



Habitat Preferences of Wild Mammalian Species around River Chenab in Sialkot, Gujrat and Gujranwala Districts, Punjab, Pakistan

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MA has collected and analyzed the data and wrote the article. AJ has supervised the work. All authors have revised this article.

Key words

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ABSTRACT

Present research was conducted to assess the anthropogenic impacts on wild mammalian diversity around river Chenab in Sialkot, Gujrat and Gujranwala districts, Punjab, Pakistan. The mammalian diversity was recorded from May, 2013 through April, 2014 along forested landscapes, cultivated plantations, semi-urban and urban areas. The data on diversity and distribution of various mammalian species of the study area were collected through linear count method viz., direct observation (personal count and record voices) and indirect observation (presences of carcasses, fecal pellets, pug marks and meeting with local communities). The habitat preferences of large, medium and small mammals varied significantly. A decrease in mammalian diversity was observed from forest habitat to urban landscapes. Indian wild boar, Asiatic jackal, Indian fox, jungle cat, Indian pangolin and long-eared desert hedgehog preferred forested areas as well as slightly modified habitats while northern palm squirrel, house mouse, house shrew and rat species preferred human habitations. Similarly, a few species like small Indian mongoose, soft-furred field rat, short tailed mole rat, Asiatic jackal and Indian gerbil preferred cultivated areas. It can be concluded from present study that many of the mammalian species area habitat specific and corridors and connections among different landscapes are important for the conservation of mammalian diversity.

INTRODUCTION

Pakistan is the sixth most populated country in the world with an estimated 207.8 million in 2017. The country population growth rate of 2.40 percent is the highest in South Asia and stands in sharp contrast to the 1.0 to 1.5 percent growth rate of other South Asian countries. Population of Pakistan has increased by more than sixfold since the first post-independence census held in 1951.

This huge growth in population puts severe challenges for socio-economic development of this country (UNDP, 2019). At the same time Pakistan is considered amongst the most diversity rich countries (Roberts, 1997), however, increase in human population has adversely affected the diversity of Pakistan as the increasing populations demand for food and shelter resulted in agriculture intensification, urbanization, industrialization and pollution (Altaf *et al.*, 2014).

During the last 10,000 years, natural vegetation has been converted to agricultural lands and other anthropogenic uses. The generalist species adopted new habitats while the more habitat-specific species became extinct (Di Giulio *et al.*, 2009). At the end of the 20th century, intense farming brought changes in land use and affected diversity of areas at a massive scale (Paarlberg and Paarlberg, 2000).

The urbanized areas are greatly different from the

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natural habitats of the species and with the development of new residential areas and allied facilities the bigger ecosystems have been fragmented, the natural vegetation has been removed (McKinney, 2002) and many native species have been replaced either with exotic ornamental or with the plants having better yields (Holway and Suarez, 2006). Therefore, the natural ecosystems have been altered and changed in urbanized, peri-urban and forested landscapes. Up to some extent, moderate urbanization enhances diversity of some of the species by providing nesting and foraging sites (Blair, 1996). However, in densely populated areas the natural vegetation has been removed leading to decrease in diversity and density of the biodiversity (Blair, 2001).

Conservationists inclined towards the restoration of species in urbanized areas have to face many challenges, therefore this part remained unattended (Miller and Hobbs, 2002). However, at the end of 20th century, levels of urbanization were (Savard *et al.*, 2000) studied wherein the management of urbanized ecosystems was especially focused (Clergeau *et al.*, 2006).

Mammals are important component of all types of ecosystems and play significant role in the sustainability of ecosystems. Many of the mammalian species have nutritional values and good source of protein in human diets (Robbins, 1983). Various species are important attractions in ecotourism and research (Virk, 1999; Bibi *et al.*, 2013).

