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Mammalian species distribution and diversity in arid region of Kachchh, Gujarat

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Abstract
The aim of this study is to examine the mammal's diversity and distribution to provide information for making informed conservation decisions. We examined four different land-use land-cover or habitats categories for mammal's diversity. Line transects for direct sightings and belt transects for indirect evidences were used to assess mammal species. For the present study the Lakhpat and Abdasa talukas and part of Nakhatrana Taluka had been identified where the major development activities are supposed to come up in the near future.
Analysis of variance was used to test hypotheses and Tukey HSD Post Hoc was used to identify specific variables those differ significantly. The variables used for testing hypothesis includes number of Species, Density, Shannon diversity index, Simpson diversity index, Dominance index, Evenness index, Menhinick species richness index, Margalef species richness and Equitability index.
Based on direct sightings and indirect evidences, a total of 20 mammal species belonging to 11 families and 16 genera were recorded during our survey. Eight species of herbivores, seven species of carnivores, two species of granivores and one species of each omnivores, frugivores and scavenger recorded from the study area. Five threatened mammals species were recorded, which included two cats (*Panthera pardus* and *Felis libyca*), one canid (*Canis lupus*), one ungulate (*Gazella gazella*) and an insectivore (*Hemiechinus auritus*). ANOVA results shows that four Land cover types or habitats differ significantly in terms of Number of species, Margalef species richness, Evenness, Equitability.

Keywords: arid, diversity, distribution, Kachchh, mammals

1. Introduction
Mammals play important roles in functioning of ecosystems and interact with other species in many ways. They share responsibility for pollinating plants and distributing seeds and at the same time act as both predators and prey. They can have immense effects on the structure and composition of vegetation, plant productivity and nutrient cycling (Laurence & Bierregaard, 1997) [19]. These familiar animals are experiencing greater population declines than any of the other vertebrate groups (IUCN, 2000) [16]. Of the known species of mammals, 25% are threatened, 11% are endangered, 4% are critically endangered and nearly 2% of the known modern-day mammals have gone extinct in the last 400 years (IUCN, 2000) [16]. The loss of mammalian diversity could alter ecosystems that we do not yet comprehend. Therefore, it is imperative that biologists develop appropriate assessment and monitoring protocols for mammals.
Disturbance is an important ecological factor affecting species diversity in natural environments and can create alterations in systems structures, reduce species competition and change resource availability. The degradation of natural environments and habitat fragmentation, substantially modifies wild population parameters including species diversity (Law & Dickman, 1998) [20]. This is especially true among mammals, for which habitat is the most important niche dimension by which species segregate (Schoener, 1974) [35].
The mammalian species are widely distributed among various habitats in arid region of Western Kachchh in Gujarat State. In this region, mostly sites specific sporadic inventories/studies of the mammalian fauna have been conducted. However, mammalian fauna of the protected area of this region is well documented. Western Kachchh region supports two ecologically important (protected) areas, Kachchh Bustard Sanctuary (KBS) and Narayan Sarovar Sanctuary (NSS). These two sanctuaries support many biologically important mammal species. Mammalian fauna of KBS and NSS are well documented and total 27 species (big and lesser cats, badger, porcupine, antelope, civet, foxes, wolf, jackal, hyena, hare, pangolin, gerbils and rats, wild boar, squirrels, hedgehogs and bats) were enlisted belonging to 16 families (Singh, 2001; GUIDE & GEER, 2001) [39, 13]. Joshua *et al*. (2006) [18] conducted studies on the status and conservation of some threatened faunal biodiversity of arid Kachchh and pointed out that habitat loss due to mining is major problem in mineral rich Kachchh and is the major threat faced by all mammal species at medium to high level, while vehicular traffic was also a threat mainly to Long-eared Hedge Hog and Desert Cat.
The region is facing many identical anthropogenic disturbances which can affect the biodiversity in the region. The mining activity, vehicular pollution and wood cutting for household are the major driving force behind the landuse changes in last few years. Mining activity has played a major role in altering and fragmenting the habitats and land cover of this region which directly affects the population dynamics. Various factors associated with different habitat types had distinct impact on mammalian species. Likewise various land use activities especially opencast mining that is being carried out at mass scale in the region, also affects the

mammals populations considerably, so we tested following research hypotheses:

- Ho: There is impact of various Landcover categories on the distribution and diversity of mammal species;

