

ECOLOGICAL ASSESSMENT OF FAUNA

at Khyberani Forest, District Matiari, Sindh

Baseline Survey 2010 - 2011

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List of Acronyms

A	Abundant
As	Arsenic
BOD	Biochemical Oxygen Demand
C	Common
CAR	Carnivore
Cd	Cadmium
CE	Critically Endangered
CEMB	Centre of Excellence in Marine Biology
CITES	Convention on International Trade in Endangered Species of Flora and Fauna
Cl	Chloride
Cr	Chromium
DO	Dissolved Oxygen
DR	Diurnal
E	Endangered
EIA	Environmental Impact Assessment
GEL	Global Environmental Lab (Pvt) Ltd.
GIS	Global Information System
GPS	Global Positioning Station
GRN	Grainivore
Ha	Hectare
HRB	Herbivore
ID	Index of Density
IDER	Indus Delta Eco-region
IFAP	Indus for All Programme
INS	Insectivore
IUCN	The World Conservation Union
KC	Kharochann
KF	Khebrani Forest
LC	Least Concern
M	meters
MAF	Million Acre Feet
Mg	Magnesium
Mm	millimeter
MNVD	Main Nara Valley Drain
ML	Manchar Lake
NC	Nocturnal
NGO	Non-Governmental Organisation
Ni	Nickel
No.	Number
NR	Natural Resource
NT	Near Threatened
NWC	Nara Wetland Complex
P	Protected

Pb	Lead
Ppt	particles per thousand
SWD	Sindh Wildlife Department
VU	Vulnerable
WHO	World Health Organisation
WWF P	World Wide Fund for Nature Pakistan

List of resource persons/consultants

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EXECUTIVE SUMMARY

WWF - Pakistan has initiated Indus Eco-region Programme, which is a 50 year vision. A total of 15 landscapes have been prioritized within the eco-region. Indus for All Programme was initiated in July 2006 with the support from Royal Netherlands Embassy, as a beginning of the implementation of the visionary Indus Eco-region Conservation Programme. Implementation of *Indus for All Programme (IFAP)* at the first instance was implemented on four out of fifteen prioritized landscapes.

The second phase of implementation of *Indus for All Programme* will start on another four prioritized landscapes, which are Karochan (coastal), Manchar Lake (Fresh water ecosystem), Khaibrani Forest (irrigated forest) and Nara Wetland Complex (wetland ecosystem). The programme aims to work with all relevant stakeholders at field, district, provincial and national levels to build capacity, support and influence planning and mainstreaming of poverty-environment issues.

Khyberani Forest is one of the selected sites of IFAP for second phase. It is situated close to river Indus near Matiari city, at a distance of about 5 km from National Highway. The forest consists of 25 compartments and the total area of forest is about 3,000 acres. It has been declared a Reserved Forest by the Sindh Forest Department. The forest consists of 25 large compartments. Like some other forests in Sindh, this forest is also facing challenges like shortage of water, encroachments and illegal logging.

Although it is a Reserved Forest, some land- lords have also control over it. The forest is under severe pressure of land grabbers. The open area is being converted into agriculture lands. The forest is in good condition after the recent floods. Lot of silt has been brought about by the recent floods.

The Government of Sindh has made allotment of lands and leased most of the compartments of the forest to some influential persons for Agro-forestry under Sindh Agro-forestry Policy 2004. This has disturbed the ecosystem as trees have been uprooted for conversion into agricultural land. The leases of the forest land do not believe in conservation ethics and are destroying the ecosystem which had important biodiversity.

Ten villages are located along the forest boundary. The communities of these villages and of some other distant villages have been grazing their livestock, sole livelihood of these people, for centuries. The forest lessees have evicted these communities from the forest land.

The dominant tree species in the forest is *Acacia nilotica* which covers the majority of compartments while a small patch of *Prosopis cineraria* exists on the eastern part of forest. *Tamarix aphylla* grows on the edges of the river channel which passes through the forest. The forest also contains *Prosopis juliflora*, *Prosopis glandulosa*, *Calotropis* and Poplar (*Populus euphratica*) trees. Khyberani forest purely represents riparian habitat.

The Sindh Forest Act 1927 which addresses the issues related to the forests in Sindh province is about 84 years old and it is not commensurate with the present day realities. It has been felt that this legislation has to be revised on priority basis. In this connection, a consultative workshop on revision of Sindh Forest Act 1927 was organized at Hyderabad on 30 May 2011 by the Sindh Forest Department and WWF Pakistan. The speakers observed that the revision of the forest act would pave the way for incorporating new concepts in forest management. The senior management of Sindh Forest Department, retired foresters and representatives of local and international NGOs participated in the workshop. It was decided to revise the forest act on priority basis and WWF Pakistan will provide support to Sindh Forest Department for this purpose.

It is an important area for the remnant populations of Hog deer, Wild boar, Indian hare, Jungle cat, and Grey and Black partridges. Now, only 2 – 4 Hog deer and 30 – 40 Wild boars are surviving in the forest.

Large Mammals: Seven species of mammals belonging to three orders have been recorded. These include hog deer, Indian jackal, jungle cat and wild boar.

Small Mammals: Seven species belonging to 3 orders and 5 families were recorded.

Birds: Sixty one species of birds belonging to 11 orders and 30 families were recorded. The grey and black partridges are the key species of the area. Some less known species were recorded from the area such as oriental honey buzzard, northern goshawk, eurasian sparrowhawk and long-billed pipit. Lot of open area is being converted into agriculture fields. There is no serious threat to Birds.

Reptiles and Amphibians: Eight species of reptiles belonging to three orders and seven families were recorded. These include Indian flap-shell turtle and Indian monitor. The threats to the species and their habitats include wood cutting, animal collection and livestock grazing.

Three species of Amphibians were recorded *viz.* skittering frog, bull frog and Indus toad.

Chapter 1: INTRODUCTION

1.1.1 Introduction to Khyberani Forest

Before the creation of Pakistan and during the British era, the Talpurs and Mirs, who were local rulers in Sindh owned almost all the well stocked forests in the province. They maintained these forests as hunting grounds. The cutting of trees in such forests was strictly prohibited. Creation and demarcation of state forests (as Reserved and Protected forests) was started in 1823 and continued till 1972.

Khyberani Forest is located along the National Highway in Matiari District. The forest consists of 25 compartments; with a total area of about 3,000 acres. Khyberani Forest was also a riverine forest which depended on Indus river water prior to the construction of Sukkur Barrage. It has been declared a Reserved Forest by the Sindh Forest Department.

In Khyberani Forest, most of the forest land has now been allotted to influential persons under Notification No. FT&WL (SO1)13(1) for agro-forestry under Sindh Agro Forestry Policy 2004. These influential persons are over ruling the conservation principle and around 95,000 trees were uprooted since May 13, 2010 (*News Report: PPI, 25 June 2010*).

Ten villages are located along the forest boundary. More than 50,000 cattle of these villages solely depend on these forests for grazing. The influential persons who have obtained the lease of the forest land have now deprived these people of grazing inside the forest. Deforestation and conversion of the forestland into agricultural land is continuing. Influential people now occupy about 2,000 acres. Wildlife habitat is being degraded because of agricultural activities. The wildlife including the endangered hog deer are under threat to be vanished from this habitat.

Climate of the area is generally hot and arid. Rainfall is scanty, erratic and mostly occurs during monsoon season i.e., from June to September. The average annual rainfall is about 200 mm. Maximum temperature in summer rises to 50°C while minimum temperature during winter is 8°C. Hot summers usually extend from April to October.

1.1.2 State of biodiversity

The area provides habitat to species of mammals, birds, reptiles and amphibians.

- **Large Mammals:** Seven species of mammals belonging to three orders and five families have been recorded. These include hog deer, Indian jackal, jungle cat and wild boar.

- **Small Mammals:** Seven species belonging to 3 orders and 5 families were recorded.
- **Birds:** Sixty one species of birds belonging to 11 orders and 30 families were recorded. The grey and black partridges are the key species of the area. Some less known species were recorded from the area such as oriental honey buzzard, northern goshawk, eurasian sparrowhawk and long-billed pipit. Lot of open area is being converted into agriculture fields. There is no serious threat to Birds.
- **Reptiles and Amphibians:** Eight species of reptiles belonging to three orders and seven families were recorded. These include Indian flapshell turtle and Indian monitor. The threats to the species and their habitats include wood cutting, animal collection and livestock grazing.

Three species of Amphibians were recorded viz., skittering frog, bullfrog and Indus toad.

1.1.3 Livelihood and Social aspects

- **Social fabric:**

1.2 Rationale and objectives

1.2.1 Large Mammals Survey

1.2.1.1 Rationale

WWF - Pakistan has initiated Indus Eco-region Programme, which is a 50 year vision. A total of 15 landscapes have been prioritized within the eco-region. Indus for All Programme was initiated in July 2006 with the support from Royal Netherlands Embassy, as a beginning of the implementation of the visionary Indus Eco-region Conservation Programme. Implementation of *Indus for All Programme* at the first instance was implemented on four out of fifteen prioritized landscapes viz. Keti Bunder (coastal), Kinjhar Lake (Fresh water ecosystem), Pai Forest (irrigated forest) and Chotiari Reservoir (wetland ecosystem). This programme will continue till June 2012.

The second phase of implementation of *Indus for All Programme* will start on another four prioritized landscapes, which are Kharochann (coastal), Manchhar Lake (Fresh water ecosystem), Khyberani Forest (irrigated forest) and Nara Wetlands Complex (wetland ecosystem). The programme aims to work with all relevant stakeholders at field, district, provincial and national levels to build capacity, support and influence planning and mainstreaming of poverty-environment issues.

The preliminary ecological assessment of the project sites has been initiated as an output of the programme to establish a baseline in and around the above mentioned sites. The

baseline will determine key livelihoods interventions of *Indus for All Programme* by identifying the gaps and opportunities.

As a part of the ecological assessment and to study the mammalian fauna of the project sites, the study sites were visited twice; during winter in November – December 2010 and in summer during July 2011. Each visit of all the four sites was of 2-4 days duration.

1.2.1.2 Objectives of the study

- a. Identify various large and medium sized mammals in the study area, develop a checklist and estimate the populations of some key mammalian species.
- b. Assess the major threats that are likely to affect the survival of large mammals and suggest mitigation measures to those threats.
- c. Identify key habitat and associated features of the large mammals habitat

1.2.2 Small mammal survey

1.2.2.1 Rationale

Small mammals are an indispensable component of fauna and they play an important role in determining the holding capacity and maintenance of the number of animals in the higher trophic level of the food chain. They not only maintain ecological balance in an ecosystem, but also play a specific role in biological control, necessary for a self sustained ecosystem. These small animals fill niches and depend upon the submerged roots, fallen seeds, rhizomes and bulbs, insects, snakes, scorpions, spiders and beetles for their food. They are in turn eaten by larger animals like foxes, jackals, cats, owls, eagles, kites, falcons and wolves living in a particular ecosystem. To determine the status of large mammals it is necessary to obtain data on small mammals.

Role of small mammals usually stem from perceived negative values associated with their role as pest and disease spreading animals. Small mammals however, play an important and perhaps indispensable role in the functioning of an ecosystem. They should not be viewed separately from other components of the ecosystem. Rather, they must be viewed in terms of their interrelationships with other components. Small mammals influence the structure and function of ecosystems as consumers of plants and small animals as movers of soil and soil nutrients, and as the primary prey of raptors, snakes, hawks, eagles, owls and carnivorous mammals. Because of their intermediate trophic position and high dispersal abilities, small mammals may track changes in biotic and abiotic environment that result from shifts in land use practices and other human activities.

Researchers have proposed various ways in which small mammals interact with plant communities. The main interactions can be categorized as those relating to primary productivity, plant species composition, plant stature and reproduction and

decomposition rates of plant materials. Small mammal herbivores may consume as much as 60% (Migula *et al.* 1970) of the total annual primary plant production. They may have localized, large scale impacts on primary productivity during population explosions. However, the effect of direct consumption of plants by herbivores must be evaluated in terms of what portion of the primary production is actually available to the animal. Estimates of vegetation consumption by small mammals ranged from <1% in short grass and mid grass sites to as much as 20% in desert grasslands (French *et al.* 1976). Harris (1971) has estimated that 0.17-5.01% of the net primary production was transferred to the rodent trophic level.

Small mammals have been credited with changing plant community composition and species distribution. Plant communities in many parts of USA have been altered by extensive damage to big sage brush during cyclic population peaks of voles. Control of pocket gophers in western Colorado resulted in an increase of perennial forbs (Turner 1969) while grass and sedge densities were higher in areas where gophers were present. Small mammals can also alter plants community composition and species distribution by consuming and caching seeds. They can also influence plant community composition by heavily grazing or damaging plants, and thus reducing their ability to produce seeds.

Seed caching activities of small mammals can alter plant distribution by either increasing or decreasing survival of plants. Yet, dispersal of seeds by small mammals can result in increased germination and survival. Some organisms may be dependent on small mammals for seed or spore dispersal. Many fungi and nitrogen fixing bacteria and yeast depend on small mammal mycophagy for spore dispersal (Fogel and Trappe 1978).

The rate of plant succession may be affected by small mammal burrowing and feeding activities. The mounds of small mammals disrupt grass associations and provide bare soil for the invasion of lower succession plants, thereby increasing the diversity of plants. Selective herbivore by small mammals can also alter plant succession rates. Rodents may aid in the recovery of overgrazed grasslands by selectively grazing on weedy plant species (Gross, 1969).

Small mammals can influence the rate of decomposition of organic materials by adding green herbage and excrements to the litter layer and by reducing the particle size of vegetative material. They are more efficient in effecting the mineralization of organic matter than either insects or ungulates (Golley *et al.* 1975). Voles affect decomposition rates by altering microclimatic conditions in the litter layer and by deposition of excrements and vegetative cuttings into litter layers, which increases micro-organism growth (Zlotin and Kodashova 1974). Reduction of particle size of living and dead vegetative material by small mammals also increases decomposition rates.

Soil structure and chemical composition are affected by the activities of small mammals. Burrowing activities largely influences soil structure. Burrowing and the addition of feces and urine to the soil influence soil chemical composition through changes in nutrient and mineral cycling rates and pathways. Soil structure may be altered as small mammals burrow, bringing large quantities of mineral soil to the surface. Pocket gophers are

reported to excavate 18 metric tons of soil material per hectare per year (Hole 1981). Abaturov (1968) estimated that mole burrows covered 36% of woodland ground surface, which resulted in increased soil porosity and drainage, and altered soil water holding capacities. Soil mounds resulting from small mammal burrowing are strongly heated and the surface crust that rapidly forms prevents evaporation. As a result, at depths of 5-20 cm the water content of the soil under mounds is 7 – 82 higher than at corresponding depths in virgin soil (Zlotin and Kodashova 1974).

The most significant role of small mammals may be their effect on the chemical composition of soils, particularly the addition and incorporation of nitrogen. Soil chemical composition can be altered by the addition of excreta and by upward displacement of nutrients through the soil profile.

Small mammals function as secondary consumers in the ecosystem by preying on invertebrates and on other mammals, which may have direct impacts on prey production. Insectivorous species may exert a regulatory effect on invertebrate populations; small mammals consumed a high percentage of invertebrate populations in nearly all grassland sites studied by French *et al* (1976). Carnivores have been shown to influence prey species densities. Hayward and Phillipson (1979) estimated that weasels consumed as much as 14% of the small mammal production, resulting in a reduction in the impact of small mammals on the rest of the ecosystem. Secondary consumption may indirectly influence primary production. Plant consumption by invertebrate herbivores may be reduced by the insectivorous feeding habits of small mammals. Destruction of small mammal predation may serve to reduce invertebrate species that are themselves predators of phytophagous insects. Small mammals also affect Land bird species. Nest predation by small mammals is the major cause of nest failure in passerines and nesting success of land birds.

