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# Macro-Biota Variation Under Human Protection in Desert Ecosystem of Cholistan (Pakistan)

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**ABSTRACT** Overexploitation is frequently believed to seriously affect the simpler ecosystem, like, deserts, and protection has been a suggested remedy without sufficient data. This attempt tries to provide some supportive data in this direction. Sand dunes and flats from Cholistan desert (Punjab, Pakistan) were sampled from five different protection levels, i.e., intensively protected enclosure, long protected (since 1972), newly protected (since 1984), unprotected and overgrazed, using quadrat method (plants = layer by layer analysis, mammals and birds = 10 – 15 $km^2$), capture along transect line (reptiles), indirect evidences and pit fall trap (nocturnal animals and walking insects), snap trapping (small rodents) and sweep nets (flying insects). The ANOVA and linear regression equation suggest a significant difference in the species diversity under different protections and that each protection level adds 6.2 species. The species diversity and relative abundance exhibits a direct linear correlation (r = 0.85) under increasing protection. There have been different patterns in changing density/ relative abundance of different species under different protections, which is expected under the habitat requirements and palatability of each species, but generally the species abundance has increased with increasing protection. This effect is more pronounced in sand dunes as compared with saline flats. Species composition has also changed with protection. Generally low values of association chi-square appear between faunal compositions of different localities, except that between newly protected and unprotected localities, suggesting independence of each locality.

## INTRODUCTION

Deserts present habitats characterized by harsh temperature, scarcity of water, high wind velocity, uneven topography, mirages and intense solar radiation (Sexena, 1991; Bhandari, 1995), where very few species of plants and animals are adapted to survive (Odum, 1971) and thence a simple ecosystem and food web. A good proportion of the human population in the subcontinent depend upon desert biotic resources and increasing human population and gradually extending communication links has extended the human exploitation of biotic resources, including grazing and hunting, into the deserts (Fullen and Mitchell, 1994), which are more prone to overexploitation (Neronov and Borbrov, 1990) due to simplicity of their ecosystems. Protection and rangeland management appears to be the only safe strategy for rehabilitation of desert habitat, ensuring the future survival of man and his livestock in such extreme habitat.

Protected areas are believed to play an important role in conserving (Soule, 1991; Wilson, 1988; Ryerson and Parmenter, 2001; Landsberg et al., 2002; Matthews and Matthews, 2004) or even increasing (Gunin and Neronov, 1986; Polyanskaya and Neronov, 1985; Rome, 1982; Heppner, 1989; Cole, 1987; New et al., 1987; Helle, 1986; Woinarski et al., 1989) biodiversity. Reclamation of deserts through protection has been suggested for different areas of Pakistan (Roberts, 1973; Mian, 1983; Arshad and Rao, 1994) without sufficient data. The present study aims at providing some data on diversity variation caused by protection under desert conditions of Cholistan (Punjab, Pakistan), where intensively protected (enclosures), long protected (since 1972), newly protected (since 1984), overgrazed and general desert areas lie side by side in/ around Lal Sohanara National Park.

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## MATERIALS AND METHODS

***Study Area:*** Cholistan desert (70.50–75.24°EL, 28.61–30.41°NL, 26,000$km^2$, northwestern part of the Indian Desert) is situated in the east of the River Satluj. Northern and eastern parts have comparatively low sand dunes, alternating with saline alluvial flats (Lesser Cholistan, 7,700$km^2$). Major parts have high sand dunes (Greater Cholistan, around 18,000$km^2$; Gupta 1975). The

climate is harsh, characterized by low sporadic precipitation (annual: <100mm in west, 200-250mm in east, mainly during July-August), extremes of temperature (average summer 34°C, touching 50°C; average winter 14°C, sometimes 0°C), low humidity and high evaporation (Bhatia, 1985; Khan 1992). Sub-recent clay tracts of Lesser Cholistan are generally homogeneous to a depth of 30-90cm, with a weak coarse or moderate angular blocky structure. The soil is classified as saline (pH 8.2-8.4) to sodic (pH 8.8-9.6), generally porous with enough gypsum. Soils of sandy terraces are moderately calcareous. The vegetation consists of xerophytic species endowed with highly adapted grasses *(Cenchrus, Panicum),* shrub *(Calligonum, Ziziphus, Haloxylon)* and trees *(Prosopis, Accacia)* capable of surviving through extended droughts. Poor, nomadic and uncontrolled grazing is the main land use. Livestock grazing pressure is higher than the carrying capacity, resulting in complete elimination or a very poor condition of palatable species (Khan, 1992).

