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Pattern of Mammalian Distribution in the Chagai Desert, Balochistan, Pakistan

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Abstract.- Distribution of mammals and the characteristics of their habitats were investigated in Chagai Desert in November 2008. The Chagai Desert, in Balochistan Province of Pakistan, is characterized by very low rainfall, high summer temperature, high velocity winds, poor soils, very sparse vegetation and a low diversity of plant species. The soils in the hills are mainly rocky and gravelly with very shallow fine material due to high aridity and wind erosion. A total of 26 plant species, belonging to 12 families were recorded from the area. Dominant plant genera were *Tamarix, Haloxylon, Fagonia, Tribulus, Zygophyllum* and *Aristida*. On the basis of vegetation characteristics and topographical features, habitats of the study area can be distinguished in to four types, *i.e*. mountain/hills, gravel plains, sandy plains and seasonal stream beds. We recorded 22.8 rodent colonies per km^2, which makes rodents the most abundant group of mammals in Chagai. Signs of fox (*Vulpes* spp.) (7.2/km^2) and jackal (*Canis aureus*) (3.3/km^2) were also relatively common; however, signs of other large mammals were very rare and limited to few areas. Principal Component Analysis (PCA) revealed that the majority of mammalian species in the area had correlated distribution pattern. Gravel plains and hilly areas, which cover major parts of the desert, were associated with the lowest mammalian densities. Higher densities of mammals were restricted to spatially limited areas of sandy plains and seasonal streambeds. The low densities of mammals can likely be explained by low productivity, fluctuation, and severity of climatic conditions in the Chagai Desert.

Key words: Chagai, mammals, Balochistan, habitats, vegetation, desert.

INTRODUCTION

The Western Balochistan is a part of the 'Palaearctic zoo-geographic region', which spans across Europe and Asia. This zoo-geographical region comprises a variety of ecological zones which are governed by abiotic conditions. Ecologically, the study area is a part of the Siestan Desert of Iran which also covers the Chagai and the Kharan Desert. Though most of the terrestrial fauna is typical of the Siestan desert affiliated with the Palaearctic region, there are some elements of the African zoo-geographical region. Despite the harsh climatic conditions, a variety of mammals have been reported from the study area (Akhtar, 1958-60; Ellerman, 1961; Ahmad and Ghalib, 1979; Roberts, 1997, 2005; Mirza, 1998). Recently Rafique *et al*. (2010) have described 23 mammalian species from the Chagai Desert. Majority of these species are burrowing taxa belonging to orders rodentia, lagomorpha and insectivora. Historically, iconic species such as the Asiatic cheetah (*Acinonyx jubatus*), chinkara (*Gazella bennettii*) and goitered gazelle (*Gazella subgutterosa*) inhabited the area in good numbers.

Phytogeographically, the study area falls in the Saharo-Sindian region. This region is considered very poor in plant diversity as despite its large size, only 9.1% of the known floral species of Pakistan are found in this region (Nasir and Ali, 1972). The vegetation in this region is degraded and sparse, and consists mainly of stunted thorny or prickly shrubs and perennial herbs resistant to drought.

Mammals in the region are well adapted to harsh conditions. They tolerate temperatures as high as 51°C in summer. Winter is generally mild, however, temperature occasionally goes down as low as -10°C at certain locations (source: weather records maintained at field camp of Tethyan Copper Company at Nok Kundi). The rainfall in the area is low, patchy, and exhibits high fluctuation over the

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years, as compared to temperate areas in Pakistan.

Topographically, the area has barren hills and vast basins of gravel plains. Such variable climatic conditions along with a combination of distinct landscape features are expected to render a divergent distribution pattern in mammalian fauna of the area. This study was aimed at characterizing the Chagai Desert according to the environmental and habitat conditions, and exploring association of mammals with environmental factors. The study is an initial step towards filling the current information gap with respect to the ecology of the Chagai Desert, and provides benchmark data for conservation planning of threatened mammal species.

MATERIALS AND METHODS

Study area

The study was carried out in western part of the Chagai district, in areas bordering with Iran in the west and Afghanistan towards the north (Fig. 1). The area has desert conditions, and can be characterized into four kinds of habitats, *i.e.*, mountain/hills, gravel plains, sandy plains, and seasonal stream beds. The hills in the study area are almost barren except for some annual herbaceous vegetation that grows following the rains. Gravel plain is the most prevalent habitat in the area, with very sparse vegetation, and the low species diversity. The sandy plains cover a smaller part of the study area; however vegetation cover is higher as compared with gravel plains. The dry stream beds include the gorges and banks of large and small seasonal streams, and are spread throughout the study area.