Small mammals serve as a food supply for a large number of predators and can exert significant influence on predator population cycles. Small mammals, especially rodents are characterized by high productivity rates, and thus even at relatively low densities, are an important source of food for predators. Densities of small mammals can have profound impacts on the reproductive potential of some predators. For example, the proportion of tawny owls that bred each year in England varied from 0 to 80% according to the number of mice and voles present (Southern, 1970). Several authors have documented cases where population levels of predators can be traced to small mammal densities. For example, population declines in black-tailed jackrabbits (*Lepus californicus*) induced significant decreases in numbers of coyotes (*Canis latrans*) in north-western Idaho and southern Idaho (Clark 1972) and kit foxes (*Vulpes macrotis*) in western Utah (Egoscue, 1975). Raptors, such as the great horned owl, may increase as much as five-fold during years of high densities of snowshoe hares in Alberta (McInville and Keith, 1974). Further, population outbreaks of small mammals can induce predators to switch from preferred prey, thus reducing predation on some game species.

1.2.2.2 Objectives of the study

- a. Collect data from the field on species occurrence, abundance and diversity of the study areas;
- b. Collect and review secondary data on small mammal species of the study sites, using the available literature and knowledge of the local inhabitants.
- c. Prepare a taxonomical checklist of the species of small mammals based on field observations, sampling and secondary data.
- d. Identify threatened mammalian species in the Indus for All Programme sites and recommend conservation measures;
- e. Study the behaviour of various species of rodents and other associated groups in relation to the habitat and diet in the study sites.
- f. Assessment of impacts of environmental changes and human population pressure on potential mammalian species and their habitats. Associated mitigation measures are to be suggested.
- g. To identify the key species of small mammals inhabiting the area.
- h. To identify impact of small mammals on the overall livelihood of the people.

1.2.3 Reptiles and amphibians

1.2.3.1 Rationale

Reptiles and amphibians are important vertebrate fauna. Amphibians show the transition from aquatic to terrestrial life. Apart from their impressive evolutionary history, they demonstrate different concepts of physiological and behavioral adaptations to different climates, from tropical forests to hot deserts and marine to fresh water. They do not have the ability to travel long distances like birds and mammals. In response to any local environmental changes they respond quickly and therefore may act as excellent biological indicators.

Amphibians and reptiles are important components of any living system and play a key role in the interlocking web of nature. At one end they prey upon insects and other invertebrates and therefore regulate the population of these animals and on the other hand they are also a major source of food for other carnivore species (birds and mammals). Their position in the ecological niche is so vulnerable that the survival and collapse of the whole energy cycle depends upon the presence and absence of amphibians and reptiles. The existence and sustainable use of this biological resource is therefore imperative around the study sites.

Despite the fact that amphibian and reptiles are an important biological resource, very little attention has been paid to them in Pakistan. The major hurdle presumably is the lack of expertise and awareness in this particular field. Moreover, our society in general and rural folk in particular is mostly repulsive and afraid of reptiles. The results of the present study will provide information on reptiles and amphibians of the Programme sites.

Furthermore, the status of all the species of Amphibians and Reptiles will be evaluated so that in any adverse circumstances the conservation strategies could be suggested.

1.2.3.2 Objectives of the study

- a. Collect and review secondary data on the reptile and amphibian species of the study sites, using the available literature and local inhabitants.
- b. Collect data from the field on species occurrence, abundance and diversity in the study areas.
- c. Prepare a taxonomical checklist of all the species with their English and local names and their status in the study sites.
- d. Identify threatened amphibian and reptile species in IFAP sites and recommend measures to improve the situation.
- e. Study the behaviour of various species of amphibians and reptiles in relation to habitat and diet in the study sites.
- f. Assessment of impacts from environmental changes and human population pressure on potential reptilian and amphibian species and their habitat and to suggest associated mitigation measures.

1.2.4 Birds

1.2.4.1 Rationale

Birds are natural indicators of the health of an ecosystem. When birds disappear from an area or have declining trend in population, it indicates the deteriorating health of the ecosystem.

The area of Indus valley is known as the best part of Pakistan for waterfowl (Koning 1987) with large areas of southern deltaic zone annually inundated during the monsoon season whilst in winter and spring the water recedes, evaporates or is used for agricultural purpose, such conditions being ideal for wintering scores of waterfowl.

The study aims to conduct ecological assessment of the avifauna in order to establish a baseline of IFAP proposed sites.

1.2.4.2 Objectives of the study

- a. Conduct a review of literature on bird fauna
- b. Develop a species inventory of the resident and migratory birds with notes on relative occurrence and distribution of each programme area
- c. Conduct a site specific study on main habitats important to bird species including habitats of critical importance.
- d. Record human impact on resident and migratory bird population.

- e. Document and describe bird species of “Special Concern” with economical and ecological perspective both in resident and migratory avifauna found within the study site.
- f. Conduct studies to describe and assess anthropogenic impacts on bird species founding the study area.

1.2.5 Physico-chemical properties of water

1.2.5.1 Objectives of the study

- a. Review and complete baseline surface hydrological conditions, baseline ground water conditions, baseline of water quality levels in the area;
- b. Collect accurate field measurements for pH, Zinc, Cyanide, Nitrate, C.O.D., oil and grease, conductivity, light transparency/turbidity, total Coli forms, Fecal E. coli, hardness, fecal Enterococci/Streptococci, Chlorides, Arsenic, and alkanity according to approved procedures;
- c. Analyse data to identify water quality contaminants of concern levels and extent of contaminating to determine ambient conditions, trending and cause/effect relationships for each area.

CHAPTER 2

2. MATERIAL AND METHODS

Faunal data were collected by different methods for each group of animals as described below. During field work, locations within the different habitats that exist in the area were sampled. The sampling locations were randomly selected, ensuring that in each habitat type sufficient location are sampled so that maximum number of species could be encountered and recorded.

2.1 Large Mammals

2.1.1 Team Composition

The study team comprising of 2-3 members conducted surveys during winter and summer. Detail of survey team is given in the annex document.

2.1.2 Point surveys

In this method, observation points were established along roads, edges of ponds or marshes, at a higher place or at any other location suitable for viewing the habitat. For a period of 15 to 60 minutes at each observation point, the observer recorded all sightings of the mammals at that site.

2.1.3 Roadside Counts

Usually it is difficult to locate a large mammal by walking in its habitat, as it can smell the human from a long distance. Hence the method of roadside counts was applied mostly for the nocturnal mammals like foxes, jackals, cats, hog deer and wild boar as well as for the diurnal mammals like mongoose. For this purpose, 4x4 vehicles were used which were driven at a slow speed (7 km/hr). These roadside counts were carried out during early morning at dawn and during night by using search lights.

2.1.4 Track Counts

Tracks can be the first indication of the presence of animals in an area. Track counts especially after rain can be useful in identifying different animals especially those which are nocturnal and secretive in habits. A fresh rain eliminates the previous tracks and the recent tracks of animals entering or leaving the study area can be used as a measure of their abundance.

During the survey period, track count technique was applied at all the four study sites and this method proved very effective to determine the present of cats, otters etc.

2.1.5 Line transects

The line transect or strip census method of population estimation involves counting the animals seen by an observer traversing a predetermined transect line and recording the animal and distances on the both side of the strip at which they were observed. The length of the strip multiplied by the average total distance of both sides of the strip is the sample area.

Line transects or strip census method is particularly useful technique when animals are difficult to observe and must be flushed to be observed and recorded.

2.1.6 Pellet counts

Pellets' counting in a specific area is a good technique for locating large mammals and assessing their populations. The technique involves removing all pellet groups from plots and then estimating from subsequent observations on those plots and number of groups per hectare to compare animal use of areas between sampling periods. In some cases it is not possible to remove all the pellet groups from an area therefore under such circumstances; an observer with a little practice can identify the fresh pellets depending on the color and dryness of the pellets. Ten to fifteen 100 m² plots (7.07 x 14.14) can be used for this purpose. These plots should be checked every three to seven days and the periods between samplings should not be so long that faeces will decompose or be destroyed by weather or insects. A random selection of plots in the study area and the number of pellet groups in each plot is tallied and summed (Bower *et. al* 1990). An index of density (ID) of the number of pellet groups per unit area is then determined as:

$$ID = n / A$$

Where n is the sum of pellet groups counted over all plots and A is the total area sampled (i.e. the sum of the areas of all plots).

This method is effective in the habitats with dry weather and little or no dung beetle activity where pellet groups remain preserved between sampling periods.

After counting pellets, one must be assured that they will not be counted on successive sampling periods so they should be removed by the observer. Defecation rates for the species under the study are closely estimated if it is desired to convert pellet counts to number of animals.

2.1.7 Interviews with local residents

Interviews with local residents are valuable not only for the survey site selection but also in identifying the potential areas and a good source of primary data about the existing wildlife of the area. This method was very helpful in locating different mammal species in all the four study sites. However, despite the effectiveness of this method, minimal

emphasis was placed on this source regarding the populations of different animals as it is assumed that the data regarding the population estimates could be biased.

2.1.8 Equipments and Field Kit

Equipments and field kits used for watching different mammals and assessing their populations in different study sites included:

1. Digital camera to record the photographic evidences of the mammals
2. Search lights for night vision of nocturnal mammals on 4x4 vehicles.
3. Measuring tape to record the size of foot prints and fecal droppings.
4. Binoculars (10x50) to observe the diurnal large mammals.
5. Geographical Positioning System (GPS) to record the coordinates.
6. Field guide books for assistance in quick identification of mammals.
7. Note book and pencils for recording field notes.
8. Satellite maps of the study sites.

2.2 Small Mammals

It is an effective way to survey mammals in active searching, particularly during the daytime. This method is equally applicable to both nocturnal and diurnal species. The study area was actively searched for potential and suitable microhabitats along the canal banks, open plains, bushy areas and agriculture fields. Active searching is very effective for inventory of *Gerbilus*, *Meriones*, *Hysrix* and *Hemiechinus species*. This method is most effective for those small mammals which cannot be trapped easily e.g. Hedgehog.

To investigate nocturnal species, night surveys were conducted in exposed areas of potential habitats on the ground. This methodology involved the use of a powerful 40rcH light, sticks, long boots, gloves etc.

2.2.1 Bait

A mixture of different food grains mixed with fragrant seeds was used as bait for the attraction of the small mammals. Wheat and rice were used as food grains while peanut butter, coriander, oats and onion were used as fragrance. This bait was found highly successful in the study area due to the overall food shortage and fragrance. Freshly prepared bait was used on every trapping morning. Only small amount of bait was placed on the platform fitted on the rear side of the trap.

2.2.2 Traps and trapping procedure

Sherman traps were used for the present studies to collect the live specimens. Fifty traps were set at a specific area on a line approximately 500 m long and traps were set

approximately 10 m apart. Each trap was marked by a colorful ribbon to locate the traps easily. The traps were set in the afternoon and checked early in the morning. The specimens were transferred into polythene bags and were identified in the field and released. The specimens with some doubt were preserved in 10% formalin and were sent to the laboratory and identified using identification keys. At least one specimen preserved for reference.

2.2.3 Data collection

The species of the trapped animal was noted as was the net weight, gender and other relevant information such as date, habitat, location, elevation and weather conditions.

2.3 Reptiles and amphibians

2.3.1 Survey method

The activities of amphibians and reptiles are highly seasonal and are influenced by the variation of weather even on a daily basis due to their exothermic and cryptic nature. It is more fruitful to survey them during their activity periods. Amphibians are usually most active just after dusk during their breeding season; many diurnal reptiles such as skinks and some lizards are active in mid-morning whereas nocturnal reptiles such as certain skinks and some lizards are active in mid-morning whereas nocturnal reptiles such as certain snakes and geckos would be active only at night.

Most amphibians and reptiles go into hibernation during winter. They would be underestimated if surveys were carried out during this time. As such, it would be essential to survey herpto-fauna at appropriate timings in order to collect a representative baseline for assessment. Many reptiles such as snakes and lizards are timid, secretive, fast moving and cryptically colored. This renders survey of reptiles difficult. The reptiles therefore tend to be under represented in ecological surveys in general. More intensive surveys with appropriate survey methodologies would rectify such limitations.

There are standard methods for the studies of Amphibians and Reptiles (Foster and Gent, 1996; Hayek and Martin, 1997). All these techniques have been summarized in the EIAO Guidance Note, 2004. A brief summary is given below:

2.3.2 Active searching

An effective way to survey amphibians and reptiles is by active searching particularly during the day time. This method is equally applicable to both nocturnal and diurnal species. The study area was actively searched for potential breeding areas of amphibians (e.g. marshes, small water poles, water channels) and suitable microhabitats for both amphibians and reptiles (e.g. stones, pond bunds, crevices, leaf litter/debris, rotten log).

These places were deliberately uncovered to search for the eggs and tadpoles of amphibians and aquatic habitats or to reveal the presence of the amphibians and reptiles hiding under these covers. Active searching was carried out in all the locations with a focus on suitable microhabitats. In winter, most of the active searching was only possible and limited to the pre-dusk time, as the low night temperatures hindered the activities of the herpetiles.

Searching for the nocturnal species of amphibians and reptiles was carried out in exposed areas of their potential habitats on ground, along the path or the pond/stream bank.

2.3.3 Trapping

‘Pit – fall’ trapping is one of the efficient methods of collecting amphibians and reptiles. Pitfalls however require regular monitoring, which is not possible in short term surveys. The most suitable location for such traps is the sandy habitat, which yields great success in trapping the animals. The drifts along which traps were placed/set, guided the animals to fall into the traps. Some leaf litter was put in the set trap to provide cover and moisture for any amphibians and reptiles, trapped inside. The traps were checked regularly within a reasonable time period, at least once per day, to avoid stress and death of trapped animals.

For the “Active Searching” and “Pit-fall trapping” requisite activities including Observations, Identification, Collection and Preservation were made as per plan of the studies.

2.3.4 Signs

Presence of signs like impression of body, tail or footprints, faecal pellets, tracks, dens or egg laying excavations were also some of the suitable methods to find out the existence, range and rough population of amphibian and reptilian fauna.

2.3.5 Collection

Hand picking (through bare hands or with the help of long forceps or snake clutch adopted for the present studies, has always been the most efficient way of collecting different species of amphibian and reptiles. However, for larger species like monitor lizard and rock agama, noose traps or other appropriate techniques were used. For handling snakes, especially poisonous ones, snake clutches/sticks were used. In addition to Hand picking, Scoop nets for shallow water and Cast nets in large water bodies were used for aquatic reptiles and amphibians. For frogs and toads, auditory detection of mating calls at the breeding sites is considered as an efficient method to find out the species; particularly the more vocal species and like toads.

2.3.6 Data Records

The species collected or observed during the survey were photographed with the digital camera and necessary field data were recorded. The coordinates and elevations were recorded with the help of GPS. The voucher specimens collected were subsequently provided to the Zoological Survey Department for reference.

2.3.7 Preservation

The amphibian or reptile specimens were arranged in a tray in a position, which showed the features important for identification, e.g. mouth wedged open, one hind leg extended and fingers and toes spread. Preservatives such as 10% Formalin solution or 50-70% alcohol or methylated spirits solution in water was added to just cover the specimens, and the container was then covered and left until the specimens were set. In case of larger specimens, a slit was made in the belly and preservative was injected to preserve the internal organs. This step was omitted in case of frogs as they have thin and permeable water proof label was added to the jar, giving details of place, date and collector's name. A label was tied to the specimen written with permanent Indian ink or simple carbon pencil. The same details were stored with tadpole specimens, which don't need to be set, just dropped into preservative.

2.3.8 Identification of species

The specimens were identified with the help of most recent keys available in literature (Khan, 2003 and 2006)

2.3.9 Data Analysis

There are several numerical indices in use, which qualitatively describe different levels of diversity and evenness in samples collected from different localities or at different times from the same environment. One such commonly used diversity index is called "Shannon-weaver" index of diversity, which combines the number of species present and evenness into a single index. The formula is given as:

$D = - \sum p_i \ln p_i$, where "i" stands for an index number for each species present in a sample, "p_i" can be calculated through "n_i/N" in which "n_i" represents the number of individuals within a species divided by the total number of individuals "N" present in the entire sample and "ln" stands for natural log. In this way the proportion "p_i" of each species in the sample times the natural log of that same value "ln p_i" the values for each species and finally multiplied by -1. The value of "D" is always higher when species are equally abundant.