The aims of this study were to understand the mammal species in different land covers of the western Kachchh region and to compare them on the basis of their species composition. The main objective was to examine diversity and distribution pattern of mammals in various land cover or habitats;

2. Material and Methods

2.1 Study Area

Kachchh, (22º41'11" to 24º41'47" N and 68º9'46" to 71º54'47"), extending over 45,652 sq. km. area lies in the western part of Gujarat state and falls under the 3B Desert - Kachchh Province and Desert bio-geographic zone (Rodgers *et al.,* 2002) [30]. The study area encompasses the terrestrial ecosystems like, tropical thorn forest, scrub savannah, grasslands and interspersed with dry land farming (arid agro-ecosystem). Kachchh falls in the arid tract and has a tropical monsoon climate. It experiences extremes of weather conditions with winter starting from mid November to end February with the temperature going down to the average minimum of 4.6ºC in January and Summer starts from March till June with maximum temperature varying from 39-45ºC. The estimated average annual rainfall is 326 mm and highly erratic leading to protracted droughts which is common phenomena. The evapo-transpiration rates are very high, with 2.25m in a year. Wind velocity is generally light to moderate.

The present study was conducted in western Kachchh (Figure 1), which is characterized by gentle undulate terrain. The forests of this district are mainly categorized as tropical thorn forest (Champion and Seth, 1968) with patches of some dry-deciduous forest in this region. Tropical thorn forest of the study area is characterized by the presence of *Acacia spp*., *Euphorbia spp.* and *Prosopis spp.* etc.

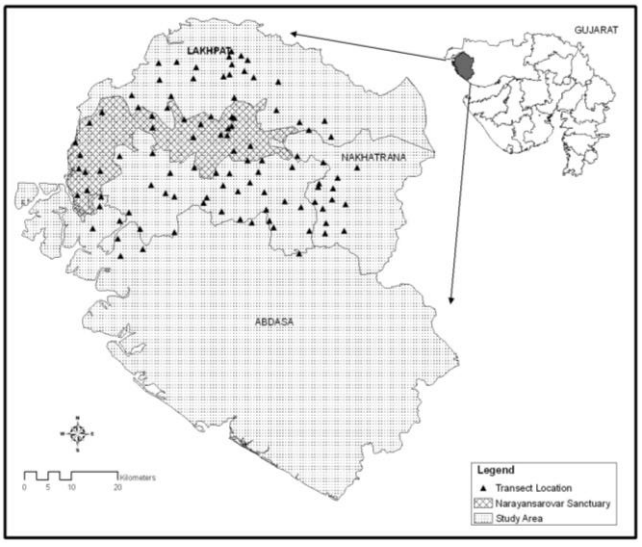

Fig 1: Study area map with location of sampling transects

2.2 Methodology

2.2.1 Sampling design and field sampling for mammals

Prior to field surveys, the study area was stratified into various landuse landcover categories such as Forest, Grasslands, Wetlands and Agriculture. After stratification, the entire area was divided into 5 x 5 km grids using Survey of India's geo-referenced co-ordinate system. Those grid cells were further subdivided into 1 x 1 km smaller grids and total 180 transects were laid in selected grids chosen randomly using random number table (Table 1). Stratified random sampling was employed to lay down samples of 1.1 km (n=180 transects) different habitats. All transects were laid diagonally to randomly picked 1x1 km grid. Care was taken to have adequate sampling in each of the topographical features across lateral and vertical gradients like altitudinal range and terrain, and spatially within each Land cover type.

Table 1: Distribution of samples in study area

Habitat	No. of Transects
1. Forest	125
2.Grassland	36
3. Wetland	6
4.Agriculture	13

2.2.2 Direct count

Terrestrial (small and large) mammals were counted following line transect of 1.1km with three meter width (Total 180 transects) (Burnham *et al.* 1980). That was done in the early and late hours of the day. For each sighting, species, numbers of individuals, age and sex, sighting distance, sighting angle, distance on transect and activity of the animal with the habitat features were documented.

2.2.3 Indirect count

Belt transects were used to search indirect evidence such as animal burrows/holes, dung, pellets, feeding signs, and tracks. These were done using plots (seven circular plot of 10m radius in each transect) and belt (six belt of 160m length with three meter width) transects following Rodgers (1991) [31]. The circular plot of 10 m radius at every 180m point along transect and belt transects of 160 x 3 m in between each circular plots had been used for quantifying indirect evidences. The passive track counts (Mohon *et al.* 1998, Edwards *et al.* 2000) [8] and scat counts (Henke and Knowlton 1995) [15] help in determining the relative abundance. In the case of threatened animal species irrespective of the group data on the habitat would also be collected.