The Lal Sohanara National Park was established in 1972, to separate 3,136km² across northwestern Cholistan for affording protection to general desert biota. Another 2,023km² was added to the park area in 1984. Four enclosures, of varying sizes, have been separated in the park using 3m high chain link for maintaining breeding stocks of artiodactyls (blackbuck, chinkara, nilgai). Fodder is provided for the breeding stocks. The Enclosure IV (9 km²) is a basically desert tract maintaining small populations of blackbuck and chinkara. *Acacia nilotica* and *Ziziphus nummularia* have been introduced into the enclosure; the former now appears as forested growth in irrigated part, while later as scattered plants. Desert tract of the park is under limited livestock grazing. The newly protected areas are within an easy access of illegal grazers, while the long protected area has normal grazing.

***Sampling:*** Five sampling stands, i.e., Enclosure IV (intensively protected), Abban Wala (protected since 1972), Ladum Sar (protected since 1984), Karim Wala (unprotected overgrazed tract immediately outside park) and Kund Wala (general desert), were selected to sample biotic diversity during April-May. Equivalent habitats (sand dunes and saline flats) were selected in each of the stand, for sampling.

Plant diversity and cover were analyzed through layer-by-layer analysis, following Slingsby and Cook (1987). Different numbers (10 - 20) of quadrats were randomly selected (depending upon size of the stand and available heterogeneity) in each habitat. Different sizes of quadrats were used for herbs (1´1 m²), shrubs (10´10 m²) and trees (10´100 m²). The optimum crown diameter of each plant, falling in the quadrat area, was recorded and used for calculation of crown area ($\pi r^2$, where $\pi$ = 3.14, r = radius). Plant species were identified/ named following Stewart (1972). The cover occupied by different species in different quadrats and localities was calculated by appropriate pooling and expressed in percentiles of the total cover under quadrat/ quadrats.

Fifteen pit fall traps (diameter 6.5cm, depth 8cm, with glycerin) were set for three successive days at each sampling site. The traps were checked daily and the collection brought to the laboratory. The insect scoop net was used to collect the flying insects. The netting was done for 40 minutes between 9.00 and 10.00 a.m.

Snap traps (40 – 60) baited with oiled bread were set in line for three successive days to sample small mammals. The traps were checked daily, the captured animals removed and trap reset (Mian et al., 1988). Quadrat method was applied to sample birds and mammals. Two workers traveled on foot to count the birds/ mammals in the quadrat area (10 – 15 km²). The population density was calculated by dividing number of individuals of a species seen in the quadrat (area = distance traveled ´ vision width) (Mian, 1989). The vision width was variable, depending upon the size of the animal and general habitat conditions. The reptiles present along the transect line were captured and identified. Indirect evidences, like, footprints and scales, etc., were collected and used as index of relative abundance for nocturnal species. Mammals were identified following Roberts (1977); birds Heinzel et al. (1979); Grewal et al. (1993) and Ali and Ripley (1983); reptiles Daniel (1989) and Khan (1983); and arthropods Wood (1993); Zahradnik and Sever (1991); Murphy and Finney (1985); Smith (1986).

Sokal and Rohlf (1969) and Mather (1965) were followed for statistical analysis.

## RESULTS

### Diversity

The data on number of species present under different protection levels (Table 1) suggest that

the number of species gradually increase with the increasing level of protection. A significant value of ANOVA ($F_{(4, 25)} = 0.46$, $P < 0.05$) and high value of correlation coefficient ($r = 0.85$) suggest a linear increase in overall biodiversity with increasing protection. Regression equation ($y = 54.8 – 6.2 (x – x$ ) suggests that each degree of protection contributes an increase of 6.2 species in total biodiversity.

A reasonably similar pattern of increasing diversity with increasing protection is followed in animals ($F = 0.52$, $r = 0.70$). The trend is though exhibited in plants, yet it is not very pronounced. A similar pattern is also present in different subgroups of plants and animals, with some degree of variation.

## Species Composition

***Flora:*** Table 2 summarizes the distribution and absolute vegetative cover of different plant species at different protection levels. The ANOVA value ($F_{(43, 17)} = 3.17$, $P<0.05$) suggests that stands under different level of protection are significantly different. The t-values suggests a significant difference of the intensively grazed and general desert from and newly protected tracts ($t = 1.64$, $3.02$, $P < 0.05$). Other t-values are, however, not significantly different at 0.05 level.