Similarly species evenness is calculated by the formula as:

$E = eD/s$, where "e" is the Shannon-weaver constant valuing 2.7, "D" is the value of Shannon-weaver index and "s" represents the number of total species in a sample. Species evenness, thus, separates the effect of different population sizes (number of individuals within species) from number of species (species diversity).

2.4 Birds

2.4.1 Survey Method

The major habitat type in the study area available for birds was identified. The species and numbers of birds of each species found in each habitat type were recorded with particular emphasis on the key species. The data was also be related to other components of the study area such as vegetation, water and soil etc. The field surveys covered both migratory and breeding surveys of birds.

The most commonly used field method in bird surveying is the “Line Transects” method. It is based on recording birds continually along a predefined route within a predefined survey unit. It can be used in terrestrial, freshwater or marine ecosystems to survey individual species, or group of species. It is used to examine bird-habitat relationships and to derive relative and absolute measures of bird abundance.

Line transects are suitable for extensive, open and uniform habitats and for large and conspicuous species. Double counting of birds becomes a minor issue as the observer is continually on the move. Line transects are suited to situations where access is good and these are very useful for bird-habitat studies (Gregory *et al* 2004).

In the present studies, each sample area was traversed and examined by two observers separately. Birds were searched on each side of the strip for 150 m so that each study strip will be 300 wide. Binoculars and telescopes were used to identify bird species and count or assess bird numbers.

2.4.2 Evaluation of water bird numbers

To evaluate the numbers of water-birds utilizing a site, observation is made from a stationary point or by moving through the area using binoculars and telescopes. Below is a summary of when to count accurately or estimate the numbers of water-birds present:

a) Counting individual birds within an area

- Small number of birds present *i.e.* <1,000
- Limited inter – or intra – site movement by water-birds *i.e.* the birds are stationary at a roost site.
- No on-site disturbance *i.e.* People, birds of prey, which may force birds to fly frequently within the site.
- The birds are well spaced out *i.e.* foraging in an open area.

b) Estimating the numbers of birds within an area

- Large numbers of birds present *i.e.* >1,000
- Birds continually in flight *i.e.* moving along the coast to a roost site in large flocks.
- A lot of disturbance forcing birds to be unsettled and continually take flight, making prolonged observation on the ground difficult.

- A closely packed flock of birds, where due to ‘tightness’ of the flock counting individual birds is difficult *i.e.* at a large roost.
- Due to poor light conditions *i.e.* viewing into the sun or over a great distance, identification of particular species is not possible.

2.4.3 Methods of accurate count

- Close viewing of individuals with binoculars or a telescope. Counting 1,2,3,4,5,6,.....etc.
- Distant viewing of an evenly distributed flock. Counting 1,2,3,4,5,6,.....etc.
- Visually dividing birds into small groups and counting each group individually, *i.e.* when there is an uneven distribution of numbers. Totals for each group are then added to form the final total.
- Counting flocks in multiples *i.e.* 3,6,9,12,15,.....etc. or 2,4,6,8,10,.....etc. This method can be used for either evenly or unevenly distribution of water-birds. (Howes, J. and Backwell, D. 1989).

Since all the birds would not be resident in the area, they may be either, winter visitors, passage migrants, summer (breeding) visitors or resident etc. Hence, an attempt will be made to cover all the recognized breeding and wintering habitat types in the area with at least one survey carried out over the summer and one in winter season for each habitat type.

2.5 Physico-chemical Properties of Water

The samples were not collected from Khyberani Forest area.

CHAPTER 3: RESULTS AND DISCUSSION

3.1 Large Mammals

3.1.1 Sampling locations

Almost all the potential sites around Khyberani Forest were searched to locate the existing large mammals; the GPS coordinates at different locations were noted. Different sampling sites around Khyberani Forest are given in the following Map.

Map 2 – Sampling sites of large mammals at Khyberani Forest



[Map 3 – Sampling sites of large mammals at Khyberani Forest during summer]

3.1.2 Species identified

During surveys conducted in November 2010 and July 2011, 16 animals of 7 different species, belonging to two orders (Carnivora and Artiodactyla) were observed in the study area, as given in Table 1 below:

Table 1 – Mammals recorded from Khebrani Forest

S. No	Common Name	Scientific Name	Order	Animals observed
1	Asiatic jackal	<i>Canis aureus</i>	Carnivora	7
2	Jungle cat	<i>Felis chaus</i>	Carnivora	1
3	Bengal fox	<i>Vulpes bengalensis</i>	Carnivora	confirmed by signs
4	Small Indian mongoose	<i>Herpestes javanicus</i>	Carnivora	4
5	Grey mongoose	<i>Herpestes edwardsi</i>	Carnivora	1
6	Hog Deer	<i>Axis porcinus</i>	Artiodactyla	confirmed by signs
7	Indian wild boar	<i>Sus scrofa</i>	Artiodactyla	3

3.1.1 Observation Records

Out of seven recorded species of large mammals, five were observed directly while two species were recorded on the basis of indirect evidences like tracks, foot prints, fecal material and interviews with the locals. Observation records of different mammalian species at Khyberani are given in the Table 2 below.

Table 2 – Observation records of different mammal species at Khyberani Forest

S. No	Species	Direct Observation	Indirect Observation		
			Foot prints	Fecal material	Interviews with locals
1	Asiatic jackal	✓	-	-	✓
2	Jungle cat	✓	-	-	✓
3	Bengal fox	-	-	✓	✓
4	Small Indian mongoose	✓	-	-	✓
5	Grey mongoose	✓	-	-	✓
6	Hog Deer	-	✓	✓	✓
7	Indian wild boar	✓	✓	-	✓

3.1.2 Conservation Status of Recorded Mammals

Out of the 7 recorded species, one is Endangered (EN), one Vulnerable (VU) and five Least Concern (LC), according to the IUCN Red List 2011. Three species are listed in Appendix I of CITES and two in Appendix II of CITES, as listed in Table 6. Appendix I of CITES lists species that are the most endangered and CITES prohibits international trade in specimens of these species. Appendix II lists the species that are not threatened now but may become so unless trade is closely controlled.

Table 3 – Conservation status of mammals found at Khyberani Forest

S. No	Mammalian Species from Khyberani	Recorded	IUCN Red List 2011	Sindh Wildlife Protection Ordinance 1972	CITES Category 2011
1	Asiatic jackal		LC	-	-
2	Jungle cat		LC	P	Appendix II
3	Bengal fox		LC		Appendix I
4	Small Indian mongoose		VU		Appendix II
5	Grey mongoose		LC		
6	Hog Deer		EN	P	Appendix I
7	Indian wild boar		LC		Appendix I

Legend: EN = Endangered, VU = Vulnerable, LC = Least Concern, P = Protected

3.1.5 Threats and recommendations

3.1.5.1 Threats

- **Persecution of wildlife:** Evidences of hunting wildlife including the endangered hog deer was found. There is no effective implementation of wildlife laws in the area and influential persons are involved in hunting. The wild boar destroys the crops in surrounding area and people shoot them whenever they get a chance;
- **Forest cutting:** Though the area is un-accessible to general public, yet wood cutting is a continuing practice in the forest. Livestock also graze in the forest. This is causing continuous disturbance in the habitat of hog deer and thus poses a threat to the hog deer population.
- **Land grabbing:** Land grabbing and lease of forest lands to influential persons and converting it in to the agricultural land by them is one of the major threats. This is degrading the forest habitat and home for many wild species of animals and birds.
- **Food Competition with livestock:** Hog deer has very limited grazing grounds in the forest. Due to hunting pressure from surrounding area, hog deer cannot forage outside the forest. Livestock grazing in the forest poses a severe food competition with hog deer.
- **Forest Fire:** There have been two forest fires in the recent years led to the habitat degradation.

3.1.5.2 Recommendations

- **Lease of Lands:** The Sindh Agro-forestry Policy 2004 should not be implemented at Khyberani Forest. The forest land should not be leased to the people for agro-forestry purpose.

- **Hog deer breeding centre:** A breeding centre may be established for captive breeding of hog deer. The animals reared at the captive breeding facility then are released in wild in the forest.
- **Incentives for wildlife watchers:** There should be some incentives for wildlife watchers for their special efforts in conserving the important wildlife of the area e.g. hog deer. They may also be given incentives and support for proper implementation of wildlife laws.
- **Promotion of ecotourism:** The facility for ecotourism may be developed and promoted at this site and visitors could see the hog deer and other interesting wildlife. This will also promote raising awareness about wildlife. Sign boards with information on the wildlife may also be erected at important points, particularly at the entrance.
- **Community mobilization:** Communities around the forest should be mobilized for biodiversity conservation and outreach programme should be established for them. The options of engaging local communities in forest and wildlife conservation may be explored. The local community can be involved in watch and ward, tree planting and after care operations.
- **Conserve habitat through alternate energy resources:** To address the fuel wood requirements of neighbouring communities other avenues must be explored. Biogas plants and other alternate energy sources can also be introduced as the most economical source of energy. Energy saving measures like the use of fuel saving stoves should also be explored.

3.2 Small Mammals

3.2.1 Sample locations

Map given below shows the sampling locations of small mammal survey at Khyberani Forest.

Map 3 – Details of trapping locations for small mammals at Khyberani Forest

3.2.2 Species account

Seven species were observed. The species belonged to 3 orders (Rodentia, Lagomorpha and Erinaceomorpha) and 5 families. Same number of species was recorded in winter and summer surveys. Table 11 gives an account of the species recorded at Khyberani along with their status, feeding habits and activity habits.

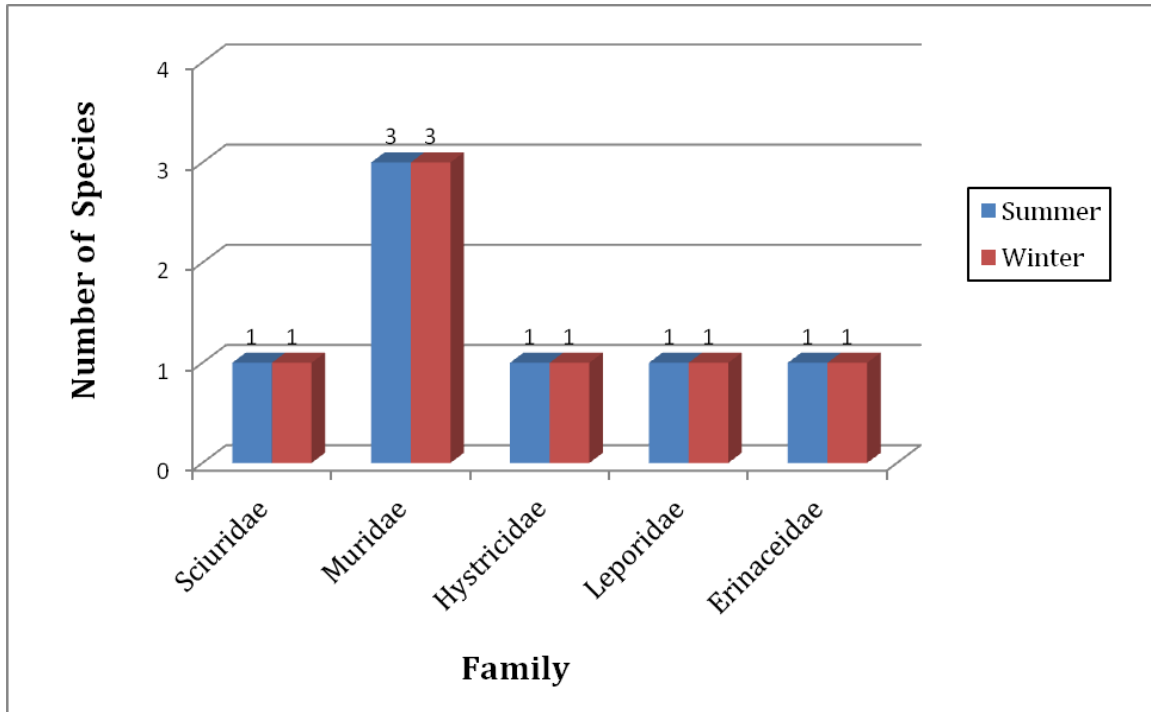
Table 4 – Species recorded at Khyberani Forest along with conservation status, feeding and activity habits

S. No	Scientific Name	English Name	Feeding Habit	Behavior	Status	Winter	Summer
Order: Rodentia							
Family: Sciuridae							
1	<i>Funambulus pennanti</i>	Palm Squirrel	GRN	DR	C	6	3
Family: Muridae							
2	<i>Rattus rattus</i>	Common Rat	GRN	NC	C	2	5
3	<i>Mus musculus</i>	Common House Mouse	GRN	NC	C	1	1
4	<i>Tatera indica</i>	Indian Gerbil	GRN	NC	C	2	2
Family: Hystricidae							
5	<i>Hystrix indica</i>	Indian crested porcupine	HRB	NC	C	1	1
Order Logomorpha							
Family Leporidae							
6	<i>Lepus nigricollis</i>	Desert hare	HRB	NC	C	2	1
Order Erinaceomorpha							
Family Erinaceidae							
7	<i>Paraechinus micropus</i>	Indian Hedgehog	INS	NC	C	1	1

Give here the legend as well.

Figure 1 below shows the number of species recorded from each family. As can be seen most of the species belong to Muridae family. There was no major change in distribution of families during winter and summer, suggesting that there is little migration of animals over the seasons. Since there are no population figures available, it is hard to predict whether any of the small mammal populations increased or decreased over the study period.

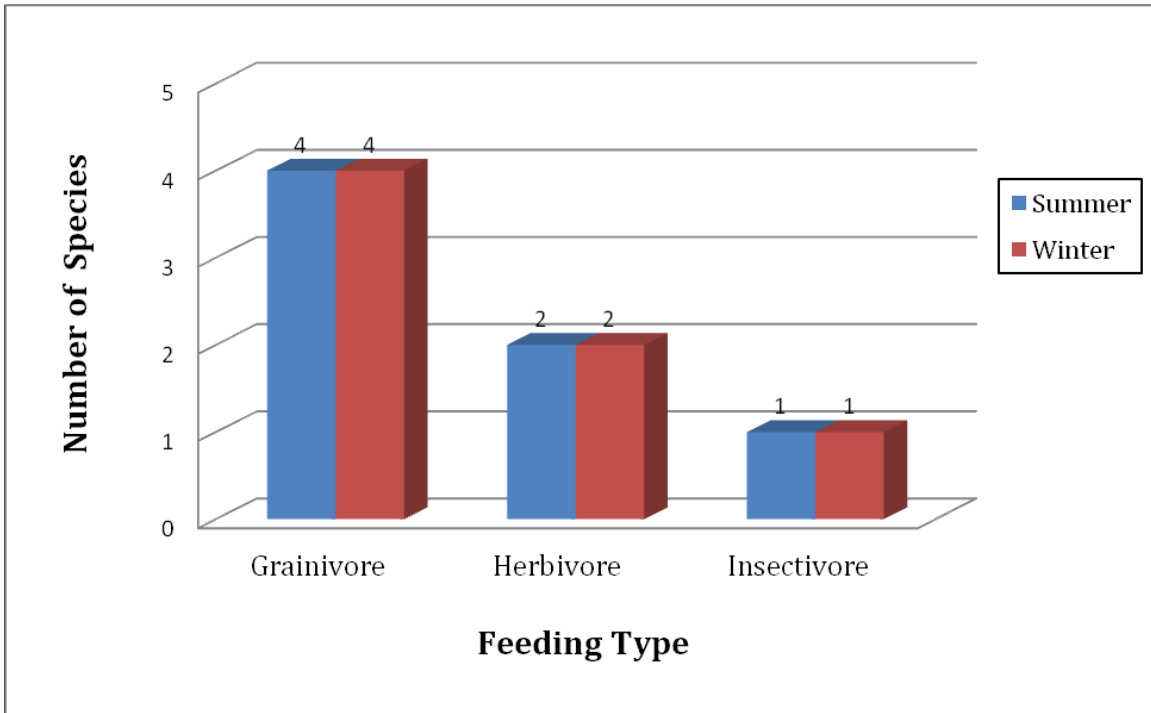
Figure 1 – Family representation of recorded small mammals at Khyberani Forest



3.2.3 Feeding habits

Most of the species recorded from Khyberani are granivorous followed by herbivores and insectivores. Figure 2 gives a graphical portrayal of the number of species by feeding habits.