2.2.4 Data analysis

2.2.4.1 Species distribution and diversity

Data collected from transect allows us to calculate (for indirect evidences) density, species diversity, richness. Encounter rate was used for direct sightings. Data was analyzed using following formulae:

Species diversity was calculated using following formulae (Magurran 1988) [22]:

A. Shannon Weiner Diversity index (H') $H' = \sum Pi \times \ln (Pi)$
B. Simpson diversity index (D): D = 1 – Dominance.
C. Menhinick richness index – the ration of the no. of taxa to the square root of sample size
D. Margalef's Richness index (Rl): Rl = S – 1/ln (n)
E. Dominance: 1 – Simpson index. $D = \text{sum } ((ni/n)^{2)}$
F. Equitability (El or J'): J' = H'/In(S)
G. Buzas and Gibson's evenness: e^H/S

The rarefaction analysis was performed using Biodiversity Pro software (Biodiversity 1997 NHM & SAMS, http://www.nhm.ac.uk/zoology/bdpro) to cope up the problem in comparing diversity among various land cover or habitat categories evaluated during present study.

2.2.5 Hypothesis testing

The null hypotheses tested for significance of differences were

1. Ha: There is no impact of various landcover categories on the distribution and diversity of mammal species;

Analysis of variance (ANOVA) was used to test these hypotheses and Tukey HSD Post Hoc was used to identify specific variables those differ significantly. The variables used for testing hypothesis includes no of Species, Density, Shannon diversity index, Simpson diversity index, Dominance index, Evenness index, Menhinik species richness index, Margalef species richness, Equilibility index (Harpar, 1999). These variables representing mammal species diversity were evaluated for each landcover class such as Forest, Grassland, Wetland and Agriculture.

3. Results

Based on direct sightings and indirect evidences, a total of 20 mammal species belonging to 11 families and 16 genera were recorded during the survey (Table 1). 560 individuals of 17 species were recorded based on 255 direct sightings. In addition, presences of 3 species were complimented through indirect evidences. Eight species of herbivores, seven species of carnivores, two species of grenivores and one species of each omnivores, frugivores and scavenger recorded from the study area.

3.1 Direct sightings

Total 17 mammal species recorded from direct sighting such as Chinkara, Nilgai, Leopard, Indian Wolf, Golden Jackal, Indian Fox, Desert Cat, Jungle Cat, Stripped Hyena, Wild Boar, Small Indian Mongoose, Grey Mongoose, Long-eared Hedgehog, Indian Hare, Desert Hare, Indian Gerbil and Desert Gerbil were recorded. Mean mammals species (±std. dev.) for transects is 1.54(±0.86 species). A transect in Forest, specifically *Euphorbia-Salvadora* habitat near Kurayani village were recorded for maximum five mammal species, while minimum one species was recorded from 102 transects laid down in different habitats where in 23 transects no direct sighting were found. Total 5 species have been listed in the red list of IUCN (Table 1).

Direct sightings were used to calculate encounter rates for different species. Encounter rate is not an absolute abundance estimate; however, it is a kind of index which basically accounts the relative abundance of a species.

Among the small mammals, Indian hare had maximum encounter rate 0.34/km, which varies between 0.22/km in grassland and 0.39/km in forest land cover. However, among rest of all other mammal species recorded, encounter rate of chinkara was highest with a value of 0.23/km. The encounter rate of chinkara is low (0.19 animals/km) in forest and high in grassland (0.41 animals/km). This variation could be due to low availability of food resource found in forest where most of the ground vegetation was dry. But in grassland the availability of ground cover or food resources was comparatively more and wide spread which made the chinkara disperse widely in grassland. Nilgai was the next most frequently encountered animal (0.22/km), seen mostly on the periphery near the cultivation. Among the Canids, jackal was the most common with an encounter rate of 0.13/km. The nocturnal animal like jungle cat was sighted only in winter while there was no record during summer. Same was the case with Hyenas, Wild boar and Desert cat. All this could be due to their nocturnal habit. Desert gerbil being a diurnal animal was the next most frequently encountered animal 0.07/km. Difference in overall encounter rate between land covers showed more animals were sighted in forest (1.52/km) than grassland (1.22/km), agriculture (1.07/km) and wetlands (1/km). Encounter rate estimated for the entire study area were 1.41 animals/km.