Nature lovers like to spend time with animals and are amused to observe their activities like feeding, voice calls etc. and these activities instigate conservation efforts among masses (McKinney, 2002). Kit fox (*Vulpes macrotis mutica*) are common in some urban habitats of USA (Nelson *et al.*, 2007). Northern palm squirrels (*Funambulus pennantii*) prefer to live in peri-urban areas of Pakistan (Altaf *et al.*, 2012). Indian wild boar (*Sus scrofa*) (Chughtai *et al.*, 2018), Indian crested porcupine (*Hystrix indica*) (Safeer *et al.*, 2018) and small Indian mongoose (*Herpestes javanicus*) (Altaf *et al.*, 2018) prefer to live in the vicinity of agriculture habitats. Data regarding mammalian diversity and distribution are the first step towards species conservation (McKinney, 2002).

Urbanization and habitat loss are the major factors of decline of mammalian diversity in Pakistan (Altaf *et al.*, 2014; Altaf, 2018). Other factors include shortage of food, change in vegetation, pollution (Shochat *et al.*, 2010) and negative human behavior (Rytwinski and Fahrig, 2012).

To understand diversity patterns it is essential to identify habitat preferences of animal species (Riem *et al.*, 2012). It is a wrong perception that diversity always decreases with increase in density with human population e.g. some species prefer to live in close association of humans (Saito and Koike, 2013; Manzoor *et al.*, 2018) and

species richness is higher in the ecotone region (Magura *et al.*, 2004). Mammalian diversity varies from forested landscapes to urban areas. Considerable work on diversity, distribution and habitat preferences of mammalian species has been conducted in USA, Australia and Europe while mammalian species of Asian region are less in focus. Primary aim of the present study was to understand habitat preferences of wild mammalian species around river Chenab in Sialkot, Gujrat and Gujranwala districts, Punjab, Pakistan.

MATERIALS AND METHODS

This one year study extending from May, 2013 through April, 2014 was conducted in three districts viz., Gujranwala, Gujrat and Sialkot in Punjab, Pakistan through which river Chenab passes. All three districts are densely populated and almost the entire natural ecosystems have been changed into agro-ecosystems. Rice, wheat and sugarcane are the most widely planted agricultural crops.

Gujranwala district covers an area of 3,622 km², is the third most populated city of the country with human population of 5.409 million, Gujrat district covers an area of 3,192 km² with human population of 2.756 million, Sialkot district covers an area of 3,016 km² with human populations of 3.894 million (Pakistan-Population-Census, 2017). Areas around the river Chenab exhibit different habitats viz., forested areas, urban centers, agricultural lands and the rural landscape. Six study sites were selected in each district for the observation of mammalian diversity of the study area (Table I).

Climate of the study area is hot and humid during summer and cold during winter with temperature ranging 4°C during winters to 40 °C during summer. June and July are the hottest months while December and January are the coldest months of the year. The topography is flat and the alluvial land is mostly fertile (Anonymous, 2007).

Prominent aquatic vegetation of the study area includes hydrilla (*Hydrilla verticillata*), water lily (*Nymphaea lotus*), horned pondweed (*Zannichellia palustris*), reed (*Phragmites karka*), curly-leaf pondweed (*Potamogeton crispus*), Indian lotus (*Nelumbo nucifera*), lesser Indian reed mace (*Typha angustata*), eel grass (*Vallisneria spiralis*), musk grass (*Chara* spp.) and lyngbye's sedge (*Carex fedia*). Important natural vegetation of the surrounding plains includes athel or frash, ghaz (*Tamarix aphylla*), jand (*Prosopis cineraria*), Indian plum or beri (*Zizyphus mauritiana*) and the forest species viz., shisham (*Dalbergia sissoo*), and Kikar or thorn-tree (*Vachellia nilotica*) and grasses like kana or sarkanda (*Saccharum bengalensis*), kans grass (*Saccharum spontaneum*) and goose grass (*Eleusine compressa*) (Roberts, 1984). Most common weed species of the study area include

Table I. Study areas river around Chenab in Sialkot, Gujrat and Gujranwala districts, Punjab, Pakistan from May, 2013 through April, 2014.