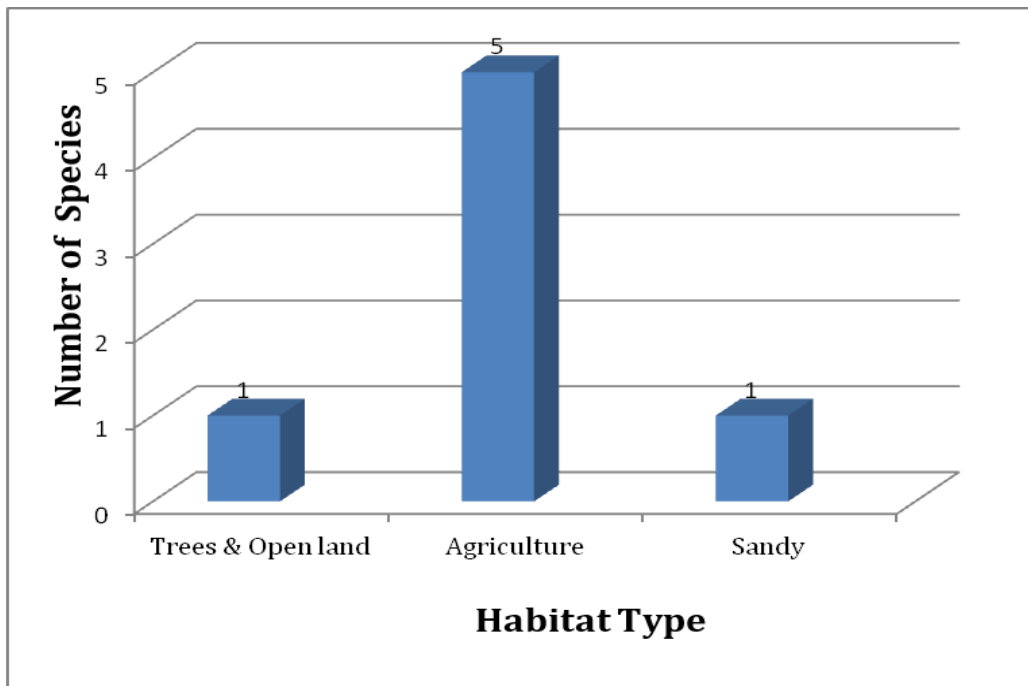
Figure 2 – Distribution of feeding types across the species recorded at Khyberani Forest



3.2.1 Habitat and occurrence

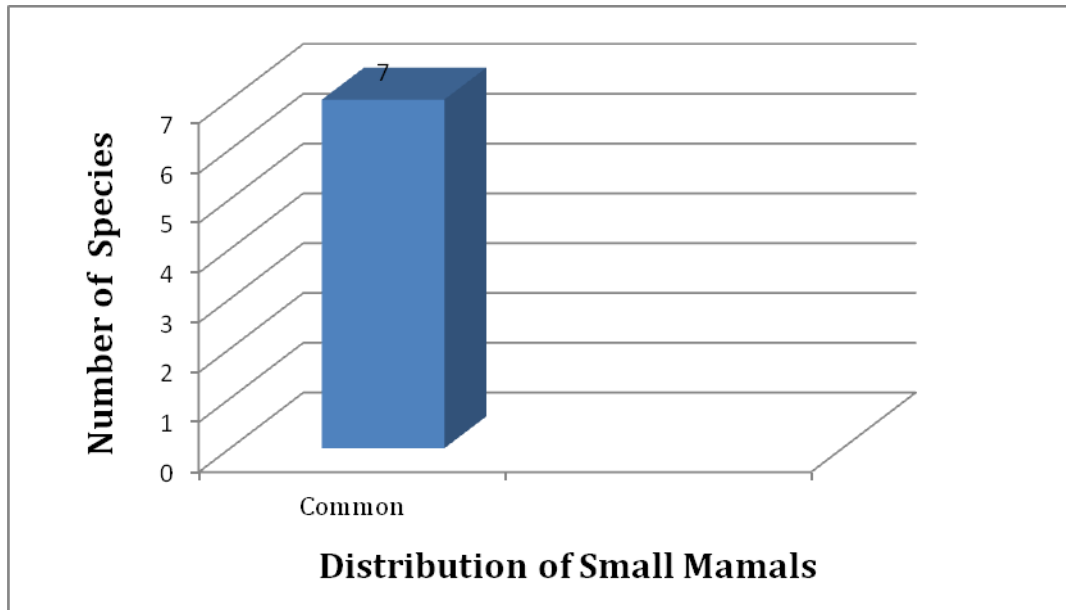
The majority of the species were recorded from agriculture land (as shown in Figure 3) followed by open land habitat. Any similarities between the results of feeding habits and habitat occupancy are probably correlated.

Figure 3 – Number of species recorded from habitat types



Almost all species recorded from Khyberani Forest are common. The numbers do not reflect the status of species at site level which requires longer term studies.

Figure 4 – Distribution of small mammal status over the species and season at Khyberani Forest



3.2.5 Threats and recommendations

3.2.5.1 Threats

- Extensive farming and application of agro-chemicals are contaminating the agriculture land and associated micro-habitats such as marginal lands in the area. Such contamination is known to directly and indirectly impact small mammal population through direct poisoning and reduction of food source, especially in the case of insectivores.
- Overgrazing seems a problem which can potentially affect herbivorous and granivorous small mammal species in terms of food source. Grazing pressure results in a reduction in ground foliage and can affect the breeding success of small mammals as well as increase the chance of predation.
- Logging and cutting of trees is the cause of degradation of habitat.

3.2.5.2 Recommendations

- Farmers/Agriculturists should be made aware of the importance of small mammal as natural pest controllers and be given instructions on wise-use of pesticides and other agro-chemicals on farm land;
- Mark and recapture studies (Lincoln index) should be undertaken for selected small mammal species. This would help in monitoring the local population of selected small mammals as an indicator of the ecosystem;
- The local communities should be educated about the importance of wild fauna like amphibians, reptiles and small mammals especially in the forest ecosystem through on job training, exposure visits.

3.3 Reptiles and amphibians

3.3.1 Sample locations

Map given below shows the details of trapping locations of reptiles and amphibians from Khyberani Forest.

Map 4 – shows the sampling/trapping location for reptiles and amphibians at Khyberani Forest

3.2.2 Summary

Khyberani Forest is situated close to river Indus near Matiari city, at a distance of about 5 km of National Highway. Various compartments of the forest were visited during surveys conducted in December 2010 and July 2011.

Eight species of reptiles and 3 species of Amphibians belonging to 9 families were recorded. These species were also classified on the basis of food habit and as a result 7 species were insectivores and 4 carnivores.

The status of species was determined at the local level. Those species which were sighted frequently in a habitat or had visible signs of its occurrence and confirmed to be common by the local people has been categorized as 'Common'. The species which was occasionally sighted and had least visible sign of its occurrence was classified as 'Rare'. According to this categorization, 5 species were abundant, 4 common and 2 rare.

Indian monitor (*Varanus bengalensis*) was the commonest reptile in the area. Tree Lizard (*Calotes versicolor*) was also common. It was observed that during floods the habitat near the embankment and canal banks was inundated hence affected the reptilian population.

The number of amphibian and reptilian species is seemingly less than what would be the actual occurrence in the area but due to some limitations the reported species may be less. The survey period was very brief and surveys in most of the areas could not be undertaken. This survey intended to provide preliminary data and status of the reptiles and amphibians in the area.

Table 5: Reptilian and Amphibian Species of Khyberani Forest

	English Name	Scientific Name	Status	Activity Pattern	Feeding Habits	Summer	Winter
Order Chelonian							
Family Trionychidae							
1	Indian Flap-shell Turtle	<i>Lissemys punctata andersoni</i>	R	Diurnal	CAR	1	1
Order Sauria							
Family Agamidae							
2	Tree Lizard or Indian Garden Lizard	<i>Calotes versicolor</i> v.	A	Diurnal	INS	8	2
Family Varanidae							
3	Bengal monitor	<i>Varanus bengalensis</i>	A	Diurnal	CAR	3	1
Family Scincidae							
4	Bronze Grass Skink	<i>Eutrophis macularia</i>	C	Diurnal	INS	4	2
Family Gekkonidae							
5	Yellow-bellied House Gecko	<i>Hemidactylus flaviviridis</i>	A	Nocturnal	INS	3	1
6	Warty rock gecko	<i>Cyrtopodion kachhensis</i> k.	C	Nocturnal	INS	2	1
Order Serpentes							
Family Elapidae							
7	Black Cobra	<i>Naja naja naja</i>	R	Mostly Diurnal	CAR	1	1
Family Viperidae							
8	Saw scaled Viper	<i>Echis carinatus</i>	C	Nocturnal	CAR	1	1
Order Anura							
Family Bufonidae							
9	Marbled Toad	<i>Bufo stomaticus</i>	A	Non-specific	INS	6	5

				(mostly diurnal)			
Family Ranidae							
10	Bull Frog	<i>Hoplobatrachus tigerinus</i>	C	Nocturnal	INS	4	2
11	Skittering Frog	<i>Euphlyctis cyanophlyctis</i>	C	Non-specific (mostly nocturnal)	INS	8	3

Legend: What are C, A, R, INS?

3.3.3 Species richness

Species Richness (s) is a relative term that refers to the number of species in a community, and is directly associated with measuring the diversity of species in a given area. A related term, evenness (E), is another dimension of diversity that defines the number of individuals from each species in the same area. Together, these terms have been used to describe species diversity patterns on Earth.

There are several hypotheses that have been proposed to explain species diversity patterns. Many of these hypotheses are based upon the idea that species are more diverse near the equator than near the poles. In other words, there is a recognized latitudinal gradient of species diversity on Earth. The hypotheses that support this latitudinal gradient can be divided into two groups: abiotic and biotic. The biotic hypotheses are those that explain species diversity patterns with relation to living organisms. The abiotic hypotheses, on the other hand, explain species diversity patterns with relation to non-living chemical and physical environmental factors.

Table 6 gives four indices of richness starting with the number of species (graphically shown in Figure 5). Evenness and two biodiversity indices are also given in the table, namely Shannon's and Margalef Index.

Shannon's Index

The Shannon-Weaver diversity index looks at how a species is distributed in the ecosystem. To perform this calculation, you need to sample a population by taking a look at a given area, counting the different species in the population and assessing their abundance there. The Shannon-Weaver diversity index is also known as the Shannon index or Shannon-Wiener index. This is an important measurement for biodiversity.

Let's use our sample data (11 species, 41 total individuals) and calculate D i.e.

Shannon Index for summer:

Species	Indian Flap-shell	Tree Lizard or	Bengal monitor	Bronze Grass Skink	Yellow-bellied House	Warty rock gecko	Black Cobra	Saw scaled Viper	Marbled Toad	Bull Frog	Skittering Frog	Total N
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	Turtle	Indian Garden Lizard			Gecko							
n_i (population size)	1	8	3	4	3	2	1	1	6	4	8	41
p_i	0.024	0.2	0.073	0.098	0.073	0.049	0.024	0.024	0.15	0.98	0.2	
ln p_i	-3.73	-1.61	-2.62	-2.32	-2.62	-3.02	-3.73	-3.73	-1.9	-2.32	-1.61	
p_i x ln p_i	-0.09	-0.32	-0.19	-0.23	-0.19	-0.15	-0.09	-0.09	-0.29	-0.23	-0.32	-2.19 = Σ

S = 11 species
N = 41 individuals
D = -Σ p_i ln p_i = -1 x -2.19 = 2.19

Remember: The value of **D** is highest when species are equally abundant.

Let's use our sample data (11 species, 20 total individuals) and calculate D i.e. Shannon Index for winter:

Species	Indian Flap-shell Turtle	Tree Lizard or Indian Garden Lizard	Bengal monitor	Bronze Grass Skink	Yellow-bellied House Gecko	Warty rock gecko	Black Cobra	Saw scaled Viper	Marbled Toad	Bull Frog	Skittering Frog	Total N
n_i (population size)	1	2	1	2	1	1	1	1	5	2	3	20
p_i	0.024	0.049	0.024	0.049	0.024	0.024	0.024	0.024	0.12	0.049	0.073	
ln p_i	-3.73	-3.02	-3.73	-3.02	-3.73	-3.73	-3.73	-3.73	-2.10	-3.02	-2.62	
p_i x ln p_i	-0.09	-0.15	-0.09	-0.15	-0.09	-0.09	-0.09	-0.09	-0.25	-0.15	-0.19	-1.43 = Σ

S = 11 species
N = 20 individuals--
D = -Σ p_i ln p_i = -1 x -1.43 = 1.43

Remember: The value of **D** is highest when species are equally abundant.

Species Evenness

The diversity of species in a particular area depends not on the number of species found, but also in their numbers. Ecologists call the number of species in an area its richness, and the relative abundance of species its evenness. They are both measures of diversity.

Divide Shannon's diversity index H by natural logarithm of species richness ln (S) to calculate the species evenness. Note that species evenness ranges from zero to one, with zero signifying no evenness and one, a complete evenness.

$$E = D / \log (S)$$

Therefore for summer it is: $E = D / \log(S) = 2.19 / \log(11) = 0.91$

For winter it is: $E = D / \log(S) = 1.43 / \log(11) = 0.59$

Margelef Index:

It is a measure of species diversity. It is calculated from the total number of species present and the abundance or total number of individuals. The higher the index the greater the diversity.

$$Da = (S-1) / \log \text{ to base } e N$$

- Where
- Da = Margalef Index
 - S = No. of Species
 - N = Total No. of Individuals
 - e = 2.7 (constant),

Therefore for Summer it will be: $Da = (S-1) / \log \text{ to base } e N$

$$\begin{aligned} Da &= 11-1 / \log (2.7 * 41) \\ &= 10 / 4.71 \\ &= 2.12 \end{aligned}$$

For winter it will be: $Da = (S-1) / \log \text{ to base } e N$

$$\begin{aligned} Da &= 11-1 / \log (2.7 * 20) \\ &= 10 / 3.99 \\ &= 2.51 \end{aligned}$$

Table 6 – Diversity indices for reptiles and amphibians recorded from Khyberani Forest

S. No.	Index type	Summer	Winter
1	Richness (number of species)	11	11

2	Evenness	0.91	0.59
3	Shannon index	2.19	1.43
4	Margalef index	2.12	2.51

Inference from the data?