Due to the wider variation in habit and habitat of the species recorded in the Western Kachchh, reliable population estimation requires species-specific quantification techniques. Moreover, it needs more manpower and time. Due to the above said constrains the data obtained through direct sightings are not adequate to estimate the population/density of a given species. In this context most of the analysis was done based on indirect evidences to get an index like species evidence density, diversity, richness, etc.

3.2 Forest

Evidences of 13 species were recorded from forest cover with mean (±std. dev.) of 112 (±95) evidences. Minimum number of species evidences in transect was recorded from *Prosopis* habitat at Panandhro dumping site (2 no), while maximum of (807 no) species were recorded from transect in *Prosopis* dominant habitat in Akri village.

For most evidences of species in forest cover in decreasing order of abundance were Gerbil, Hare, Nilgai and Porcupine while least abundance species were Hedgehog, Fox, Wild boar and Cat. Mean (±std. dev.) of mammals indirect evidences density on transects for forest cover is 220(±188) evidences/ha. The forest Shannon diversity for evidences (H') is 1.53 with mean H' (±std. dev.) for transects is 1.16 (±0.28). Shannon diversity values range from 0 in *Prosopis* and GMDC dumping sites to 1.68 transect in *Acacia* forest habitat near Walka mota village. The forest Margalef species richness index from evidences for study area is 1.25 with mean richness value (±std. dev.) for transects is 1.33 (±0.36). Richness index values range from 0 in *Prosopis* and GMDC dumping sites to 2.05 in *Acacia* forest habitat near Walka mota village. The forest species evidences evenness index value for study area is 0.35 with mean evenness value from evidences (±std. dev.) for transects is 0.48 (±0.12). Evenness index values range from 0.28 in *Acacia* forest habitat near Walka mota village to 1 in *Prosopis* and GMDC dumping sites. Other index values are given in Table 2.

3.3 Grassland

Evidences of 11 species were recorded from grassland cover with mean (±std. dev.) of 100(±136) species. Minimum number of species evidences in transect was recorded from dense grassland habitat near Lala village (12 no), while maximum of (844 no) species were recorded from transect in sparse grassland at Jagora dungar near Paneli village.

For most evidences of species in grassland cover in decreasing order of abundance were Gerbil, Hare, Nilgai and Chinkara while least abundance species were Fox, Mongoose, Wild boar and Jackal. Mean (±std. dev.) of

mammals indirect evidences density on transects for grassland is 196(±268) evidences/ha. The grassland Shannon diversity for evidences (H') is 1.50 with mean H' (±std. dev.) for transects is 1.13 (±0.28). Shannon diversity values range from 0.47 in sparse grassland at Jagora dungar near Paneli village to 1.73 transect in sparse grassland habitat near Sheh village. The grassland Margalef species richness index from evidences for study area is 1.22 with mean richness value (±std. dev.) for transects is 1.17 (±0.40). Richness index values range from 0.35 in sparse grassland habitat near Denma village to 1.73 in sparse grassland habitat near Harudi village. The grassland species evenness index value for study area is 0.41 with mean evenness value from evidences (±std. dev.) for transects is 0.56 (±0.15). Evenness index values range from 0.32 in sparse grassland habitat at Jagora dunger near Paneli village to 0.98 in dense grassland habitat near Lala village. Other index values are given in Table 2.

3.4 Wetland

Evidences of 12 species were recorded from wetland cover with mean (±std. dev.) of 63 (±27) species. Minimum number of species evidences in transect was recorded from natural wetland habitat near Mata-na-madh village (20 no), while maximum of (94 no) species were recorded from transect in man-made wetland habitat near Guharnani village.

For most evidences of species in wetland cover in decreasing order of abundance were Hare, Gerbil, Porcupine and Hyena while least abundance species were small Indian Civet, Fox, Wild boar and Cat. Mean (±std. dev.) of mammals indirect evidences density on transects for wetland cover is 125(±54) evidences/ha. The wetland Shannon diversity for evidences (H') is 1.54 with mean H' (±std. dev.) for transects is 1.32 (±0.19). Shannon diversity values range from 1.17 in wetland habitat near Mata-na-madh village to 1.65 transect in man-made wetland habitat near Fulara village. The wetland Margalef species richness index from evidences for study area is 1.84 with mean richness value (±std. dev.) for transects is 1.54 (±0.34). Richness index values range from 1 in wetland habitat near Mata-na-madh village to 2.01 in man-made wetland habitat near Fulara village. The wetland species evenness index value for study area is 0.38 with mean evenness value from evidences (±std. dev.) for transects is 0.54 (±0.13). Evenness index values range from 0.43 in man-made wetland habitat near Dhareshi village to 0.80 in wetland habitat near Mata-na-madh village. Other index values are given in Table 2.