Study Area	Type	Coordinate	Elevation (ft)
Head Marala (Sialkot)	Forest habitat (FH-1)	32°39'59 N, 74°28'05 E	811
Bahlolpur	Rural forest habitat (RFH-1)	32°34'55 N, 74°25'41 E	840
Motra	Agri-rural habitat (ARH-1)	32°23'07 N, 74°25'18 E	777
Latif Abad	Urban non vegetative habitat (UNH-1)	32°29'42 N, 74°32'05 E	840
Murad Pur	Urban vegetative habitat (UVH-1)	32°31'09 N, 74°30'05 E	808
Head Khanki (Gujrat)	Forest habitat (FH-2)	32°28'32 N, 73°03'39 E	712
Ghazi Chak	Rural forest habitat (RFH-2)	32°30'00 N, 73°05'39 E	739
Kunjah	Agri-rural habitat (ARH-2)	32°31'52 N, 73°58'29 E	735
Walled City	Urban non vegetative habitat (UNH-2)	32°34'26 N, 74°04'39 E	802
Green Town	Urban vegetative habitat (UVH-2)	32°33'27 N, 74°04'39 E	756
Head Qadirabad (Gujranwala)	Forest habitat (FH-3)	32°19'06 N, 073°41'36E	683
Kot Hara	Rural forest habitat (RFH-3)	32°16'06 N, 073°42'22E	695
Varpal Chattha	Agri-rural habitat (ARH-3)	32°13'02 N, 073°54'26E	704
Noor Bawa	Urban non vegetative habitat (UNH-3)	32°09'44 N, 074°10'56E	758
Qila Sundar singh	Urban vegetative habitat (UVH-3)	32°08'33 N, 074°10'00E	731

Table II. Mammalian distribution around the river Chenab in Sialkot, Gujrat and Gujranwala districts, Punjab, Pakistan from May, 2013 through April, 2014.

Scientific name	Common name	Code	FH (RA)	AFH (RA)	RFH (RA)	ARH (RA)	UVH (RA)	UNH (RA)
<i>Suncus murinus</i>	House shrew	HS	0.00	4.34	5.10	3.88	17.09	23.81
<i>Suncus etruscus</i>	Mediterranean pygmy shrew	MPS	3.16	0.87	1.02	2.33	0.00	0.00
<i>Lepus nigricollis dayanus</i>	Desert hare	DH	6.58	2.31	5.10	0.00	0.00	0.00
<i>Funnambulus pennantii</i>	Northern palm squirrel	NPS	9.21	5.78	16.84	9.30	8.55	0.00
<i>Hystrix indica</i>	Indian crested porcupine	ICP	27.64	20.23	22.19	0.00	0.00	0.00
<i>Millardia meltada</i>	Soft-furred field rat	SFR	0.00	4.34	0.00	3.88	0.00	0.00
<i>Rattus rattus</i>	House rat	HR	0.00	5.78	10.46	28.68	25.64	27.62
<i>Mus musculus</i>	House mouse	HM	0.00	4.34	9.44	25.58	42.74	48.57
<i>Tatera indica</i>	Indian gerbil	IG	5.00	4.34	0.51	11.63	0.00	0.00
<i>Hemiechinus collaris</i>	Long eared desert hedgehog	LEDH	1.58	2.89	3.83	0.00	0.00	0.00
<i>Canis aureus</i>	Asiatic jackal	AJ	2.63	18.79	6.38	0.00	0.00	0.00
<i>Vulpes bengalensis</i>	Indian/Bengal fox	IF	1.32	0.58	0.00	0.00	0.00	0.00
<i>Herpestes javanicus</i>	Small Indian mongoose	SIM	7.89	13.01	5.61	5.43	5.98	0.00
<i>Sus scrofa</i>	Indian wild boar	IWB	31.58	8.67	12.76	0.00	0.00	0.00
<i>Nesokia indica</i>	Short tailed mole rat	STMR	1.84	2.89	0.00	9.30	0.00	0.00
<i>Manis crassicaudata</i>	Indian Pangolin	IP	0.53	0.29	0.26	0.00	0.00	0.00
<i>Felis chaus</i>	Jungle Cat	JC	1.05	0.58	0.77	1.53	0.00	0.00