The climate of the area is hyper-arid, and almost 75% of the rain is received in winter and spring (December to April). Summer months, particularly August and September, are almost dry (Hagler Bailly Pakistan, 2009). The total average annual rainfall in Zahedan (across the border with Iran) and Dalbandin is 82 mm and 85 mm, respectively. In contrast, the total average rainfall in Nok Kundi is only 36 mm. This shows that climatic conditions get more severe towards the western parts of the Chagai Desert. The time series analysis for Nok Kundi indicates that typically the drought cycle consists of 6-7 years. In this period, there is one year with rainfall more than twice or thrice the annual average and there are two years of moderate rainfall following 3-4 years of drought (Hagler Bailly Pakistan, 2009).

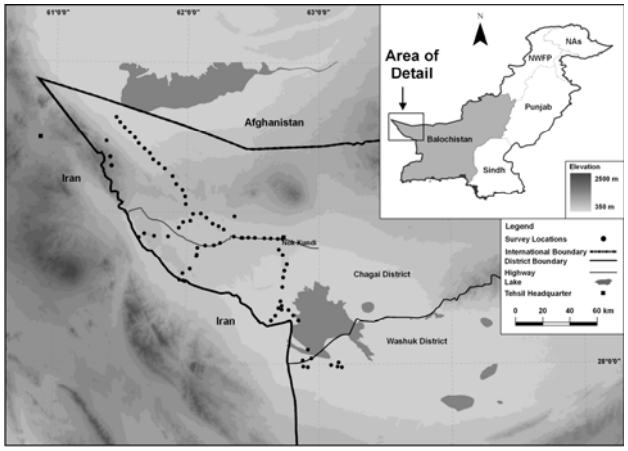

Fig. 1. Map of the study area, showing survey locations.

Data collection

The field survey was conducted during November 5-20, 2008. Most of the Chagai Desert could be accessed by jeep, which allowed us to travel to various parts of the study area. Survey locations were placed systematically every five kilometers along the travel routes (Fig. 1). A 500x500 m sign survey plot was laid at each location and sightings and signs (tracks, feces, burrows, and dens) of mammals were recorded. A team of three researchers walked randomly at each survey plot, and searched for signs for 30-45 minutes. The presence of rodents was mostly confirmed by their colonies, and only active colonies (confirmed by the rodent activity) were considered. The presence of hedgehog (*Hemiechinus collaris)* was determined by their dens and droppings. Fox (*Vulpes* spp.) tracks were distinguished from that of jackal (*Canis aureus*) by their smaller size, relatively oval shape due to elongated front toes, and sometimes hair imprints (of their furry feet) on soft substrate. Based on the previous experience, scats that were relatively

smaller and were largely composed of hairs were assumed to be that of fox. Jackal scats contained diverse matters with fruits as a dominant part. Individual tracks were distinguished based on their direction, distance from each other, and connectivity between them. The vegetation sampling was carried out by laying 2 to 3 quadrats (10 x 10 m) at each sampling site. A total of 167 quadrats were laid at 75 survey plots. Plants from each quadrat were noted and collected for the assessment of relative abundance of the species. Additional plant species in the area adjacent to the quadrat that were not present in the quadrats were also noted down and collected to record the occurrence of the species. Plants were identified following the nomenclature from Flora of Pakistan (Nasir and Ali 1972-1994; Ali and Qaiser, 1995-to date). Collected plant species were deposited at Pakistan Museum of Natural History, Islamabad for future reference.

Data analysis

Principal Component Analysis (PCA) was performed using R program, version 2.9.2 (R Development Core Team, 2009), to determine the association among mammal species with regard to their distribution in the study area. The PCA is a statistical procedure that transforms a number of possibly correlated variables into a smaller number of uncorrelated variables called principal components. The variable used in this analysis was number of signs of all groups recorded at each plot. The first principal component accounts for as much of the variability in the data as possible, and each subsequent component accounts for as much of the remaining variability as possible (Johnson and Wichern, 2002). A biplot of the first two Principal Components (PC) was developed to visualize relationships. A biplot represents both the observations and variables of a matrix of multivariate data on the same plot (Gabriel 1971). Observations are represented as points and variables as vectors. Associations of mammalian species with habitat types, and associations between dominant plant species and habitats, were also explored through PCA. Habitat type was used as a Boolean variable (0= absent, 1=present), and for plant genera their densities at each plot were used for the analysis.