Table suggests that four species (*Stipa ciliaris, Saccharum munja, Acacia nilotica, Ziziphus numularia*) are limited to intensively protected areas. *Cenchrus setigerus, Stipa* sp., *Cymbopogon jwarancusa, Panicum turgidum, Heliotropium strigosum, Calligonum polygonoides, Haloxylon salicornicum, Salsola foetida, Crotolaria burhia, Leptodenia pyrotechnica, Prosopis cineraria, Tamarix dioica* and *Acacia farnesiana* exhibit a gradual increase in the cover, occupied by them under increasing protection. Out of these, *P. turgidum, H. strigosum, C. burhia, S. ciliaris* and *Alhagi* sp. are completely absent in unprotected localities. The relative abundance of most of these species is low/ very low in all the sampling areas.

The distribution of different species and their relative abundance in saline flats has been presented in Table 3. The t-values suggest that intensively protected areas have a significant difference from all other localities ($t = 3.73$, $4.12$, $2.60$, $2.90$, $P < 0.05$). The other localities do not appear to be significantly different from one another. The table suggests that the relative abundance of most of the species, i.e., *Stipa* sp., *Cymbopogon jwarancusa, Cenchrus setigerus, Panicum turgidum, Cressa cretica, Suaeda fruticosa, Salsola foetida, Crotolaria burhia, Saccharum munja, Capparis deciduas, Tamarix dioca, Acacia farnesiana, A. nilotica* and *Ziziphus nummularia*, increase with increasing degree of protection, *P. turgidum, C. cretica, C. burhia, T. diocia* and *A. farnesiana* are completely absent from unprotected localities. The relative abundance of *Aruara jawanica* and *Calatropis sp.* has decreased with increasing protection. The other species give an erratic pattern and appeared to have remained unaffected by the different levels of protection.

Variation in relative abundance of different species in sand dunes (Table 4) suggests more pronounced effect of protection on species composition. Intensively protected locality is not significantly different (at 0.05) from long protected but it has significant difference with newly protected ($t = 2.55$), intensively grazed ($t = 3.98$) and general desert ($t = 5.10$) tracts. Long protected tracts are significantly different from unprotected ($t = 2.78$) and general desert ($t = 4.23$). A direct overview suggests that quite a few species are not represented (*Cressa cretica,*

**Table 1: Number of species of different groups recorded under different degree of protection.**

| *Species/Groups* | *Intensively protected* | *Long protected* | *Newly protected* | *General desert* | *Intensively grazed* |
|---|---|---|---|---|---|
| Total | 67 | 59 | 51 | 47 | 39 |
| *Plants* | 21 | 22 | 21 | 14 | 16 |
| Herbs | 7 | 9 | 8 | 4 | 6 |
| Shrubs | 8 | 9 | 9 | 7 | 7 |
| Trees | 6 | 4 | 4 | 3 | 3 |
| *Animals* | 46 | 37 | 30 | 33 | 23 |
| Mammals | 6 | 6 | 3 | 4 | 3 |
| Birds | 14 | 13 | 11 | 13 | 6 |
| Reptiles | 3 | 3 | 3 | 3 | 3 |
| Arthropods | 23 | 15 | 13 | 13 | 11 |

**Table 2: Absolute vegetative cover (%) ± standard error of mean occupied by different plants species in areas under different level of protection.**