FH, forest habitat; RFH, rural forest habitat; ARH, agriculture rural habitat; UVH, urban vegetative habitat; UNH, urban non-vegetative habitat.

common cockle-bur or bugwood (*Xanthium strumarium*), burra gokharu (*Tribulus terrestris* L.), prostrate spurge (*Euphorbia prostrata* L.), white-top weed or gajart booti (*Parthenium hysterophorus*), devil's horsewhip (*Achyranthes aspera*), Indian doab or khabbal (*Cynodon dactylon*), slender amaranth (*Amaranthus viridis*), and marijuana (*Cannabis sativa*). wheat (*Triticum aestivum*), rice (*Oryza sativa*), sugar cane (*Saccharum officinarum*) and pea plants (*Pisum sativum*) are the prominent crops of the area (Umair *et al.*, 2013).

The data regarding mammalian diversity were collected during dawn and dusk hours. Linear count survey method was used for population estimation of mammalian fauna of the study area; 15 transect lines were selected, each of one km. One year data were collected by two trained observers, each site was visited once in a month in the morning (5 a.m. to 10 a.m.) and in the night (6 p.m. to 10 p.m.). Both, direct (total/physical count and calls or voices) and indirect (nests, fecal pellets, foot-prints, marks on trees, and group questionnaire survey) methods were applied to find out mammalian diversity of the area. The questionnaire data were collected only to know the location and presences of species. Small animal data were collected by traps fixed (n=10) for two nights at each place and once in a month in shops, houses fields and the forest. Binocular (32x50) was used to observe the animals and "Mammals of Pakistan" was consulted to correctly identify the species (Roberts, 1997).

For the statistical analysis PAST version 2.17c was used (Hammert *et al.*, 2001) to determine the Simpson diversity, Shannon diversity (H), Evenness (E), Margalef (R), Dominance, Dentrered component analysis (DCA) and Cluster analysis. DCA was used to examine relationships between mammalian fauna and habitat variables.

RESULTS AND DISCUSSION

Seventeen mammalian species (11 small and 6 large and medium) were recorded from the study area. All 17 species were recorded from the agriculture forest habitat (AFH), while 13, 14, 10, 5 and 3 species were recorded from the forest habitat (FH), rural forest habitat (RFH), agriculture rural habitat (ARH), urban vegetative habitat (UVH) and urban non-vegetative habitat (UNH) respectively (Fig. 1, Tables II and III).

Forest habitat had the highest Simpson index (0.8828) and Shannon-Wiener index (2.398) among all the habitats, however Richness/Margalef (R) value (2.694) was the highest at forest habitat and also noted that Evenness (0.9505) was the highest at urban non-vegetative habitat (Table III). Simpson index, Shannon-Wiener index and

Margalef show that rich number of species was present in natural habitats.

Two groups are present in the cluster analysis i.e. Group one (G1) and Group two (G2). G1 has two habitats urban vegetative habitats and urban non vegetative habitats, both have close association with each other and a similarity between them is near 0.8. while G2 has two further sub groups i.e. Sub Group 1 (SG1) and Sub Group 2 (SG2) have comparatively low similarities (0.4). SG1 is also further two groups i.e. Sub Group 1A (SG1A) and Sub Group 1B (SG1B), both are moderately similar (0.5). SG1B has two habitats; both (agriculture and forest habitats) are more similar (0.8) (Fig. 2). Each habitat is compared on the basis of vegetation size.

Table III. Statistical analysis of different habitats of mammalian species around river Chenab in Sialkot, Gujrat and Gujranwala districts, Punjab, Pakistan from May, 2013 through April, 2014.