RESULTS

Flora and habitats

Natural vegetation is xerophytic having strong deep root system, which makes it possible for the plants to obtain subsoil moisture and grow in the dry climate. Due to climatic factors, the ephemeral plants appear during the rainy season and complete their life cycle before the advent of summer, leaving the bulk of the open, sandy plains barren once again. Most species of shrubs also flower and set seeds during the same period. A total of 28 species, belonging to 12 families (Table I) were recorded from the study area. The common plant genera in the area were *Tamarix, Haloxylon, Fagonia, Tribulus, Zygophyllum* and *Aristida*. A biplot of PCA exhibits relationship between the six common plant genera and habitat types (Fig. 2). *Tamarix* and *Zygophyllum* were associated with sandy plains. Correlations among the distribution of these two genera and sandy plains were significant ($r=0.28$ and 0.55, $p< 0.05$). *Zygophyllum* also had strong negative correlation with elevation ($r= -0.21$, $p< 0.05$). *Aristida, Fagonia,* and *Tribulus* were associated with gravel plains. The genus *Haloxylon* did not show association with any particular habitat.

Distribution of mammals

A total of 75 sign survey plots were searched in November 2008 throughout the study area. Carnivore species that are relatively tolerant to humans, such as fox and jackal, were common in the study area. Foxes were abundant, with total signs of 135 recorded in 75 search plots (500 x 500 m), giving an average density of 7.2 per km^2 (range: 0-40). Three species of foxes (*Vulpes cana, Vulpes rueppelli* and *Vulpes vulpes*) are reported from the area (Rafique *et al*., 2010), with *Vulpes vulpes* (red fox) being the most common. We made sighting of six red foxes during this study, and one was photographed. A total of 62 jackal signs were identified, giving an average of 3.3 per km^2 (range: 0-48). Rodent species and hedgehog were common in the area. During the sign surveys, 431 rodent colonies were recorded, averaging 22.8 per km^2 (range: 0-156). Records of hedgehog burrows ranged 0-6 at survey sites, averaging 1.8 per km^2. A few signs of goitered gazelle were observed in areas

Table I.- Plant species recorded from the Chagai Desert, Balochistan, Pakistan, along with Phytosociological attributes.

Botanical Name	Local name	Life form	D1	D2	C	F1	F2	IVI
Poaceae								
Aeluropus lagopoides	-	Grass	+	+	+	+	+	+
Aristida sp.		Grass	2.5	30.33	12.25	0.7	25.37	22.65
Cymbopogon jwarancusa		Grass	1.0	6.56	9.10	0.8	11.54	9.07
Unidentified grass species		Grass	1.7	6.97	6.13	0.7	7.74	6.95
Panicum sp.		Grass	0.8	4.92	12.18	0.5	7.69	8.26
Panicum turgidum		Grass	0.3	1.23	9.11	0.3	3.81	4.72
Palmae								
Phoenix dactylifera	Khajoor	Tree	0.7	2.67	15.22	0.3	3.81	7.23
Areceae								
Anabasis setifera		Herb	+	+	+	+	+	+
Artemisia scoparia		Shrub	1.8	11.48	3.50	1.0	15.38	10.12
Artemisia sp.		Shrub	+	+	+	+	+	+
Chenopodiaceae								
Haloxylon persicum	Taghaz	Shrub	2.0	17.35	23.79	0.6	15.19	18.78
Haloxylon salicornicum	Lardug	Shrub	1.0	13.60	27.23	0.7	28.73	23.19
Haloxylon stocksii	Shoodee	Shrub	1.3	16.87	18.82	0.7	24.96	20.22
Fabaceae								
Alhagi maurorum	Jhik	Shrub	2.9	16.06	17.48	0.7	11.56	15.03
Tephrosia uniflora		Shrub	1.8	11.48	14.38	0.75	11.54	12.47
Cucarbitaceae								
Citrullus colocynthis		Shrub	1.3	5.33	6.11	1	11.55	7.663
Moraceae								
Ficus johannis	Jhanglee Injir	Shrub	+	+	+	+	+	+
Polygonaceae								
Calligonum comosum	Phog	Shrub	0.9	8.26	0.46	0.67	16.67	8.463
Calligonum polygonoides	Phog	Shrub	0.9	8.35	16.51	0.9	14.64	13.17
Tamaricaceae								
Tamarix aphylla	Gaz	Tree	1.3	12.51	21.95	0.7	12.35	15.60
Tamarix stricta	Gaz	Shrub	1.3	13.65	20.12	0.6	14.22	16.00
Zygohyllacaea								
Fagonia ovalifolia	Karkawa	Herb	1.9	20.3	23.34	0.7	17.69	20.44
Peganum harmala		Herb	+	+	+	+	+	+
Tribulus terrestris	Sarring	Herb	1.7	21.95	8.08	0.7	24.29	18.11
Zygophyllum simplex		Herb	1.3	10.87	13.5	0.71	16.21	13.53
Convolvulaceae								
Seddera latifolia		Herb	2.3	14.75	10.13	1.0	15.38	13.42
Cressa sp		Herb	2.7	11.07	12.13	0.33	3.81	9.003
Boraginaceae								
Heliotropium crispum		Herb	1.3	15.13	12.48	0.8	19.69	15.77