3.5 Agriculture

Evidences of 11 species were recorded from agriculture cover with mean (±std. dev.) of 93 (±44) species. Minimum number of species evidences in transect was recorded from fallow agriculture habitat near Kurayani village (37 no), while maximum of (218 no) species were recorded from transect in fallow agriculture near Fulara village.

Four most evidences of species in agriculture cover in decreasing order of abundance were Gerbil, Hare, Chinkara and Mongoose while least abundance species were Cat, Hyena, Fox and Wild boar. Mean (±std. dev.) of mammals indirect evidences density on transects for agriculture cover is 184(±87) evidences/ha. The agriculture Shannon diversity for evidences (H') is 1.62 with mean H' (±std. dev.) for transects is 1.28 (±0.21). Shannon diversity values range from 0.81 in fallow agriculture habitat near Kurayani village to 1.68 transect in fallow agriculture habitat near Pranpar village. The agriculture Margalef species richness index from evidences for study area is 1.40 with mean richness value (±std. dev.) for transects is 1.46 (±0.30). Richness index values range from 0.83 in fallow agriculture habitat near Kurayani village to 1.85 in fallow agriculture habitat near Sinapar village. The agriculture species evenness index value for study area is 0.46 with mean evenness value from evidences (±std. dev.) for transects is 0.49 (±0.10). Evenness index values range from 0.39 in fallow agriculture habitat near Sinapar village to 0.77 in fallow agriculture habitat near Pranpar village. Other index values are given in Table 2. Rarefaction was used to standardize unequal sampling sizes (Figure 2).

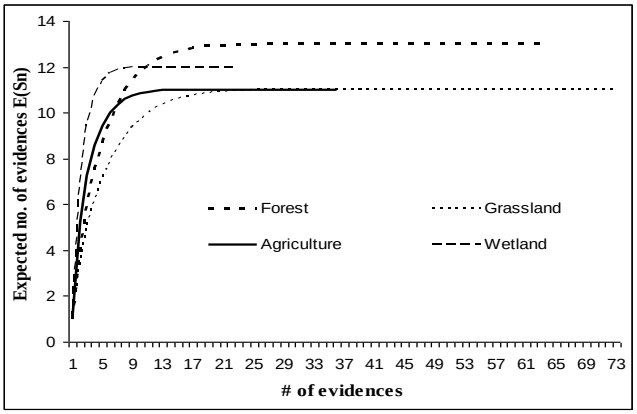

Fig 2: Rarefaction curves for various land covers

ANOVA results shows that four Land cover types differ significantly in terms of Number of species ($F=3.888$, $df=3$, $p< 0.05$) (Figure 3), Margalef species evidences richness ($F=3.236$, $df=3$, $p< 0.05$) (Figure 4), Evenness ($F=3.153$, $df=3$, $p< 0.05$), Equitability_J ($F=2.760$, $df=3$, $p< 0.05$) (Figure 5). Further a Turkey HSD Post Hoc analysis run in order to detect differences on each land cover type. In term of mean number of species from their evidences, grassland differed significantly from all other land covers ($p<0.05$).