Diversity indices	FH	AFH	RFH	ARH	UVH	UNH
No. of species	11	17	14	10	5	3
Individuals	380	346	393	131	117	105
Dominance (D)	0.1918	0.1172	0.1272	0.1797	0.2885	0.3689
Simpson (S)	0.8082	0.8828	0.8728	0.8203	0.7115	0.6311
Shannon (H')	2.054	2.398	2.244	1.947	1.393	1.048
Evenness (E)	0.4588	0.6472	0.6739	0.7005	0.8053	0.9505
Margalef (R)	2.694	2.737	2.176	1.846	0.84	0.4297

FH, forest habitat; RFH, rural forest habitat; ARH, agriculture rural habitat; UVH, urban vegetative habitat; UNH, urban non-vegetative habitat.

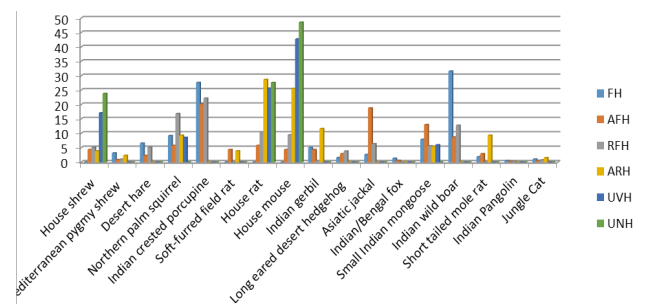


Fig. 1. Mammalian diversity in the study area.

In the Dentrered Component Analysis (DCA), the results indicate that the habitat characteristics affect the mammalian community structure. Indian fox (*Vulpes bengalensis*) has more correlation with the agriculture

forest habitat (AFH) and forest habitat, however Indian wild boar, Mediterranean pygmy shrew (*Suncus etruscus*), desert hare (*Lepus nigricollis dayanus*), jungle cat (*Felis chaus*), Indian crested porcupine (*Hystrix indica*), small Indian mongoose (*Herpestes javanicus*) and long eared desert hedgehog (*Hemiechinus collaris*) and Indian pangolin (*Manis crassicaudata*) show positive correlation with natural and slightly disturbed habitats as; forest habitat, rural forest habitat and agriculture habitat. Northern palm squirrel show highly positive correlates in slightly disturbed areas as rural forest habitat. Indian gerbil (*Tatera indica*) and short tailed mole rat show (*Nesokia indica*) more correlation with agriculture habitat and agriculture and forest habitat. And house shrew (*Suncus murinus*), house mouse (*Mus musculus*) and house rat (*Rattus rattus*) show more correlation with agriculture forest habitat, urban vegetative habitat and urban non-vegetative habitat (Fig. 3).

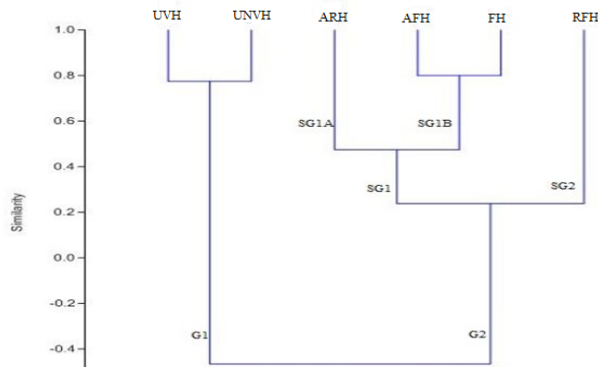


Fig. 2. Cluster analysis of landscape use ratio in different habitats (i.e. forest habitat (FH), rural forest habitat (RFH), agriculture rural habitat (ARH), urban vegetative habitat (UVH) and urban non-vegetative habitat (UNH)) around river Chenab in Sialkot, Gujrat and Gujranwala districts, Punjab, Pakistan from May, 2013 through April, 2014.