Figure 5 – Number of reptile and amphibian species recorded during summer and winter from Khyberani Forest

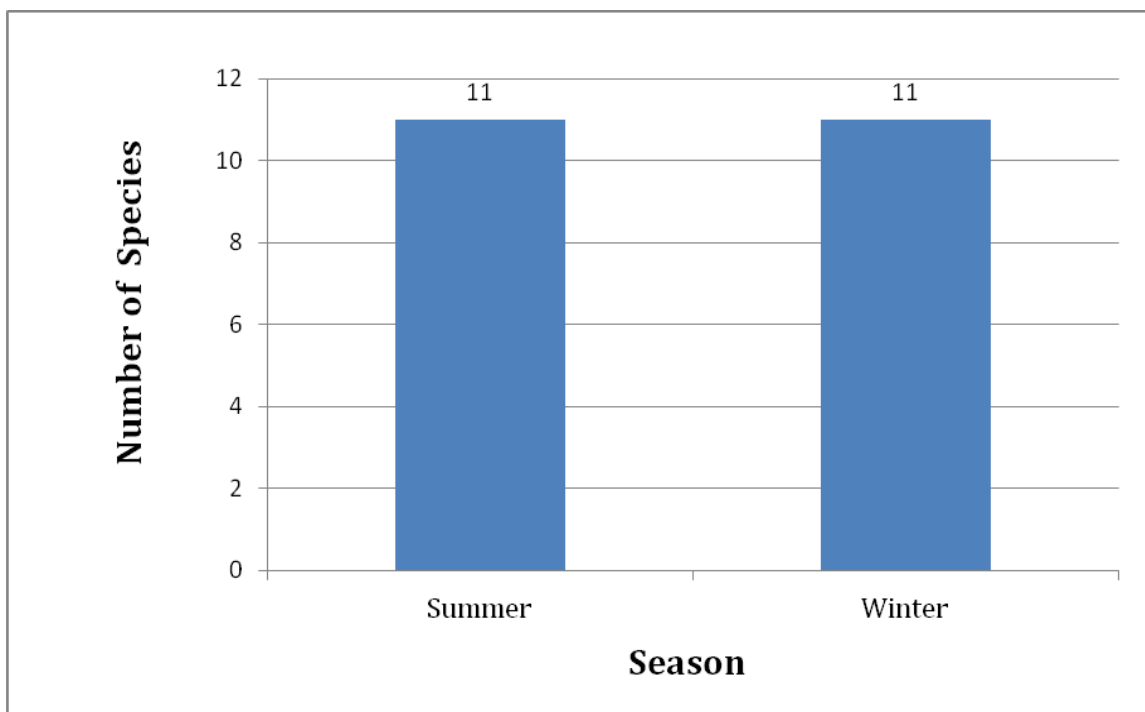


Figure 6 – Evenness of species recorded in summer and winter from Khyberani Forest

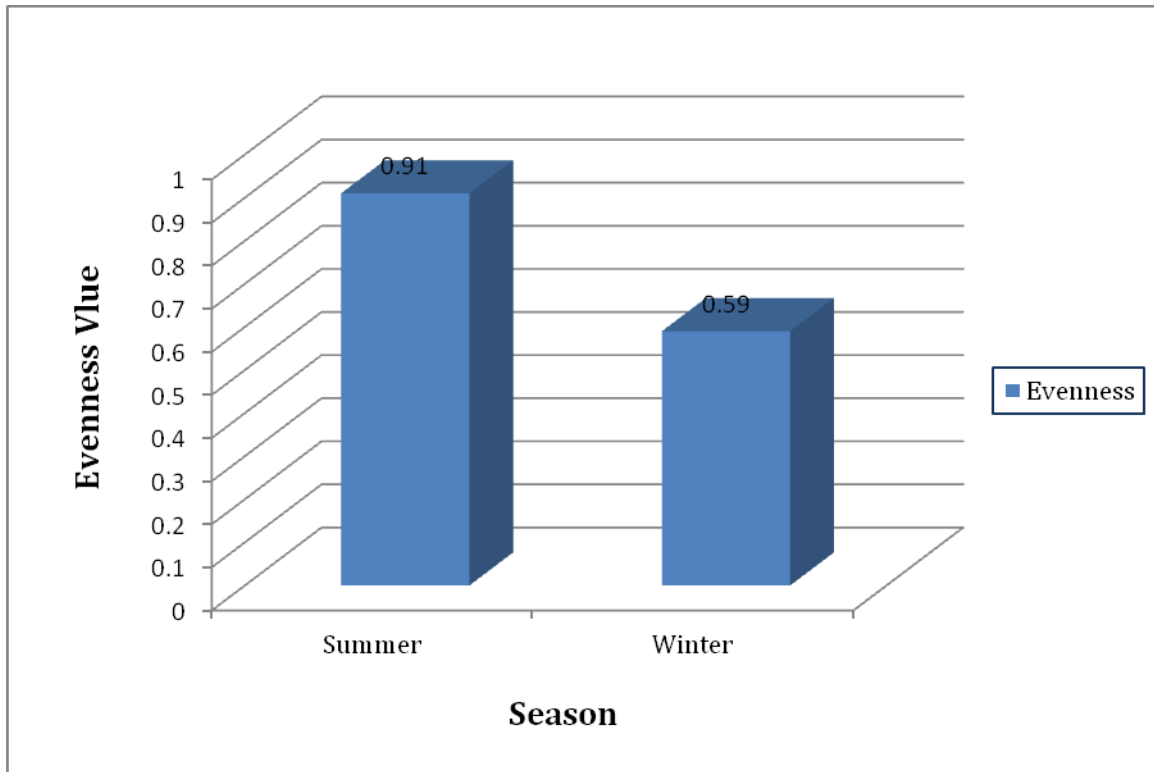
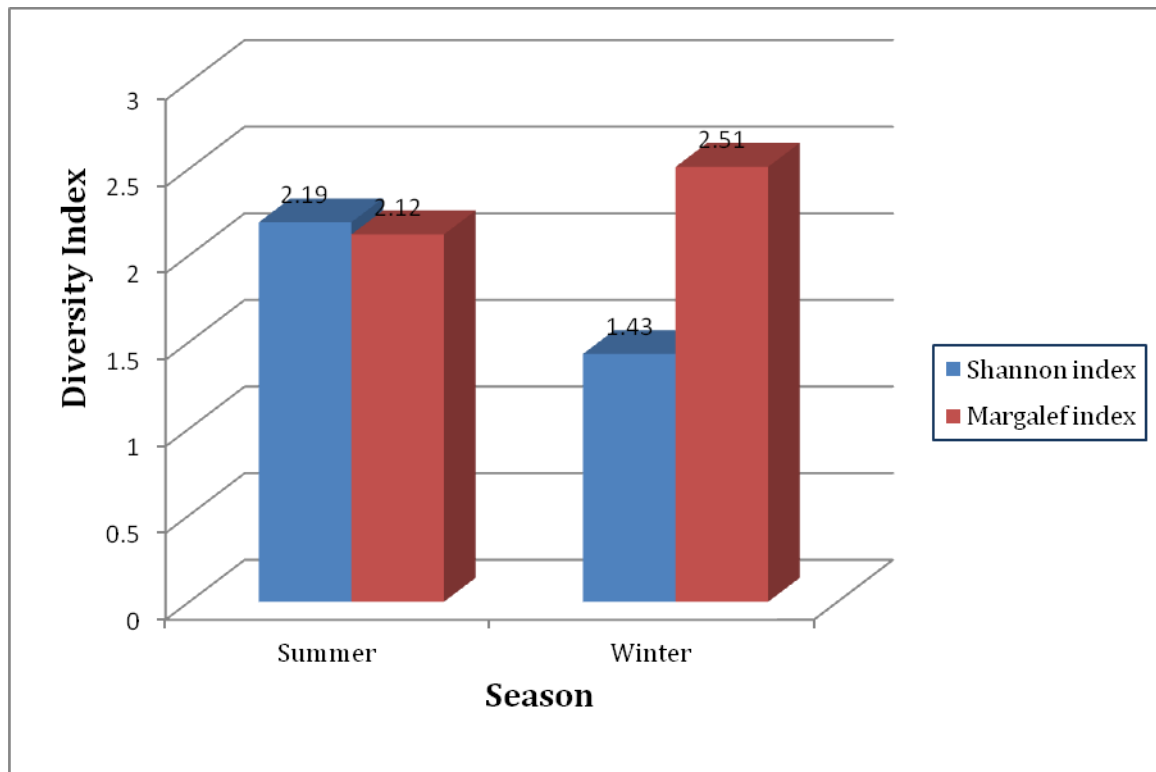


Figure 7 – Shannon and Margalef indexes for summer and winter at Khyberani Forest



3.3.4 Discussion

The same number of species of reptiles and amphibians were recorded in summer and winter at Khyberani. However, the population was observed to be less in winter. The reptiles and amphibians usually hibernate in winter so it is not an unusual phenomenon.

3.3.5 Threats and recommendations

3.3.5.1 Threats

- The forest is under extreme stress of livestock grazing and wood cutting from the local communities, thus destroying the habitat for the associated herpeto-fauna;
- There is an un-checked and un-controlled cutting of trees by local communities for fuel wood and other purposes. It thus deprives the reptiles of their habitat, which is already decreasing in the area;
- The meager wildlife and forest department staff is technically not sound and poorly equipped;
- The locals are afraid of lizards and snakes and kill every individual they encounter.

3.3.5.2 Recommendations

- The local communities and the wildlife staff should be educated about the importance of amphibian and reptilian fauna in the forest ecosystem through trainings, workshops, pamphlets and brochures;
- The cutting down of wood from the forest and lease of forest land and its conversion into agricultural land should be immediately prevented.
- The plantation of the actual non-invasive flora in the degraded areas of the forest should be initiated.
- There should be a complete ban on the collection of reptiles for un-scientific purposes including trade;
- A comprehensive and regular survey of reptiles in the area may be undertaken at regular intervals for two years in order to ascertain the status of reptiles in the area;
- Establishment of small research grants to the young researchers and university students for different herpetological surveys of economically important species of this area;
- To protect and conserve the vital species of amphibians and reptiles, there should always be the signboards on the road, depicting the importance of nearby heavily populated amphibian or reptile species and the speed of vehicles must remain within limits accordingly.

3.4 Birds

3.4.1 Sampling locations

The Map given below shows the observation points of bird surveys at Khyberani Forest over summer and winter.

Map 6 – Sampling sites of birds at Khyberani Forest

3.4.2 Species account

3.4.2.1 Winter and Summer

Table 7 shows the birds species observed at Khyberani during winter and summer.

Table 7 – List of bird species recorded from Khyberani Forest during winter

	English name	Scientific name	Status	Occurrence	Count	
					Winter	Summer
Order Ciconiiformes						
Family Ardeidae						
1	Cattle Egret	<i>Bubulcus ibis</i>	Common	Resident	22	50
2	Intermediate Egret	<i>Egretta intermedia</i>	Scarce	Resident	5	-
3	Little Egret	<i>Egretta garzetta</i>	Scarce	Resident	10	2
4	Indian Pond Heron	<i>Ardeola grayii</i>	Common	Resident	8	14
Order Falconiformes						
Family Accipitridae						
5	Common Kite	<i>Milvus migrans</i>	Common	Resident	52	36
6	Northern Goshawk	<i>Accipiter gentiles</i>	Rare	Winter visitor	2	-
7	Shikra	<i>Accipiter badius</i>	Rare	Resident	4	2
8	Eurasian Sparrow Hawk	<i>Accipiter nisus</i>	Rare	Winter visitor	2	-
9	Long legged Buzzard	<i>Buteo rufinus</i>	Rare	Winter visitor	3	-
10	Oriental Honey Buzzard	<i>Pernis ptilorhynchus</i>	Rare	Winter visitor	4	-
Family Falconidae						
11	Merlin	<i>Falco columbarius</i>	Rare	Winter visitor	2	-
12	Common Kestrel	<i>Falco tinnunculus</i>	Scarce	Winter visitor	8	-
Order Galliformes						
Family Phasianidae						
13	Grey Partridge	<i>Francolinus pondicerianus</i>	Common	Resident	30	8
14	Black Partridge	<i>Francolinus francolinus</i>	Scarce	Resident	10	-
Order Charadriiformes						
Family Recurvirostridae						
15	Black-winged Stilt	<i>Himantopus himantopus</i>	Common	Resident	31	5
Family Charadriidae Common						
16	Red wattled Lapwing	<i>Vanellus indicus</i>	Common	Resident	-	55

Family Laridae						
17	River Tern	<i>Sterna aurantia</i>	Scarce	Resident	11	4
Order Columbiformes						
Family Columbidae						
18	Blue Rock Pigeon	<i>Columba livia</i>	Common	Resident	14	35
19	Little Brown Dove	<i>Streptopelia senegalensis</i>	Common	Resident	175	90
20	Ring Dove	<i>Streptopelia decaocto</i>	Common	Resident	255	102
Order Cuculiformes						
Family Cuculidae						
21	Crow Pheasant	<i>Centropus sinensis</i>	Scarce	Resident	10	11
Order Strigiformes						
Family Strigidae						
22	Spotted Owlet	<i>Athene brama</i>	Rare	Resident	-	2
Order Caprimulgiformes						
Family Caprimulgidae						
23	Sykes's/Sind Night jar	<i>Caprimulgus</i>	Rare	Resident	-	2
Order Piciformes						
Family Picidae						
24	Lesser Golden backed Wood pecker	<i>Dinopium benghalensis</i>	Rare	Resident	-	4
Order Coraciiformes						
Family Alcedinidae						
25	Common Kingfisher	<i>Ceryle rudis</i>	Rare	Resident	2	-
26	Whitebreasted Kingfisher	<i>Halcyon smyrnensis</i>	Scarce	Resident	6	5
Family Meropidae						
27	Green Bee eater	<i>Merops orientalis</i>	Common	Resident	20	125
Family Family Coraciidae						
28	Indian Roller	<i>Coracias bengalensis</i>	Common	Resident	4	33
Family Upupidae						
29	Hoopoe	<i>Upupa epops</i>	Rare	Winter visitor	3	-
Order Passeriformes						
Family Alaudidae						
30	Crested Lark	<i>Galerida cristata</i>	Common	Resident	68	10
Family Hirundinidae						

31	Pale Martin	<i>Riparia diluta</i>	Scarce	Winter visitor	10	-
32	Common Swallow	<i>Hirundo rustica</i>	Scarce	Winter visitor	13	-
Family Laniidae						
33	Rufous tailed or Isabelline Shrike	<i>Lanius isabellinus</i>	Rare	Winter visitor	4	-
Family Dicruridae						
34	Black Drongo	<i>Dicrurus adsimilis</i>	Common	Resident	18	35
Family Sturnidae Common						
35	Bank Myna	<i>Acridotheres gingianus</i>	Common	Resident	46	130
36	Indian Myna	<i>Acridotheres tristis</i>	Common	Resident	15	36
Family Corvidae						
37	House crow	<i>Corvus splendens</i>	Common	Resident	75	134
38	Tree Pie	<i>Dendrocitta vagabunda</i>	Common	Resident	9	20
Family Pycnonotidae						
39	White-cheeked Bulbul	<i>Pycnonotus leucogenys</i>	Common	Resident	62	45
40	Red-vented Bulbul	<i>Pycnonotus cafer</i>	Scarce	Resident	12	9
Family Timaliidae						
41	Common Babbler	<i>Turdoides caudatus</i>	Common	Resident	76	12
42	Jungle Babbler	<i>Turdoides striatus</i>	Common	Resident	340	56
Family Rhipiduridae						
43	White-browed Fantail	<i>Rhipidura aureola</i>	Rare	Resident	2	-
Family Sylviidae						
44	Clamorous Reed Warbler	<i>Acrocephalus stenoreus</i>	Rare	Winter visitor	3	-
45	Yellow bellied Prinia	<i>Prinia flaviventris</i>	Rare	Resident	4	-
46	Rufous vented Prinia	<i>Prinia burnesii</i>	Rare	Resident	2	-
47	Tailor Bird	<i>Orthotomus suturius</i>	Rare	Resident	4	5
48	Lesser White throat	<i>Sylvia curruca</i>	Common	Winter visitor	34	-

49	Common Chiffchaff	<i>Phylloscopus collybita</i>	Common	Winter visitor	28	-
Family Turdidae						
50	Blue throat	<i>Luscinia svecicus</i>	Scarce	Winter visitor	8	-
51	Black Redstart	<i>Phoenicurus ochruros</i>	Scarce	Winter visitor	12	-
52	Pied Bushchat	<i>Saxicola caprata</i>	Common	Resident	37	17
53	Isabelline Wheatear	<i>Oenanthe isabellinus</i>	Scarce	Winter visitor	5	-
54	Indian Robin	<i>Saxicoloides fulicata</i>	Common	Resident	36	12
Family Motacillidae						
55	Paddyfield Pipit	<i>Anthus rufulus</i>	Rare	Resident	4	3
56	Longbilled Pipit	<i>Anthus similis</i>	Rare	Resident	2	-
57	Yellow wagtail	<i>Motacilla flava</i>	Common	Passage Migrant	40	-
58	White Wagtail	<i>Motacilla alba</i>	Common	Winter visitor	50	-
Family Nectariniidae						
59	Purple Sunbird	<i>Nectarinia asiatica</i>	Scarce	Resident	12	3
Family Passeridae						
60	House Sparrow	<i>Passer domesticus</i>	Common	Resident	100	22
61	Sind Sparrow	<i>Passer pyrrhonotus</i>	Common	Resident	130	60
TOTAL					1956	1194

3.4.3 Summer and winter

A total of 61 species of birds belonging to 11 orders and 30 families were recorded. Among them, 57 species belonged to 8 orders and 26 families were recorded in winter whereas in summer 36 species of birds belonging to 11 orders and 25 families were recorded. The total number of birds counted in winter was 1956 and in summer it was 1194. The results show that the number of species found in the winter was greater than the amount in summer. The major reason for recording more species in winter and counting more birds could be the presence of migratory birds in the winter.