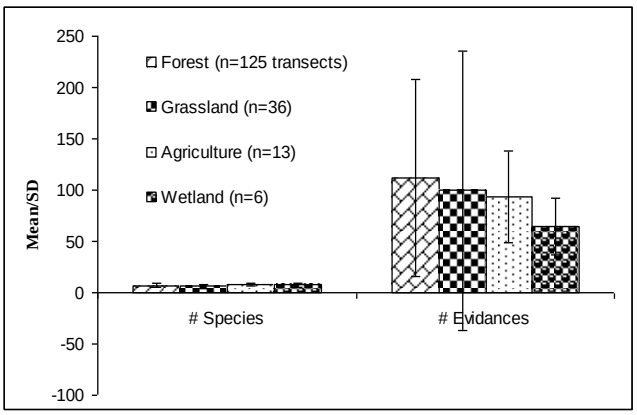

Fig 3: Land covers wise number of species and number of evidences

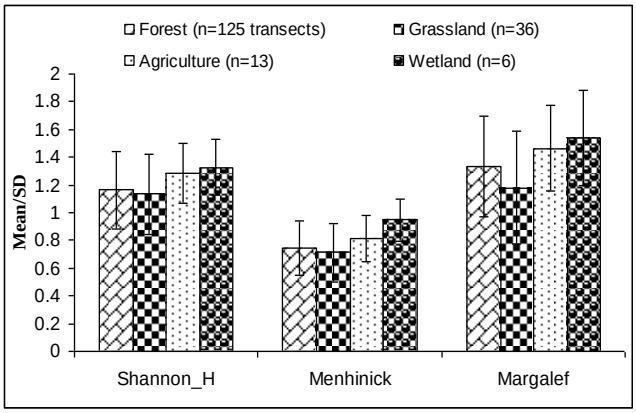

Fig 4: Land covers wise species evidences richness and diversity

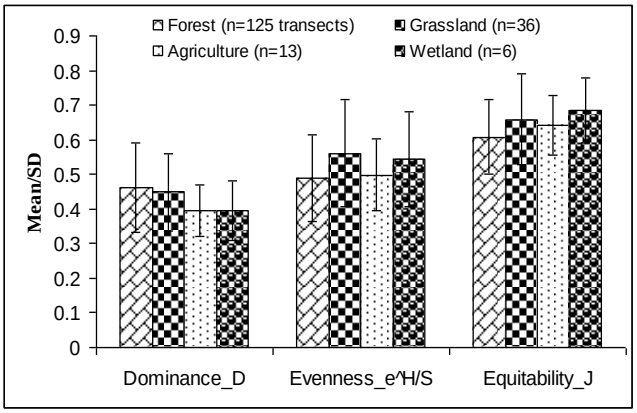

Fig 5: Land covers wise species evidences dominance, evenness and equitability

Table 1: Checklist of Mammal species in the western Kachchh

Sr. No.	Scientific Name	Species	Food Habit	IUCN status
	Bovidae			
1	*Boselaphus tragocamelus* (Pallas, 1766)	Nilgai	H	
2	*Gazelle gazelle*	Chinkara	H	V
	Canidae			
3	*Canis aureus* (Linnaeus, 1758)	Golden Jackal	O	
4	*Canis lupus* (Linnaeus, 1758)	Indian Wolf	C	V
5	*Vulpes bengalensis*	Indian Fox	C	
	Erinaceidae			
6	*Hemiechinus auritus*	Longeared Hedgehog	H	I
7	*Paraechinus micropus*	Indian Hedgehog	H	
	Felidae			
8	*Panthera pardus*	Leopard	C	T
9	*Felis silvestris ornata*	Desert Cat	C	E
10	*Felis chaus (*Schreber,1777)	Jungle Cat	C	
	Herpestidae			
11	*Herpestes auropunctatus*	Small Indian Mongoose	F	
12	*Herpestes edwardsii (E.Geoffroy Saint-Hilaire,1818)*	Grey Mongoose	C	
	Hyaenidae			
13	*Hyaena hyaena (*Linnaeus,1758)	Striped Hyena	S	
	Hystricidae			
14	*Hystrix indica* (Kerr,1792)	Indian Porcupine	H	
	Leporidae			
15	*Lepus nigricollis* (F.Cuvier,1823)	Indian Hare	H	
16	*Lepus nilgricollis dayanus*	Desert Hare	H	
	Muridae			
17	*Meriones hurrianae (*Jordon,1867)	Desert Gerbill	G	
18	*Tatera indica* (Hardwicke,1807)	Indian Gerbill	G	
	Suidae			
19	*Sus scrofa (*Linnaeus,1758)	Wild Boar	H	
	Viverridae			
20	*Viverricula indica (*Desmarest,1804)	Small Indian Civet	C	