| *Species* | *Intensively protected* | *Long protected* | *Newly protected* | *General desert* | *Intensively grazed* |
|---|---|---|---|---|---|
| Herbs | | | | | |
| *Panicum turgidum* | 10.59± | 0.43± | 0.01± | - | - |
| *Cenchrus setigerus* | 4.74 | 1.08 | 0.45 | 0.05 | 0.29 |
| *Stipa* sp. | 0.46 | 0.35 | 0.03 | + | 0.01 |
| *Cymbopogon jawarancusa* | 0.18 | 0.05 | 0.15 | 0.06 | 0.03 |
| *Fagonia cretica* | 0.02 | + | 0.11 | - | 0.02 |
| *Stipa ciliaris* | 0.02 | - | - | - | - |
| *Alcerops lagopoides* | - | 0.34 | 0.99 | 4.18 | 1.29 |
| *Cressa cretica* | 0.02 | + | 0.01 | - | - |
| *Heliotropium strigosum* | - | 0.01 | + | - | - |
| Shrubs | | | | | |
| *Calligonum polygonoides* | 4.65 | 1.52 | 1.13 | 0.13 | 0.85 |
| *Suaeda fruticosa* | 1.41 | 0.27 | 0.12 | 0.14 | 0.48 |
| *Haloxylon salicornicum* | 0.42 | 0.15 | 0.19 | 0.22 | 0.18 |
| *Salsola foetida* | 0.13 | 0.20 | 0.08 | + | 0.05 |
| *Haloxylon multiflorum* | 0.01 | 0.01 | + | 0.52 | + |
| *Crotolaria burhia* | 0.02 | 0.01 | + | - | - |
| *Saccharum munja* | 0.02 | - | - | - | - |
| *Aerua javanica* | + | 0.34 | 0.53 | 3.63 | 1.29 |
| *Alhagi* sp. | - | 0.01 | + | - | - |
| *Leptodenia pyrotechnica* | - | 0.04 | - | - | - |
| *Calatropis* sp. | - | - | + | 0.15 | 0.03 |
| Trees | | | | | |
| *Prosopis cineraria* | 2.38 | 1.00 | 1.02 | 0.34 | 1.53 |
| *Capparis deciduas* | 0.23 | 1.81 | 1.20 | 0.90 | 1.38 |
| *Tamarix dioica* | 0.54 | 0.13 | 0.02 | + | - |
| *Acacia farnesiana* | 2.24 | 3.51 | 1.75 | - | 1.12 |
| *Acacia nilotica* | 0.42 | - | - | - | - |
| *Ziziphus nummularia* | 0.02 | - | - | - | - |
| Total | 28.68± | 11.58± | 7.78± | 9.32± | 9.43± |

**Table 3: Absolute vegetative cover (%) ± standard error of mean of different plant species in saline flats under different degree protection level.**

| *Species* | *Intensively protected* | *Long protected* | *Newly protected* | *General desert* | *Intensively grazed* |
|---|---|---|---|---|---|
| Herbs | | | | | |
| *Stipa* sp. | 0.78±0.54 | 0.67±0.47 | + | + | + |
| *Cymbopogon jawarancusa* | 0.31±0.24 | 0.08±0.05 | 0.29±0.12 | 0.09±0.07 | 0.04±0.02 |
| *Cenchrus setigerus* | 0.19±0.13 | 0.04±0.19 | 0.01±0.01 | 0.01±0.04 | 0.01±0.01 |
| *Fagonia cretica* | 0.03±0.01 | + | 0.12±0.11 | - | 0.02±0.01 |
| *Panicum turgidum* | 19.42±8.75 | 0.85±0.08 | 0.03±0.01 | - | - |
| *Alcerops lagopoides* | - | 0.68±0.52 | 1.07±0.69 | 5.66±2.35 | 2.59±1.2 |
| *Cressa cretica* | - | 0.08±0.06 | - | - | - |
| Shrubs | | | | | |
| *Suaeda fruticosa* | 2.59± | 0.53±0.02 | 0.25±0.85 | 0.21±0.12 | 0.96±0.35 |
| *Haloxylon salicornicum* | 0.07±0.66 | 0.04±0.02 | 0.06±0.02 | 0.14±0.08 | 0.11±0.06 |
| *Haloxylon multiflorum* | 0.02±0.01 | 0.02±0.01 | + | 0.79±0.34 | + |
| *Salsola foetida* | 0.12±0.09 | 0.40±0.15 | 0.07±0.10 | - | 0.07±0.03 |
| *Crotolaria burhia* | 0.02±0.01 | 0.02±0.02 | 0.05±0.03 | - | - |
| *Saccharum munja* | 0.04±0.04 | - | - | - | - |
| *Aerua javanica* | - | 0.68±0.52 | 1.07±0.69 | 5.66±2.35 | 2.59±1.20 |
| *Calatropis* sp. | - | - | + | 0.23±0.22 | 0.07±0.50 |
| Trees | | | | | |
| *Prosopis cineraria* | 3.58±8.75 | 0.95±0.39 | 0.93±0.44 | 0.44±0.20 | 2.14±1.11 |
| *Capparis deciduas* | 0.23±0.14 | 0.52±0.25 | 0.73±0.16 | 1.26±0.46 | 0.99±0.28 |
| *Tamarix dioica* | 0.88±0.43 | 0.26±0.29 | 0.05±0.05 | - | - |
| *Acacia farnesiana* | 1.25±1.09 | 0.34±0.35 | - | - | - |
| *Acacia nilotica* | 0.78±0.77 | - | - | - | - |
| *Ziziphus nummularia* | 0.03±0.04 | - | - | - | - |
| Total | 30.34±9.10 | 6.14±0.91 | 3.66±1.04 | 8.88±2.21 | 8.92±3.07 |