Among the total species of birds recorded, 43 were resident, 17 winter visitors and one passage migrant. The status of birds found in the area was derived on the basis of their occurrence in this area denotes <5 as rare, 6 to 15 as scarce and >15 as common. On the basis of the developed criteria, 29 species were common, 19 rare and 14 scarce.

The winter migrants start arriving in the area in late August and depart by April. As regards the breeding of birds in the area in summer, it requires further investigation and could not be observed in the brief survey.

Some less known species of birds were recorded from the area such as oriental honey buzzard, now very rare, northern goshawk, uncommon, eurasian sparrowhawk and long-billed pipit. Although all these birds are categorized as 'Least Concern' according to IUCN Red data list 2011, their population is declining within the country.

Figure 8 – Number of species, families and orders observed during winter and summer season

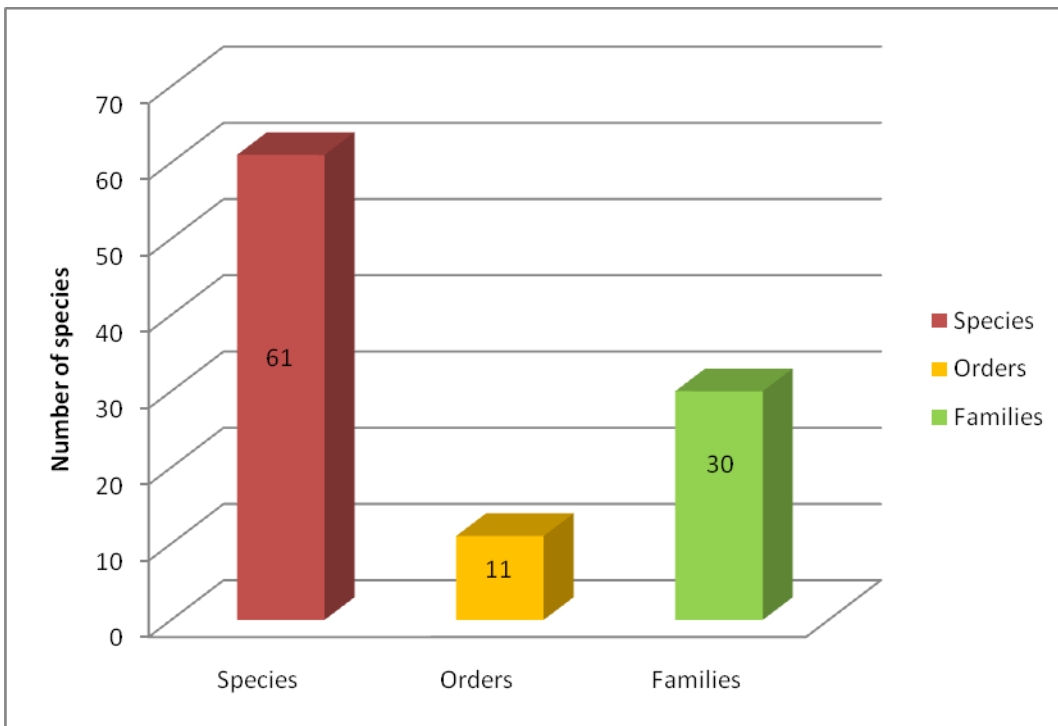


Figure 9 – Number of species during summer and winter seasons

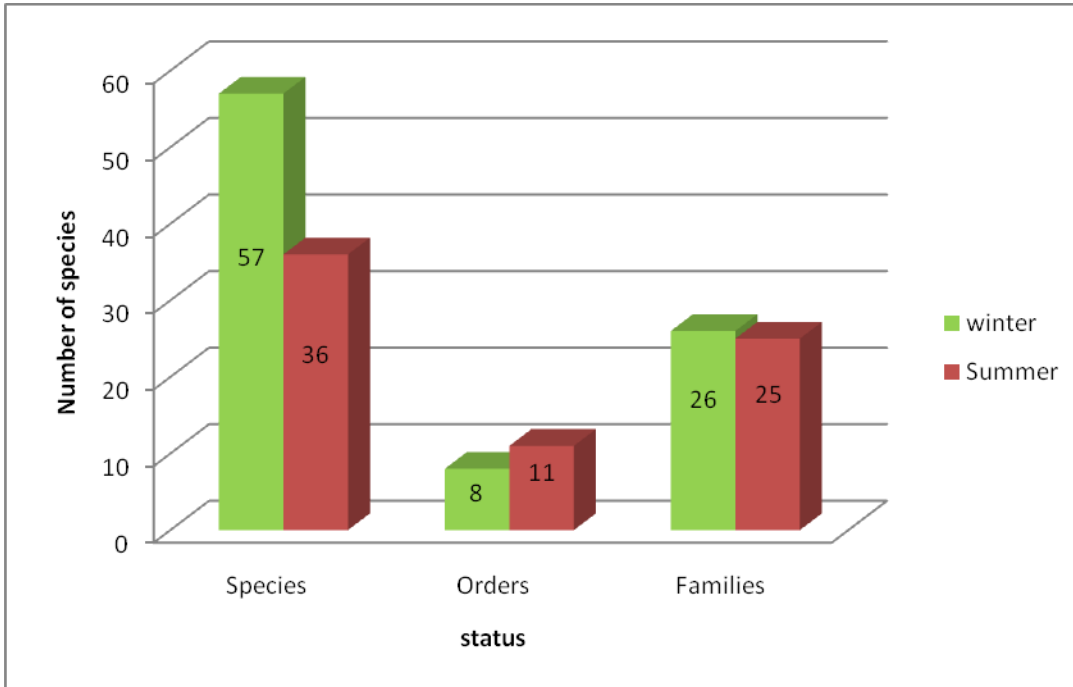


Figure 10 – Number of birds recorded during summer and winter

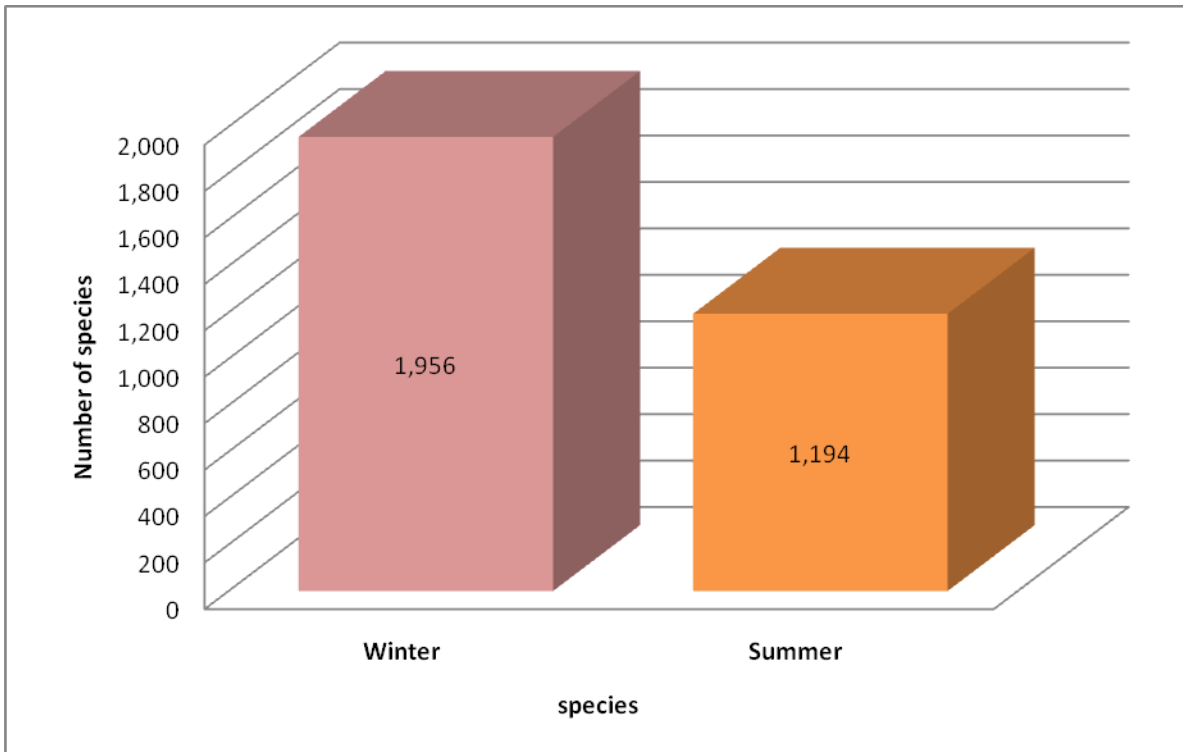
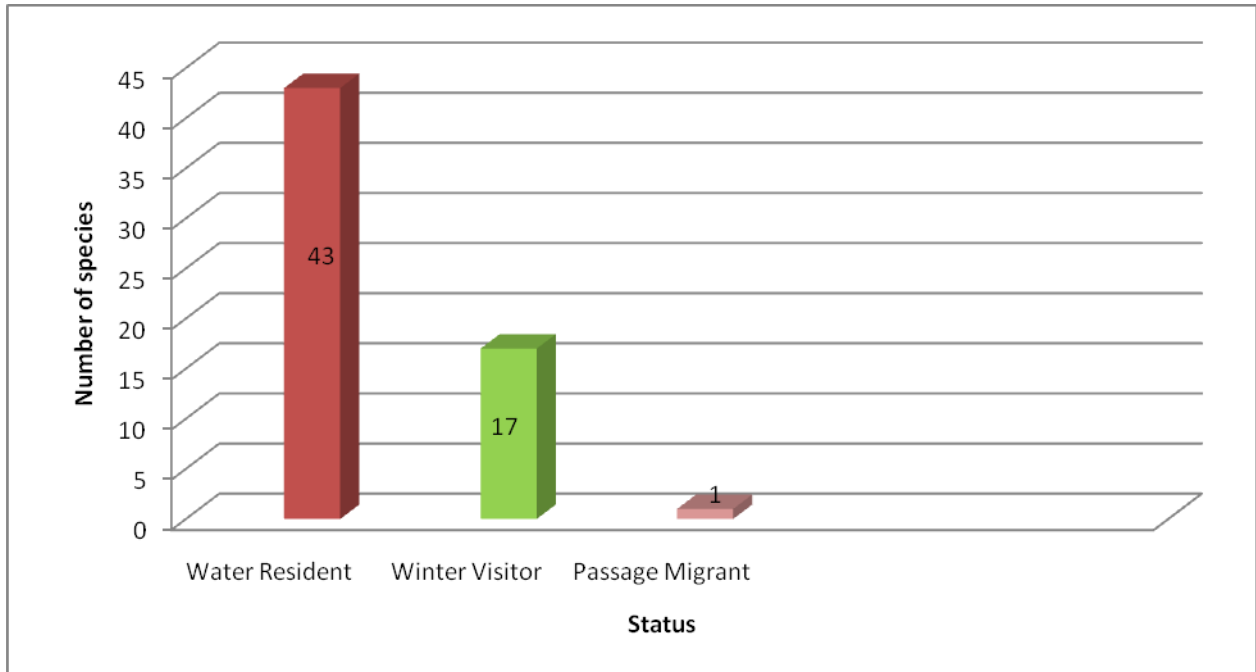


Figure 11 – Number of bird species recorded from Khyberani Forest by seasons and occurrence



3.4.4 Threats and recommendations

3.4.1 Threats

- Hunting and poaching of birds is a major threat in the area. The disturbance by humans is also a threat.
- Removal of habitat, especially undergrowth in and around the forest is resulting in the poor reproductive success. The variety of grasses and herbaceous plants are important for terrestrial birds;
- Though there is no direct evidence, the relatively intensive agriculture and use of agro-chemicals may be affecting the ability of bird species to survive in the area;
- Cutting of mature trees is harmful to certain species of birds that rely on these for feeding and breeding.

3.4.2 Recommendations

- Efforts should be made to manage and control the hunting and poaching. Demonstration in other parts of the country have shown that community managed game reserves are instrumental in managing wildlife populations. Such model could be experimented on the periphery of the forest;
- There is also a need to develop a conservation plan that will encompass interventions for the bird species found in and around the forest. This should include zoning of the forest so that disturbance is reduced to a minimum;

- An environmental awareness outreach programme needs to be initiated, targeting local community at various levels. This outreach programme should include topics such as the importance of birds as pest controllers and seed dispersers;
- Some initiative should be taken to reduce dependency of local community on the forest particularly in terms of fuel-wood and fodder. Alternatives to fuel-wood and fodder should be provided to the local inhabitants.

CHAPTER 4: COMPARISON OF THE FOUR STUDY SITES

Mammals

Summary:

There are no significant difference in results of the summer and winter surveys of the study areas. The same 13 species were recorded from the study areas during both the winter and summer surveys. Moreover, most of the mammals particularly the nocturnal mammals were found more active during the summer surveys and the less active comparatively during the winter surveys. The reasons seem to be the homoeothermic and the hibernation factors for less activeness of mammals during winter.

The population estimation of animals was not attempted during this preliminary study. Estimating population of mammals required large efforts and maximum time which was inadequate.

Habitat loss and natural disasters affect wildlife species but the mammalian fauna of the area is facing serious threats from anthropogenic activities. The apparent low abundance of many large mammalian species is strong evidence that hunting and habitat degradation is having a considerable effect on their population.

A few wildlife species also create problems for the local people and thus are considered as problem species. The major concerns about wild animals in different sites are the damages to crops through agricultural pests like wild boar and porcupine and threats to human lives from mad / feral dogs and snake bites.

Some socio-economic issues like un-employment, less education, lack of awareness, less availability of basic needs etc. At different sites are also important factors in wildlife conservation and management in the study area.

Species identified

During surveys a total of 13 large and medium sized mammal species belonging to three orders (Carnivora, Artiodactyla, and Pholidata) were recorded from the four sites. Ten species were recorded from Nara Wetland Complex, five from Manchhar, ten species from Kharochann and seven from Khyberani Forest.