The landscape gradients are the factors that affect the diversity and distribution of large, medium and small wild mammalian species around the river Chenab (Table II). Based on our statistical analysis, we can place the wild mammals in a given landscape gradient. Mammalian species react spontaneously to anthropogenic activities (Stoate et al., 2009). Conservation and restoration plans for mammalian species, especially forest species, should be measured in the global context (Branton and Richardson, 2011). However, small green spaces and corridors are important for mammal conservation in the urban habitats from where large forest patches have been cleared away. In

the Detrended Component Analysis the results indicate that anthropogenic impact indirectly impacts on the distribution of mammals (Fig. 2). Conservation plans must focus on the management of urbanization.

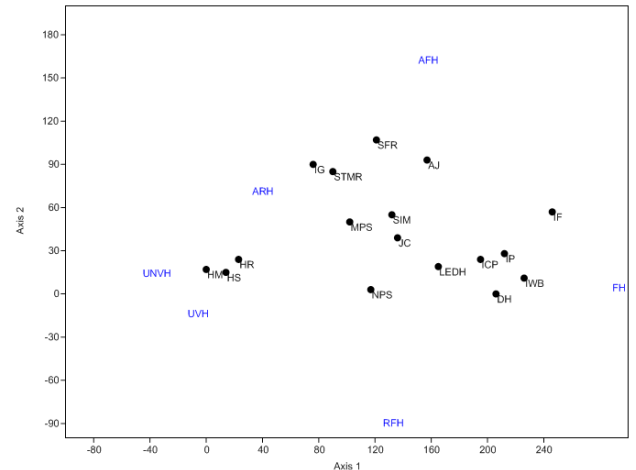


Fig. 3. DCA of patterns of occupancy of sample plots predicted for 17 wild mammalian species (with code present in Table II) relative to six habitat characteristics i.e. forest habitat (FH), rural forest habitat (RFH), agriculture rural habitat (ARH), urban vegetative habitat (UVH) and urban non-vegetative habitat (UNH).

Sightings of the most mammalian species decreased from forest to urban habitats, while some species preferred slightly or completely disturbed habitats. Large and medium sized mammalian species i.e. Indian fox, Indian wild boar, Indian pangolin, desert hare and jungle cat usually occupy forest landscape. This result is supported by different researches (Bateman and Fleming, 2012; Riem et al., 2012). Northern palm squirrel, small Indian mongoose, Mediterranean pygmy shrew, Asiatic jackal, soft-furred field rat and Indian crested porcupine prefer slightly disturbed habitats. Some species prefer completely disturbed areas like house shrew, house rat and house mouse.

Garbage in urban core has food for mammalian species, which can be consumed by carnivorous and omnivorous species (Hirasawa et al., 2006). The results suggest that open habitat where animal food is available is main factor in the distribution of mammals. Urban and rural areas provide food and anthropogenic shelters i.e. roofs and houses spaces. Some mammalian species are shy in nature; they do not like human involvement in habitats. This could be a main contributor to the distribution of mammals in urbanized areas. However, they enter in the populated areas in the absence of humans or at night e.g. Asiatic jackal and wild boar. However, people often do not

know the existence of medium or small sized mammals (i.e. small Indian mongoose, jungle cat and Indian crested porcupine) even though these animals live around residential areas.

The study reports on the mammalian diversity and distribution in different habitats around river Chenab in Sialkot, Gujrat and Gujranwala districts, Punjab, Pakistan. Factors such as food, shelter, human presence, large fragmentation, loss of habitat, invasive plant species and removal of plantation impact the distribution of mammalian diversity.

It is concluded that the landscape gradients are the factors affecting the diversity and distribution of mammalian species. Mammalian species react rapidly to anthropogenic impact. Conservation and restoration plans for mammalian species, especially forest diversity, should be measured in the large scale. However, small green spaces and corridors are important for mammalian conservation in the urban habitats from where large forest patches have declined. Conservation plans must be focused on the management of urbanization.

Statement of conflict of interest

The authors have declared no conflict of interest.

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