**Table 4: Absolute vegetative cover (%) ± standard error of mean of different plant species in sand dunes under different degree protection level.**

| *Species* | *Intensively protected* | *Long protected* | *Newly protected* | *General desert* | *Intensively grazed* |
|---|---|---|---|---|---|
| Herbs | | | | | |
| *Stipa ciliaris* | 0.05±0.05 | - | - | - | - |
| *Cenchrus setigerus* | 10.22±2.9 | 2.13±0.61 | 0.89±0.20 | 0.11±0.05 | 0.56±0.12 |
| *Stipa* sp. | 0.08±0.14 | 0.02±0.00 | 0.06±0.04 | + | 0.02±0.02 |
| *Cymbopogon jawarancusa* | 0.02±0.02 | 0.03±0.02 | 0.01±0.01 | + | 0.02±0.01 |
| *Cressa cretica* | - | + | + | - | - |
| *Alcerops lagopoides* | - | + | 0.91±0.90 | 1.54±1.54 | 0.02±0.03 |
| *Heliotropium strigosum* | - | 0.03±0.33 | + | - | - |
| *Fagonia cretica* | - | - | 0.10±0.08 | - | 0.02±0.01 |
| Shrubs | | | | | |
| *Crotolaria burhia* | 0.02±0.01 | - | - | - | - |
| *Calligonum polygonoides* | 10.23±3.80 | 3.04±1.48 | 2.26±0.08 | 0.38±0.14 | 1.70±0.05 |
| *Haloxylon salicornicum* | 0.85±0.10 | 0.26±1.20 | 0.31±0.09 | 0.37±0.17 | 0.25±0.08 |
| *Salsola foetida* | ± | ± | ± | 0.01±0.67 | -0.03±0.02 |
| *Aerua javanica* | + | + | - | - | - |
| *Alhagi* sp. | - | 0.02±0.01 | - | - | - |
| *Suaeda fruticosa* | - | 0.01±0.00 | + | - | - |
| *Leptodenia pyrotechnica* | - | 0.08±0.06 | - | - | - |
| *Hloxylon multiflorum* | ± | ± | - | 0.05±0.03 | - |
| Trees | | | | | |
| *Prosopis cineraria* | 0.94±0.51 | 1.05±0.60 | 1.12±0.91 | 0.16±0.10 | 0.91±0.10 |
| *Capparis deciduas* | 0.23±2.40 | 3.10±1.75 | 1.68±0.63 | 0.25±0.10 | 1.77±0.58 |
| *Acacia farnesiana* | 3.83±2.04 | 6.68±2.71 | 3.50±1.42 | - | 2.24+0.73 |
| *Tamarix dioica* | 0.15±0.47 | - | - | + | - |
| Total | 26.55±5.78 | 16.47±9.10 | 10.94±3.01 | 2.89±1.60 | 6.82±1.23 |

*Heliotropium strigosum, Aerua javanica, Crotolaria burhia, Alhagi* sp., *Suaeda fruticosa, Leptodenia pyrotechnica*) or poorly represented (*Stipa* sp., *Cymbopogon jwarancusa, Fagonia cretica, Tamarix dioica*) in unprotected area. Quite a few others species show a gradual increase or remain unaffected with increasing protection. The species, like, *Cressa cretica, Alcerops lagopoides, Heliotropium strigosum, Fagonia cretica, Alhagi* sp., *Suaeda fruticosa, Leptodenia pyrotechnica* and *Haloxylon multiflorum,* are, however, completely absent from intensively protected tract.

***Fauna:*** Table 5 summarizes the relative abundance/distribution of different animal species in different localities under different levels of protection. The values of association chi-square, calculated for the distribution of animal species in different localities, suggest that different localities are not significantly associated with one another. There is, however, a significant association (chi-square = 9.00, $P < 0.05$) between newly protected and unprotected areas, indicating a similarity in species composition of these tracts. Similar pattern is generally followed in all the major groups of animals, under study.

A minimum of nine species of mammals are present in different tracts. Out of these four species (*Tatera indica, Gerbillus nanus, Felis* sp., *Vulpes* sp.) are widely distributed. *Millardia gleadowi, Lepus nigricollis* and *Sus scrofa* are limited to intensively protected areas, while *Herpestes edwardsi* and *Canis lupus* are represented in long protected areas. None of the species of mammals has appeared in unprotected areas only.