Table 8- Species recorded from different sites

S.No	Common Name	Zoological Name	Local Name	Order
1	Asiatic Jackal	<i>Canis aureus</i>	Giddar	Carnivora
2	Jungle Cat	<i>Felis chaus</i>	Jang Billo	Carnivora
3	Fishing Cat	<i>Prionailurus viverrinus</i>	Mash Billo	Carnivora

4	Indian Desert Cat	<i>Felis sylvestris ormata</i>	Sahrai Billi	Carnivora
5	Bengal Fox	<i>Vulpes bengalensis</i>	Lumar	Carnivora
6	Desert Fox or Red Fox	<i>Vulpes vulpes pusilla</i>	Sahrai Lumar	Carnivora
7	Smooth coated Otter	<i>Lutrogale perspicillata</i>	Lunher	Carnivora
8	Small Indian Mongoose	<i>Herpestes javanicus</i>	Neola	Carnivora
9	Grey Mongoose	<i>Herpestes edwardsi</i>	Neola	Carnivora
10	Small Indian Civet	<i>Viverricula indica</i>	Kasturi Billa	Carnivora
11	Hog Deer	<i>Axis porcinus</i>	Para	Artiodactyla
12	Indian Wild boar	<i>Sus scrofa</i>	Suar	Artiodactyla
13	Indian Pangolin	<i>Manis crassicaudata</i>	Bagra, Silu	Pholidota

Observation records:

Out of the total 13 recorded species, 6 species were observed directly while the remaining 7 species were recorded on the basis of indirect evidences such as the presence of fecal materials, foot prints and interviews of local residents and wildlife watchers. The observation records of different mammals found in all the five sites are given in the Table 9

Table 9 Observation record of large mammals

S. No.	Species	Direct Observations				Indirect observations through tracks, feces and interviews from local people			
		NWC	ML	KC	KF	NWC	ML	KC	KF
	Asiatic Jackal	✓	✓	✓	✓	✓	✓	✓	✓
	Jungle Cat	✓	✓	✓	✓	✓	✓	✓	✓
	Fishing Cat					✓		✓	
	Desert Cat					✓		✓	
	Bengal fox					✓		✓	✓
	Red fox	✓	✓			✓	✓		
	Smooth coated otter					✓			
	Small Indian Mongoose	✓	✓	✓	✓	✓	✓	✓	✓
	Grey Mongoose	✓	✓	✓	✓	✓	✓	✓	✓
	Small Indian Civet							✓	
	Indian Wild boar	✓		✓	✓	✓		✓	✓
	Hog Deer					✓			✓
	Indian Pangolin							✓	

Legend: NWC = Nara Wetland Complex, ML = Manchar Lake, KC = Kharochann, KF = Khyberani Forest

Conservation status of mammal species

According to IUCN International Red List 2011, Asiatic Jackal, Jungle Cat, Desert Cat, Bengal Fox, Red Fox, Grey Mongoose, Small Indian Civet, Indian Wild Boar are categorized as Least Concern (LC), Fishing Cat, Smooth Coated Otter, Small Indian Mongoose as Vulnerable (VU), Hog Deer as Endangered (EN) and Indian Pangolin as Near Threatened (NT).

Seven species are protected in Sindh under Sindh Wildlife Protection Ordinance 1972. Six species are enlisted in Appendix II while three species in Appendix I of the CITES category 2011. The conservation status of different mammals found at Indus for All Programme sites is given in Table 10 below.

Table 10 Conservation status of mammals found at sites

S.NO	Mammalian Species Recorded	IUCN Red List 2011	Sindh Wildlife Protection Ordinance 1972	CITES Category 2011
1	Asiatic Jackal	LC	-	-
2	Jungle Cat	LC	P	Appendix II
3	Fishing Cat	VU	P	Appendix II
4	Desert Cat	LC	P	Appendix II
5	Bengal Fox	LC	-	Appendix I
6	Red Fox	LC	-	
7	Smooth coated Otter	VU	P	Appendix II
8	Small Indian Mongoose	VU	-	Appendix II
9	Grey Mongoose	LC	-	
10	Small Indian Civet	LC	P	Appendix I
11	Indian Wild Boar	LC	-	
12	Hog Deer	EN	P	Appendix I
13	Indian Pangolin	NT	P	Appendix II
Legends: EN= Endangered, VU= Vulnerable, NT= Near Threatened, LC= Least Concern				

Species Diversity

Looking at the diversity index over the four sites Nara Wetland Complex and Kharochann holds the highest level of diversity of mammals followed by Khebrani Forest. Given the variety of habits at Nara Wetland Complex (desert, wetland and forest) it is not surprising that this site holds the highest index. Similarly Kharochann comprises of both terrestrial and marine habitats which results in a high diversity index despite apparent environment degradation both inland and in the creeks. Even with some variance in diversity the evenness of diversity across the sites is quite regular, except for Nara Complex. These indexes do not take into account the diversity across seasons, something that is discussed further on in this chapter.

Comparison of Species observed during summer and winter

Number of animals recorded during summer and winter surveys are merely rough estimates and not the actual populations (Shown in Table 11 - 14). The last column in the following tables showing total animals is not reflecting the total population of different species at different sites. Rather it is just the sum of observed animals observed during summer might be the same counted or observed during winter.

Table 11 Mammals observed at Nara Wetlands Complex during summer and winter Surveys

S.NO	Common Name	Winter	Summer	Total Animals
1	Asiatic Jackal	4	1	5
2	Jungle Cat	1	-	1
3	Red Fox	1	-	1
4	Small Indian Mongoose	5	5	10
5	Grey Mongoose	3	1	4
6	Indian Wild Boar	4	-	4

Table 12 Mammals observed at Khyberani Forest during summer and winter surveys

S.NO	Common Name	Winter	Summer	Total Animals
1	Asiatic Jackal	5	2	7
2	Jungle Cat	1	-	1
3	Small Indian Mongoose	2	2	4
4	Grey Mongoose	1	-	1
5	Indian Wild Boar	3	-	3

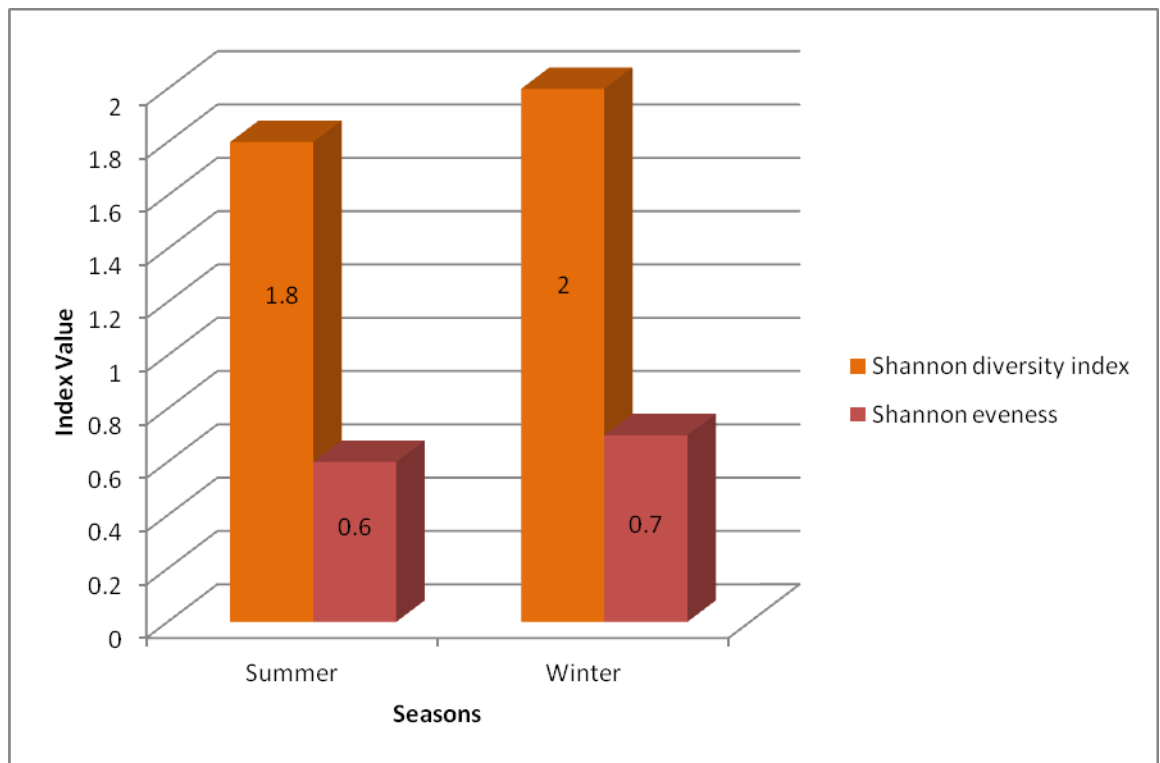
Table 13 Mammals observed at Manchhar Lake during summer and winter surveys

S.NO	Common Name	Winter	Summer	Total Animals
1	Asiatic Jackal	2	-	2
2	Jungle Cat	1	-	1
3	Small Indian Mongoose	1	1	2
4	Grey Mongoose	1	-	1

Table 14 Mammals observed from Kharochann during summer and winter surveys

S.NO	Common Name	Winter	Summer	Total Animals
1	Asiatic Jackal	3	-	3
2	Jungle Cat	1	-	1
3	Small Indian Mongoose	3	2	5
4	Grey Mongoose	1	-	1
5	Indian Wild Boar	4	-	4
6.	Indian Pangolin	1	-	1

Figure 12- Shannon diversity and Evenness index over all sites for summer and winter



There was more diversity of medium and large mammals in winter than summer across the four sites. There may be several reasons for this such as mammals were more active in winter foraging for food or were more detectable due to less vegetation on the ground.

Population Estimation

Populations of large mammals were not estimated as sufficient data in this respect could not be collected.

Assessment of level of threats to mammals at different study sites

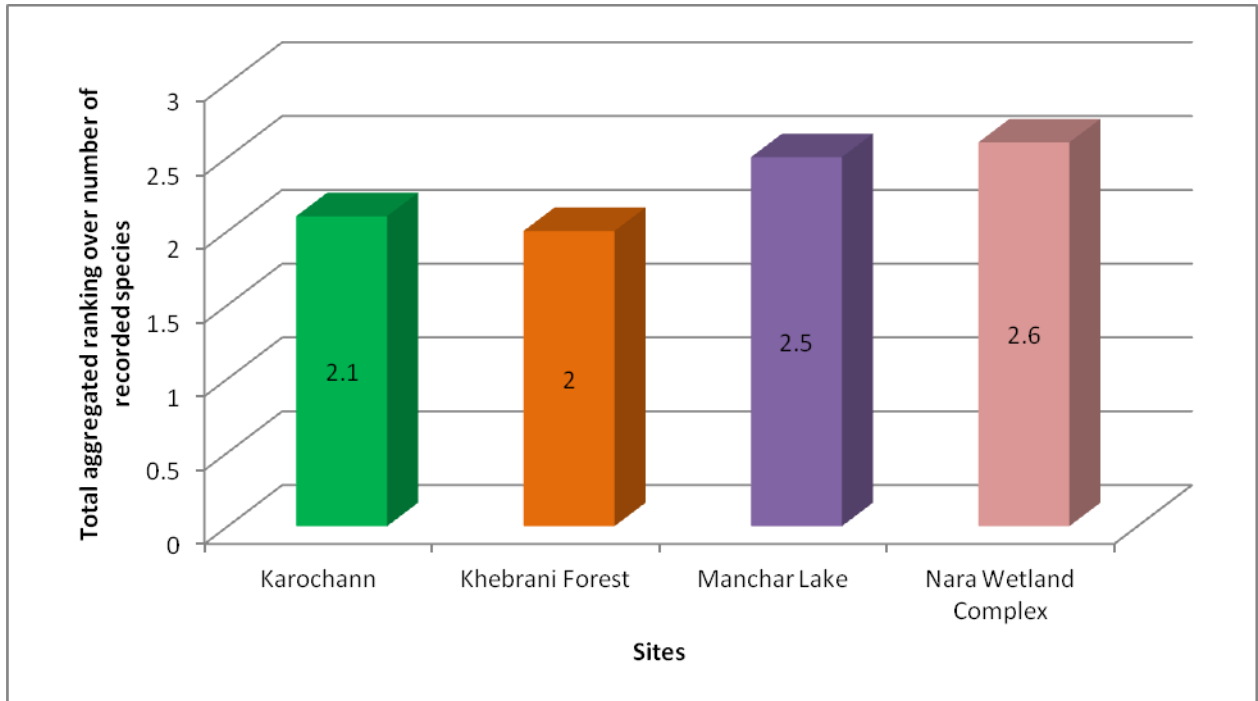
Various threats to different mammals were identified at four different study sites that include; habitat destruction, illegal hunting, poaching, live trapping, food competition, lack of awareness, law and order situation, weak enforcement of wildlife laws etc. Based on indirect and direct observations in the field and after interviewing different people from local communities and wildlife watchers and forest guards an assessment was made to indicate the level of threats to every mammal species in four sites.

1= no threats, 2= minor threats, 3= moderate threats, 4= highly threatened, 5= critically threatened

Table 15 Assessment of level of threats to mammals at different study sites

S.No	Common Name	Kharochann	Khyberani Forest	Manchhar Lake	Nara Wetland Complex
1	Asiatic Jackal	2	2	2	2
2	Jungle Cat	2	2	3	3
3	Fishing Cat	3	-	-	3
4	Indian Desert Cat	3	-	-	3
5	Bengal Fox	3	2	2	-
6	Desert Fox or Red Fox	3	-	2	3
7	Smooth coated otter	-	-	-	5
8	Small Indian Mongoose	1	1	1	1
9	Grey Mongoose	1	1	1	1
10	Small Indian Civet	3	-	-	-
11	Hog Deer	-	5	-	4
12	Indian Wild Boar	1	1	-	1
13	Indian Pangolin	3	-	-	-

Figure 13 Aggregated threat ranking adjusted against number of species recorded from each site



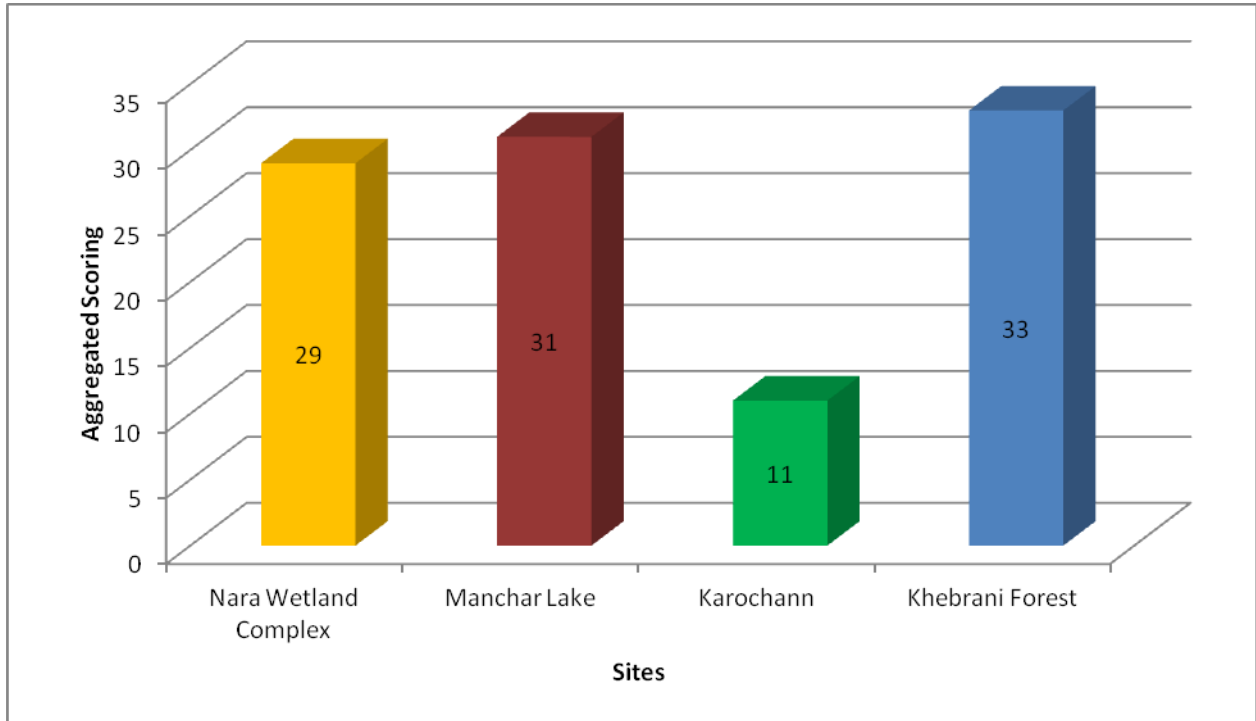
Khyberani Forest and Manchar Lake had the highest averaged disturbance factor against the species that were recorded there. Though this is an arbitrary scoring it does give an indication over the overall threat to large mammals at each site. Figure 22 gives the aggregated score for all sites.