+, observed outside quadrats; D1, Density (the number of individual of a species counted in a unit area); D2, relative density (the proportion of a density of a species to that of a stand as a whole); C, relative cover (the proportion of the total frequency of a species to sum of the frequency of all the species in area); F1, frequency (percentage of sampling plots in which a given species occurs); F2, relative frequency (the proportion of the total of a species to the sum of the cover of all the plants of all species in the area); IVI, importance value index: It is obtained by adding the values of relative density, relative cover and relative frequency and dividing it by three.

close to Kirtika mountains, and none for Asiatic cheetah and other large mammals.

Association among mammalian species

The PCA, using data on mammalian densities, helped to determine the association among mammals with regard to their distribution in the study area. The eigean analysis of the correlation matrix indicated that the first two principal components (PCs) explained 83% variation in the

data, suggesting that PC1 and PC2 are adequate to explain pattern in the data. The biplot of PC1 and PC2 (Fig. 3) indicated that, on the PC1 axis, all mammals under discussion had a correlated pattern in distribution. The PC2 axis separates hedgehog distribution from the rest of mammals. This is probably because hedgehog was completely absent from hilly areas, where other mammals were present in low densities. The biplot also shows distribution of 75 survey sites (represented as asterisk in Fig. 3), in relation to mammalian distribution. The majority of points are clustered close to the base of arrows, suggesting that major part of the study area is low in mammalian abundance.

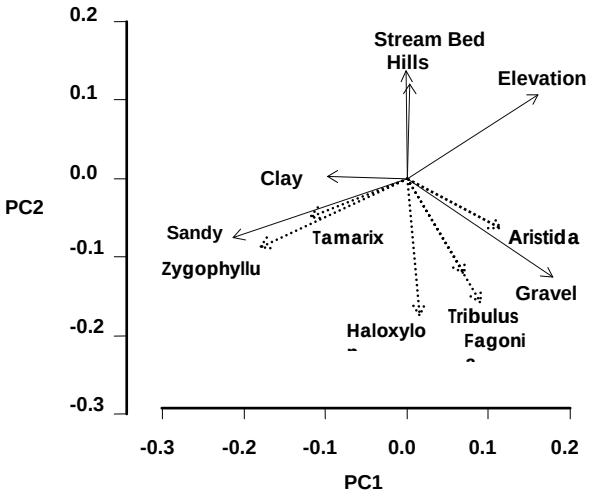

Fig. 2. A biplot of principal component analysis showing relationship between common plant genera and habitats in Chagai Desert, Balochistan, (PC, Principal Component).

Association of mammals with habitat types

Another PCA was run on the mammal data together with environmental variables. Environmental variables included elevation and habitat types (gravel plains, clay plains, sandy desert, stream beds, and hills). The first two principal components explain 61% of total sample variance, and reveal relationships of mammals with environmental variables. The biplot (Fig. 4) show a strong pattern with gravel plains. Mammals and gravel plains were in opposite directions, suggesting that such habitats were least productive in the study area. Streambeds and sandy deserts seem to be relatively higher in productivity, while clay plains and hilly areas were at low to intermediate levels.

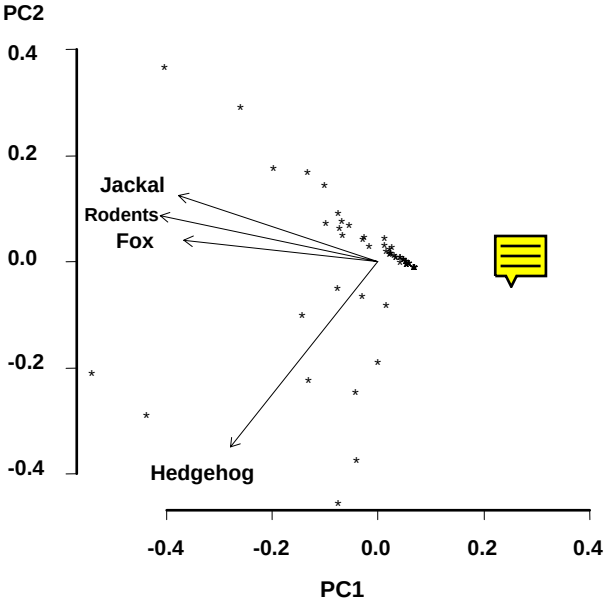

Fig. 3. A biplot of principal component analysis showing relationship between distribution of mammal species in Chagai Desert, Balochistan (*, Survey Locations).