Five species of birds (*Turdoides caudatus, Anthus compestris, Streptopelia senegalensis, S. decaocto, Tephrodornis pondicerianus*) are widely distributed. Species, like, *Phoenicopterus ochruros, Motacila alba, Saxicola* sp., *Scotocera inquieta, Elanus caeruleus, Francolinus pondicerianus* and *Motacila, alba* are limited to intensively protected locality. Most of the species found in the newly protected area are shared with unprotected areas. *Saxicola caprata, Oenanthe* sp., *Saxicola torquata* and *Nectarina asiatica* are present in general desert tract only. All the species of reptiles are widely distributed in all the localities, except for *Naja naja,* which is found only in the intensively protected area.

The distribution of arthropods species suggests that *Lasius niger, Monomorium* sp. *Camponotus* sp., *Anopheles* sp., *Culex* sp.,

*Chironomous* sp., *Oedipoda* sp., *Aeshna* sp., *Danaus chrysippus* and *Scorpio* sp. are widely distributed in different localities. *Sympetrum* sp., *Coenagrina* sp. *and Crysopa* sp., are limited to intensively protected areas only. *Carabis* sp. and *Enceladus* sp. are limited to general desert locality. *Extobius* sp. is distributed to long and newly protected areas.

## DISCUSSION

The present analysis on biodiversity variation under increasing protection has sound basis of its reliability. Five different sampling sites have been selected with gradually increasing level of protection. A variety of sampling techniques have been employed to sample not only the species diversity, but relative abundance/ density of different species. Adequate sampling has been exercised for different groups, i.e., 10-20 quadrats for plants in each habitat and trapping for three consecutive days for animals. Identical habitats (sand dunes and saline flats) have been selected in the areas under different protection levels to simplify the sampling design, allowing a direct analysis of effect of protection. None of the studies available from Pakistan attempts such a direct analysis of the effect of protection on biodiversity and/ or species composition. Such studies are available for different parks of the world, e.g., Turan lowland desert (Gunin and Neronov, 1986; Polyanskaya and Neronov, 1985; Neronov and Borbrov, 1985), Dumago Bone National Park (Helle, 1986), El Kala National Park (Stevenson, 1988), Kakadu National Park (Woinarski et al., 1989), etc., though each study has concentrated upon some selected groups. The present is a very preliminary study, with limited body of data collected for a short period and during a part of the year (April-May). Further this study does not include the soil biota and microorganisms.

### Biodiversity

The present study suggests a direct increase in the biodiversity with increasing level of protection. This trend has appeared not only in the total biodiversity, but to different degrees, in all the different groups, i.e., plants (herbs, shrubs, trees) and animals (mammals, birds, arthropods), except for reptiles, where the total number of the species remain low and constant. This is the first published report from the area to suggest a direct correlation of degree of protection and biodiversity. Though, the exact level of human exploitation have not been quantified for different tracts, yet our results suggest an average increase of 6.2 species per increasing degree of protection, envisaged under the present analysis. This is despite the fact that the exploitation and changed habitat is known to add some invasive/ hardy species into the system.

A number of previous reports suggest a change in the biodiversity with protection. A continuous ecological monitoring of Turan lowland desert (USSR) has suggested increase in biodiversity of the reserve (Gunin and Neronov, 1986; Polyanskaya and Neronov, 1985; Neronov and Borbrov, 1985). Heppner (1989) reported a significantly high diversity of Lepidoptera in the Dumago Bone National Park. Protection is believed to have increased the diversity of butterflies in Ujung Kulon National Park (Cole, 1987). Helle (1986) reported an increase in the biodiversity of resident bird species and decrease in that of the migrants under protection in Oulanka National Park. However, none of these reports has attempted the study of the total biodiversity variations under generally increasing levels of protection by developing a simplified model evolved through selection of identical sampling biotopes. This area appears to be important for future studies on the effect of protection on biodiversity variation in lowland deserts with a minimum of five protection levels, lying side by side in the same general habitat.