E=Endangered, V=Vulnerable, I=Indeterminate, T=Threatened

Table 2: Diversity indices in various land use land cover and habitat categories

	Dominance_D		**Simpson_1-D**		**Menhinick**		**Equitability_J**	
	Index value	**Mean ± SD**	**Index value**	**Mean ± SD**	**Index value**	**Mean ± SD**	**Index value**	**Mean ± SD**
Overall	0.299	0.45 ± 0.12	0.701	0.54 ± 0.12	0.1012	0.75 ± 0.19	0.5851	0.62 ± 0.11
Forest	0.3018	0.46 ± 0.12	0.6982	0.53 ± 0.12	0.11	0.74 ± 0.19	0.5977	0.60 ± 0.10
Grassland	0.3028	0.44 ± 0.11	0.6972	0.55 ± 0.11	0.1837	0.71 ± 0.20	0.6293	0.65 ± 0.13
Agriculture	0.2723	0.39 ± 0.07	0.7277	0.60 ± 0.07	0.3154	0.81 ± 0.16	0.6795	0.64 ± 0.08
Wetland	0.3799	0.39 ± 0.08	0.6201	0.60 ± 0.08	0.6132	0.94 ± 0.15	0.6197	0.68 ± 0.09

4. Discussions

Among direct sightings of the mammals, chinkara has the most sighting (102 individuals). Jackal was mostly recorded near mining area and near human habitation due to his feeding pattern and also 14 road kills found of this species. One hyena also found killed in road accident close to GMDC mining site near Panandhro village. Wolf was sighted only once near godhatad dam in *Prosopis* dominated habitat. Among the indirect evidences of mammals, hare and gerbils were most abundant species and well distributed

among all the habitats. Indirect evidences indicate that all the mammal species were found almost in each and every habitat.

Five threatened mammals species were recorded including two cats (Leopard - *Panthera pardus* and Desert Cat –*Felis libyca*), one canid (Indian Wolf-*Canis lupus*), one ungulate (Chinkara or Indian Gazelle –*Gazella gazella*) and an insectivore (Long-eared Hedge Hog –*Hemiechinus auritus*). Of these leopard, desert cat and long-eared hedge hog were less abundant (<10 individual), while chinkara was found with moderate numbers (102 individuals) and categorized under highly threatened species. Desert cat once said to have had a wider distribution in semi arid parts of Gujarat, is now confined to some areas of Kachchh (Singh 2001) [39]. Though, all these mammals were found in different habitats. Chinkara was recorded in open scrub and grassland due to his feeding behavior. Other species like wolf and hedge hog had restricted distribution, being found only in *Prosopis* dominant, dense scrub and mixed thorn habitats. Desert cat and leopard were sighted in open scrub and it addition to also having been reported in undulating thorn forests, grasslands, sandy desert (Prater 1971, Anon 1981 and Mukherjee 1982) [29, 1, 25], while desert cat use open scrub and forest areas equally as reported by Prater (1971) [29], Singh (1998a & b) [39], and Sharma (1998). Hedge hog reported to shelter by day in the holes in the sand or beneath thorny bushes or tufts of grass (Prater 1971) [29], was found predominantly in the dense scrub. Habitat loss was the major threat faced by all mammal species at medium to high level, while vehicular traffic was also a threat mainly to long-eared hedge hog, desert cat and jackal. Hedge hog and desert cat are smaller in size; they are more prone to road accidents.

It is well known fact that, habitat loss is the threat to mammalian fauna evident from other studies; Caracal (Sharma and Shankala 1992) [34], Desert cat (Panwar & Gopal 1984, Sharma 1998 and Mouler *et al*. (eds) 1998) [28, 25, 24], Chinkara (Nowak and Paradiso 1983 and Tikader 1983) [27]. Habitat loss due to mining is major problem in mineral rich Kachchh. It is clearly evident that, the well known Narayan Sarover Wildlife Sanctuary which abode 27 mammal species has been de-notified from 765 sq km to 444 sq km for the development of mining and mineral based industries (Tiwari and Rahmani 1996, GEER and GUIDE 2001). Important wildlife areas include the western part of Narayan Sarovar Wildlife Sanctuary covering the forest areas of Piper, Gugariana, Lakki, Mori, Hanumankundi and Tehra villages. This encompasses the Tropical Thorn Forest interspersed with village and the agriculture ecosystem.

The second Important wildlife areas which falls fully within the western part of Narayan Sarovar Wildlife Sanctuary (NSS) includes the forested areas of Piper, Mori, Gugariana, Lakki, Khirsara and Hamankundi. These areas of the hotspot has already been recommended as a mini core area (GEER and GUIDE 2001), which needs to be implemented immediately to protect from grazing, fuel wood and fodder cutting etc. Further, strict protection of these important areas would ensure the safety to the last remnant of tropical thorn forest and conservation of the indicator species of the chinkara as well as other reported threatened faunal species.

5. Acknowledgement

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