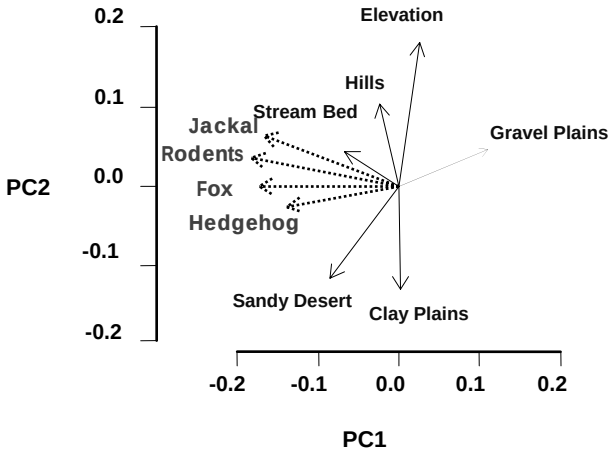

Fig. 4. A biplot of principal component analysis showing distribution of mammals in relation to habitat types in Chagai Desert, Balochistan.

DISCUSSION

The climate of the area is hyper-arid with hot summers and mild winters. The precipitation during winter is, however, more predictable with its peak in January. The average annual rainfall is as low as 36 mm, the western part of the Chagai desert is even drier (Hagler Bailly Pakistan, 2009). The area also experiences 3-4 years of drought in a cycle of 6-7 years. The soils in the hills are mainly rocky and gravely (Hagler Bailly Pakistan, 2009), and vegetation cover is sparse. The hot winds in summer and less commonly cold winds in winter carry a large quantity of sand leading to dust abrasion. Consequently, plant growth is slow and recovery from damage is protracted. The catchment areas of wetlands such as Tahlab are the only areas where dense vegetation could be found, whereas a major part of the desert is devoid of vegetation. Thus, the low densities of mammals observed during this study can likely be explained by low productivity, fluctuation and severity of climatic conditions. The PCA supports that mammals have correlated distribution pattern in Chagai, and are concentrated only in selected habitats such as sandy plains that provide more conducive environment, whereas, widespread habitats such as gravel plains and hilly areas, either lack mammalian populations or have low densities.

In addition to the prevailing natural challenges in the area, anthropogenic factors have an evident contribution in shaping mammalian composition of the area. Generally species that are adaptable to human presence (fox, jackal), or have least conflicts with humans (rodents) are common. On the other hand species with potential conflicts with humans (cheetah, wolf etc.), or having economic value to the communities (goitered gazelle, chinkara), are either extirpated or become very rare. Due to uncontrolled hunting in the area over a long period of time, large mammals have gone ecologically extinct from the area. Even when some animals, such as goitered gazelle, visit from neighboring areas of Iran, they are generally shot before they can establish a population (Rafique *et al*., 2010).

Large carnivore species (*e.g*., cheetah, wolf, cats etc.) are highly elusive and predominantly nocturnal, which make their detection difficult. These species also have large home ranges and exist in thin populations, which further reduces chances of encountering them or their signs. Intensive sign surveys were carried out to increase detection probability, and local informants were consulted to evaluate survey findings. However sign surveys have certain limitations; for example signs are less visible on hard substrate (like gravel plains, and hilly areas), and sometimes it is confusing to differentiate between signs of related species. Advanced techniques such as remote cameras and conservation genetics are considered more reliable and accurate. In the present study all rodent species were placed in a single group, which did not allow exploring habitat preferences at species level. Live trapping of small mammals at an appropriate scale will help identify individual species and assess distribution patterns at species level.

The historic large mammal fauna of the area is now either extinct or survive in low densities. Nevertheless, the study area provides a vast span of habitat where populations of large mammals can potentially be restored through dedicated efforts. The low human density, limited infrastructure, poor land potential for economic activities (*e.g*., agriculture) could be considered advantageous towards this end. Strict control over poaching and awareness campaigns could play effective role in halting further damage to mammal populations, and recovering populations of some species such as goitered gazelle. Improving prey base in the area will increase chances of the recovery of the Asiatic cheetah, which still survive in neighboring areas of Iran (Farhadinia, 2004).

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