Increase in biodiversity under protection is a positive sign for the future development and management of vast desert, occupying the major part of the southern Pakistan. This lends a direct support to previous similar general observations of Roberts (1973); Mian (1983) and Arshad and Rao (1994) for different areas of Pakistan. This may also suggest that these tracts still have sufficient potentials of reclamation under rangeland management strategy, depending upon controlled exploitation. Fullen and Mitchell (1994) suggested that grazing population of one sheep per 0.87km$^2$ can re-vegetate the area in five years. They believe that continuous maintenance of such condition for over six years is required before significant impact of land reclamation is evident.

**Table 5: Presence/density (per km$^2$) of the different animal species under different levels of protection afforded in Desert of Cholistan.**

| *Species* | *Intensively protected* | *Long protected* | *Newly protected* | *General desert* | *Intensively grazed* |
|---|---|---|---|---|---|
| **Mammals** | | | | | |
| **Rodents** | | | | | |
| *Tatera indica* | + | + | + | + | + |
| *Gerbillus nanus* | + | + | - | + | - |
| *Millardia gleadowi* | + | - | - | - | - |
| **Lagomorphs** | | | | | |
| *Lepus nigricollis* | 0.33 | - | - | - | - |
| **Artiodactyles** | | | | | |
| *Sus scorfa* | + | - | - | - | - |
| Canivores | | | | | |
| *Felis* sp. | + | + | + | + | + |
| *Canis lupus* (wolf) | - | 0.13 | - | - | - |
| *Vulpus* sp. (desert fox) | - | 0.40 | 0.13 | 0.13 | 0.70 |
| Birds | | | | | |
| *Tudoides caudatus* (Common babler) | 2.91 | 5.00 | - | 8.33 | 3.33 |
| *Turdoides straityus* (Jungle babbler) | 2.08 | - | - | - | - |
| *Anthus camestraitus* (Pipet) | 2.08 | 8.33 | 15.33 | 7.33 | - |
| *Pycnonotus leucogenys* (White cheeked bulbul) | 1.66 | - | - | - | 1.33 |
| *Streptopelia sensgalensis* (Brown dove) | 1.25 | 0.60 | - | 1.00 | 1.33 |
| *Riparia riparia* ( Sand martin) | 1.25 | - | - | 0.66 | - |
| *Vanellus indicus* (Lapwing) | 0.83 | - | - | - | - |
| *Caprimuglus* sp ( Night jar) | 0.83 | - | - | - | - |
| *Francolinus pondecerianus* (Grey partridge) | 0.83 | 0.60 | - | - | - |
| *Motacila alba* (Pied wagtail) | 0.83 | - | - | - | - |
| *Saxicola* sp. (Grey bush chat) | 0.41 | - | - | - | - |
| *Scotocera inquieta* (Scrub warbler) | 0.41 | - | - | - | - |
| *Elanus caeruleus* (Black winged kite) | 0.41 | - | - | - | - |
| *Phoenicopterus ochruros* (Black redstart) | 0.41 | - | - | - | - |
| *Strnus roseus* (Rosy Starling) | - | 13.40 | - | - | - |
| *Acridotheres tristis* (Commom Myna) | - | 10.00 | - | - | - |
| *Calandrella cinerea* (Short toed Lark) | - | 2.00 | 1.30 | - | - |
| *Galerida cristata* (Crested Lark) | - | 2.00 | 1.30 | - | - |
| *Streptopelia decaocto* (Collared Dove) | - | 1.33 | 2.56 | 1.33 | 1.33 |
| *Merops orientalis* (Bee Eater) | - | 0.66 | - | - | - |
| *Parus major* (Grey Tit) | - | 0.33 | 0.66 | 1.00 | - |
| *Falco tinnunculus* (Kestreil) | - | 0.33 | - | - | - |
| *Tephrodornis pondicerianus* (wood Shrike) | - | 0.33 | 0.66 | 1.00 | - |
| *Hippolais caligata* (Booted Warbler) | - | - | 0.60 | - | 0.60 |
| *Gypus indicus* (Vulture) | - | - | 0.60 | - | - |
| Ugbz (Accipitridae) | - | - | 0.33 | - | - |
| *Lanius excubitor* (Great Grey Shrike) | - | - | 0.33 | 0.30 | 1.33 |
| *Aquila* sp. (Eagle) | - | - | 0.33 | - | - |
| *Coracina melanoptera* (Cuckoo Shrike) | - | - | - | 3.33 | - |
| *Neophron percnopterus* (Scavenger Vulture) | - | - | - | 0.66 | - |
| *Saxicola caprata* (Pied Bush Chat) | - | - | - | 0.66 | - |
| *Oenanthe* sp. (Wheatear) | - | - | - | 0.33 | - |
| *Saxicola torquata* (Colared Bush Chat) | - | - | - | 0.33 | - |
| *Nectarina asiatica* (Purple Sun Bird) | - | - | - | 0.33 | - |
| **Reptiles** | | | | | |
| *Acanthodactylus cantropis* | 4.16 | 3.00 | 1.33 | 3.33 | 1.33 |
| *Agama* sp. | 3.33 | 0.66 | 1.00 | 2.00 | 0.33 |
| *Uromastix hardwickii* (Spiny Tail Lizard) | - | 2.00 | 1.33 | 5.00 | 2.00 |
| *Naja naja* (Cobra) | + | - | - | - | - |
| Arthropods | | | | | |
| Hymenoptera | | | | | |
| *Lasius niger* | 15.33 | 18.66 | 20.86 | 34.26 | 10.60 |
| *Monomorium* sp. | 0.56 | 0.06 | 0.26 | 0.93 | 0.20 |
| *Lasius fuliginosus* | 0.43 | - | - | - | - |
| *Formica* sp. | 0.49 | - | - | - | - |
| *Camponotus* sp. | - | 0.06 | 0.06 | - | 0.36 |

