Apus affinis</i>
106	Eurasian Hoopoe - <i>Upupa epops</i>
107	Indian Gray Hornbill - <i>Ocyceros birostris</i>
108	Common Kingfisher - <i>Alcedo atthis</i>
109	White-throated Kingfisher - <i>Halcyon smyrnensis</i>
110	Pied Kingfisher - <i>Ceryle rudis</i>
111	Green Bee-eater - <i>Merops orientalis</i>
112	Blue-tailed Bee-eater - <i>Merops philippinus</i>
113	Indian Roller - <i>Coracias benghalensis</i>
114	Coppersmith Barbet - <i>Psilopogon haemacephalus</i>
115	Brown-headed Barbet - <i>Psilopogon zeylanicus</i>
116	Yellow-crowned Woodpecker - <i>Dendrocopos mahrattensis</i>
117	Black-rumped Flameback - <i>Dinopium benghalense</i>
118	Red-necked Falcon - <i>Falco chicquera</i>
119	Alexandrine Parakeet - <i>Psittacula eupatria</i>
120	Rose-ringed Parakeet - <i>Psittacula krameri</i>
121	Plum-headed Parakeet - <i>Psittacula cyanocephala</i>
122	Common Woodshrike - <i>Tephrodornis pondicerianus</i>
123	Small Minivet - <i>Pericrocotus cinnamomeus</i>
124	Bay-backed Shrike - <i>Lanius vittatus</i>
125	Long-tailed Shrike - <i>Lanius schach</i>
126	Southern Gray Shrike - <i>Lanius meridionalis</i>
127	Eurasian Golden Oriole - <i>Oriolus oriolus</i>

128	Black Drongo - <i>Dicrurus macrocercus</i>
129	White-bellied Drongo - <i>Dicrurus caerulescens</i>
130	White-browed Fantail - <i>Rhipidura aureola</i>
131	Rufous Treepie - <i>Dendrocitta vagabunda</i>
132	House Crow - <i>Corvus splendens</i>
133	Large-billed Crow - <i>Corvus macrorhynchos</i>
134	Common Raven - <i>Corvus corax</i>
135	Rufous-tailed Lark - <i>Ammomanes phoenicura</i>
136	Ashy-crowned Sparrow-Lark - <i>Eremopterix griseus</i>
137	Singing Bushlark - <i>Mirafra cantillans</i>
138	Indian Bushlark - <i>Mirafra erythroptera</i>
139	Dusky Crag-Martin - <i>Ptyonoprogne concolor</i>
140	Barn Swallow - <i>Hirundo rustica</i>
141	Wire-tailed Swallow - <i>Hirundo smithii</i>
142	Red-rumped Swallow - <i>Cecropis daurica</i>
143	Streak-throated Swallow - <i>Petrochelidon fluvicola</i>
144	Cinereous Tit - <i>Parus cinereus</i>
145	White-naped Tit - <i>Machlolophus nuchalis</i>
146	Red-vented Bulbul - <i>Pycnonotus cafer</i>
147	White-eared Bulbul - <i>Pycnonotus leucotis</i>
148	Common Chiffchaff - <i>Phylloscopus collybita</i>
149	Common Tailorbird - <i>Orthotomus sutorius</i>
150	Ashy Prinia - <i>Prinia socialis</i>
151	Plain Prinia - <i>Prinia inornata</i>
152	Lesser Whitethroat - <i>Sylvia curruca</i>
153	Western Orphean Warbler - <i>Sylvia hortensis</i>
154	Yellow-eyed Babbler - <i>Chrysomma sinense</i>
155	Oriental White-eye - <i>Zosterops palpebrosus</i>
156	Common Babbler - <i>Turdoides caudata</i>
157	Large Gray Babbler - <i>Turdoides malcolmi</i>
158	Jungle Babbler - <i>Turdoides striata</i>
159	Asian Brown Flycatcher - <i>Muscicapa dauurica</i>
160	Indian Robin - <i>Copsychus fulvicatus</i>

161	Oriental Magpie-Robin - <i>Copsychus saularis</i>
162	Bluethroat - <i>Luscinia svecica</i>
163	Black Redstart - <i>Phoenicurus ochruros</i>
164	Blue Rock-Thrush - <i>Monticola solitarius</i>
165	Siberian Stonechat - <i>Saxicola maurus</i>
166	Pied Bushchat - <i>Saxicola caprata</i>
167	Indian Chat - <i>Cercomela fusca</i>
168	Variable Wheatear - <i>Oenanthe picata</i>
169	Asian Pied Starling - <i>Gracupica contra</i>
170	Brahminy Starling - <i>Sturnia pagodarum</i>
171	Common Myna - <i>Acridotheres tristis</i>
172	Bank Myna - <i>Acridotheres ginginianus</i>
173	Purple Sunbird - <i>Cinnyris asiaticus</i>
174	Citrine Wagtail - <i>Motacilla citreola</i>
175	Gray Wagtail - <i>Motacilla cinerea</i>
176	White Wagtail - <i>Motacilla alba</i>
177	White-browed Wagtail - <i>Motacilla maderaspatensis</i>
178	Paddyfield Pipit - <i>Anthus rufulus</i>
179	House Sparrow - <i>Passer domesticus</i>
180	Chestnut-shouldered Petronia - <i>Petronia xanthocollis</i>
181	Baya Weaver - <i>Ploceus philippinus</i>
182	Indian Silverbill - <i>Euodice malabarica</i>

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