**Table 5: Contd. ...**

| *Species* | *Intensively protected* | *Long protected* | *Newly protected* | *General desert* | *Intensively grazed* |
|---|---|---|---|---|---|
| Coleoptera | | | | | |
| *Bruncchus* sp. | 0.06 | - | - | - | - |
| *Carabus* sp.(I) | - | - | 0.06 | 0.06 | - |
| *Carabus* sp. (II) | - | - | - | - | 0.26 |
| *Enceladus* sp. | - | - | - | - | 0.13 |
| Orthoptera | | | | | |
| *Oedipoda* sp. | 0.06 | + | 0.06 | - | + |
| *Tryxalis* sp. | + | - | - | - | - |
| Dictyoptera | | | | | |
| *Extobius* sp. | - | - | 0.20 | - | - |
| Homoptera | - | 0.06 | - | - | - |
| Diptera | | | | | |
| *Anopheles* sp. | + | - | - | - | - |
| *Culux* sp. | + | - | - | - | - |
| *Chironomous* sp. | + | + | - | - | - |
| Odonata | | | | | |
| *Aeshna* sp. | + | + | + | + | - |
| *Sympetrum* sp. | + | - | - | - | - |
| *Coenagrina* sp. | + | - | - | - | - |
| Neuroptera | | - | - | - | - |
| *Crysopa* sp. | + | - | - | - | - |
| Lepidoptera | | | | | |
| *Danaus chrysippus* | + | + | + | - | + |
| Arachnida | | | | | |
| *Scorpio* sp. | - | 0.12 | 0.06 | 0.20 | - |

## Species Composition

The analysis of species composition under the present study suggests that protection not only changes overall biodiversity, but it also has a significant effect on the community structure. The total composition of the community changes, and there are different sets of dominant and sub-dominants under different levels of protection. There are various direct and indirect reports to suggest a change in the community complexion under different degree of grazing (change in the climax grasses, Torttier, 1986; unpalatable sagebrush being dominant: Miller, 1991; Piper, 1991; Olson et al., 1994; elimination of juniper from arid mountains around Quetta: Roberts, 1973; decrease in population of Asiatic otter, Asiatic wild ass, goitred gazelle and blue sheep: Neronov and Borbrov, 1990) and hunting (extinction of blackbuck from Cholistan, Roberts, 1977; decrease in population of Houbara Bustard: Mian, 1997). However, little efforts have been directed towards analysis of total ecosystem/ species composition. Stevenson (1988) suggested the presence of distinct bird community in Kakadu National Park, indirectly indicating a change in bird community under protection.

The shift in the vegetative complexion can be ascribed to different palatability of different plant species and their potentials of a natural increase. Different species of livestock are known to have different degree of stress on different plant species depending upon their feeding habits (Stiles, 1987; Field, 1979; Stohlgren and Parsons, 1986).

The presence of the animal species, like, wolf and grey partridge, in protected areas is a direct indication of improvement in desert ecosystem under protection. The data on relative abundance of animals, especially birds and arthropods, suggest some inconsistent patterns. This can be explained on a wider range of the animal activities and their chance occurrence at places. Many species are associated with human habitation, which are more common around human habitations and water points (focal points in desert life). The animals, being located at a higher trophic level, may also take a longer time to show the effects of protection.

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