Table 16 Threats Ranking for Large Mammals at Sites

S.No	Nature of Threats	Nara Wetland Complex	Manchar Lake	Kharochann	Khyberani Forest
1	Habitat removal/ degradation	3	4	1	4
2	Wood cutting	2	1	2	5
3	Hunting Pressure	5	4	1	5
4	Poaching/ Live trapping	3	3	1	3
5	Food Competition with livestock	2	2	-	2
6	Use of fire alarms	4	4	-	5
7	Pollution	2	5	3	1
8	Weak enforcement of wildlife laws	5	5	2	5
9	Law and order situation	1	1	-	3
10	Natural threats	2	2	1	-

Total Score	29	31	11	33
1 = low, 2 = medium, 3 = average, 4 = significant, 5 = high				

Figure 14 Aggregated score for distribution factors across sites



4.2 Small mammals

4.2.1 Species recorded

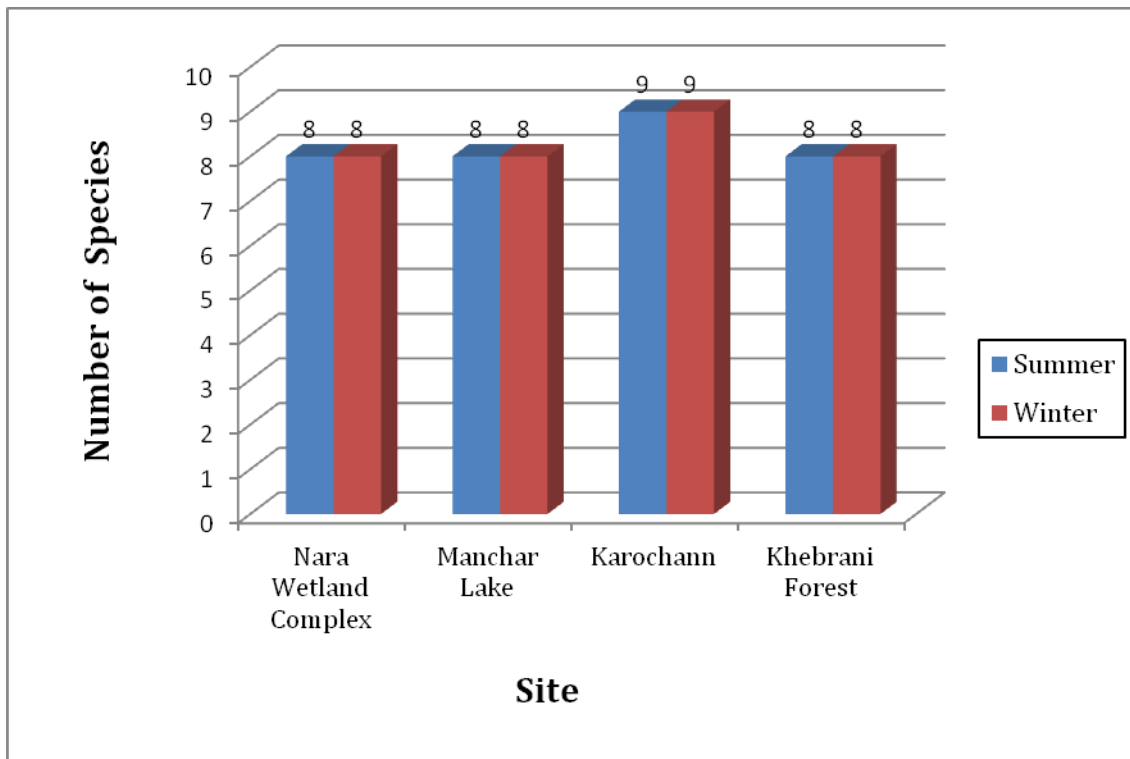
A total of 11 small mammal species were observed from the four sites, 8 from Nara Wetland Complex, 8 from Manchar Lake, 9 from Kharochann and 8 from Khyberani Forest. Most of small mammals are widespread and have been recorded from all of the four sites. The widespread small mammals were Palm Squirrel, Common House Mouse, Indian Gerbil, Indian Desert Gerbil, Indian crested Porcupine and Desert Hare. The species which is restricted to only one site were Mole rat Kharochann and Indian hedge hog at Khyberani Forest. Table below gives an account of species found at each side.

Table 17 LIST OF SMALL MAMMAL SPECIES RECORDED FROM EACH SITE

	Common Name	Nara Wetland Complex		Manchar Lake		Kharochann		Khyberani Forest	
		W	S	W	S	W	S	W	S
1	Palm Squirrel	+	+	+	+	+	+	+	+
2	Common Rat					+	+	+	+
3	Common House Mouse	+	+	+	+	+	+	+	+
4	Indian Mole Rat					+	+		
5	Indian Gerbil	+	+	+	+	+	+	+	+
6	Indian Desert Jird	+	+	+	+	+	+	+	+
7	Balochistan Gerbil	+	+	+	+	+	+		
8	Indian crested Porcupine	+	+	+	+	+	+	+	+
9	Desert hare	+	+	+	+	+	+	+	+
10	Indian hedgehog							+	+
11	Long eared Hedge hog	+	+	+	+				

Figure 15 below shows the number of small mammal species recorded at each site over winter and summer.

Figure 15 – Comparison of number of small mammal species over winter and summer



4.2.2 Feeding habits

The feeding habits of small mammals varied over sites with no particular trend over sites. Figure 16 and 17 give details of the percentage of species in each site against the main feeding habits.

Figure 16 – Percentage of species recorded for each site over feeding habit

	Common Name	Karochoann			Khebrani Forest			Manchar Lake			Nara Wetland		
		W	S	%	W	S	%	W	S	%	W	S	%
1	Grainivore	7	7	77.7	4	4	57.1	5	5	62.5	5	5	62.5
2	Herbivore	2	2	22.2	2	2	28.5	2	2	25	2	2	25
3	Insectivore	-	-	0	1	1	14.3	-	-	0	-	-	0
4	Omnivore	-	-	0	-	-	0	1	1	12.5	1	1	12.5

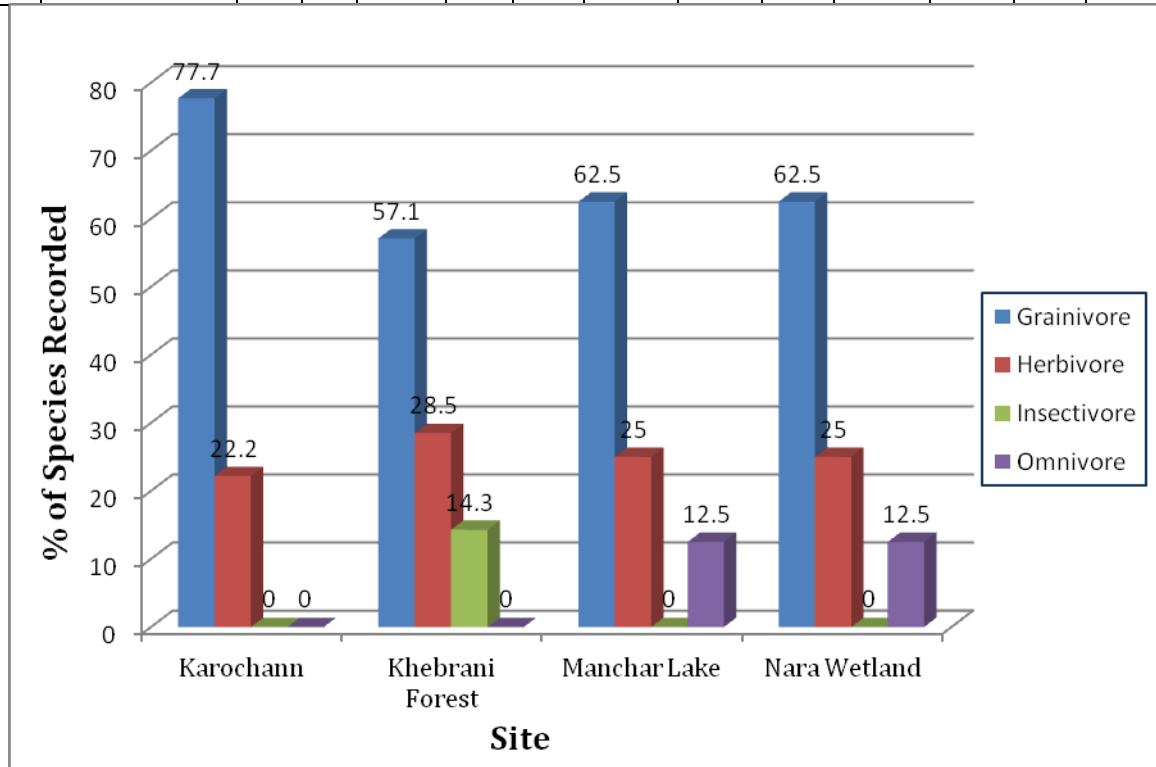
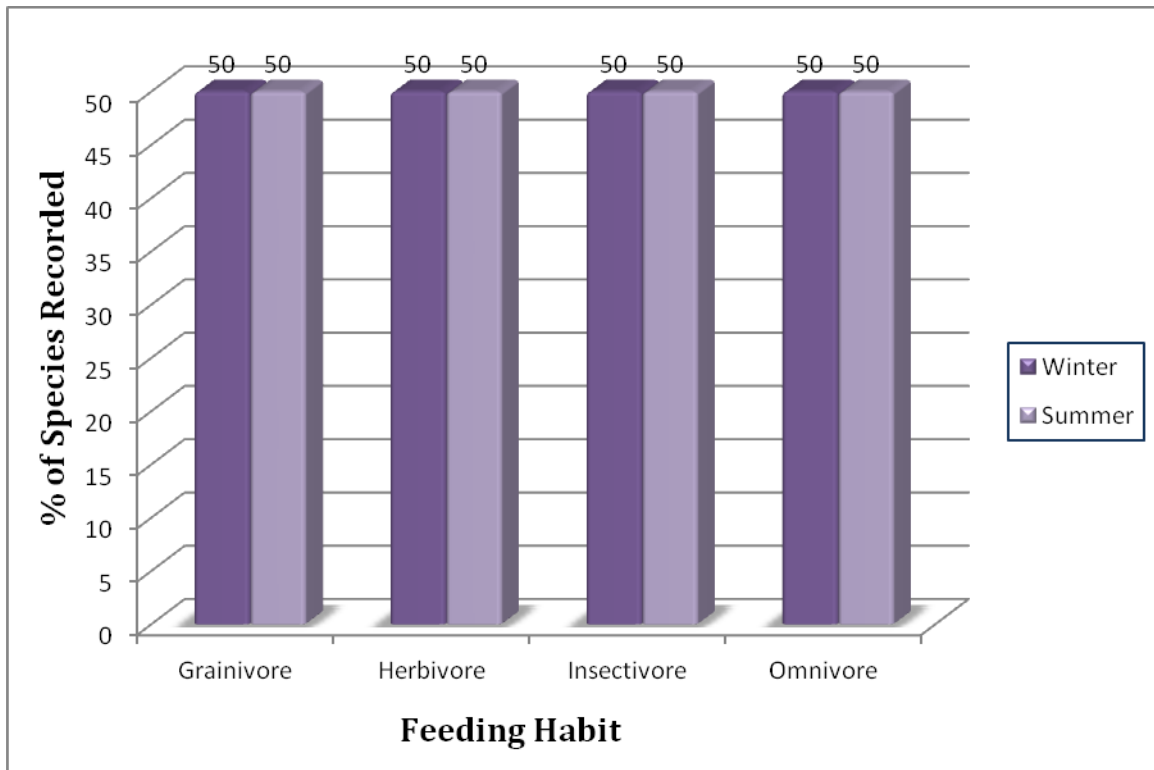


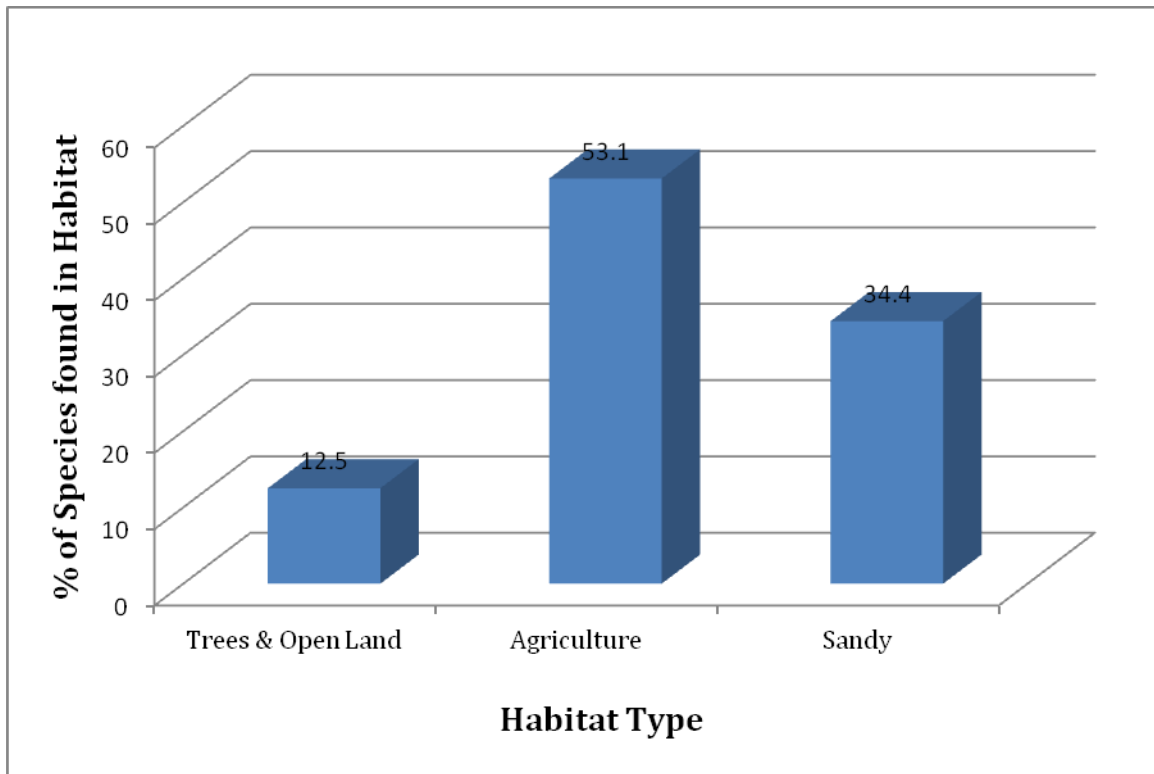
Figure 17 – Percentage of species recorded over season and against feeding habits



4.2.3 Habitat

Over the four sites agriculture habitat supported the most species with more than 63% of all records being taken from agriculture habitats followed by sandy habitat (27.3%).and open land 9%

Figure 18 – Number of species observed according to habitat



4.2.4 Status of small mammals across the survey sites

All the small mammals recorded during the survey were categorized as Common or of Least Concern. There are no rare, endangered or endemic species though many parts of the country are data deficient for several species so these categories are still quite speculative. There was no obvious trend or dominance of the two categories. Figures 19 and 20 show the results over site and season

Figure 19 – Percentage of species recorded across sites against status categories

	Common Name	Kharochann			Khyberani Forest			Manchar Lake			Nara Wetland		
		W	S	%	W	S	%	W	S	%	W	S	%
1	Common	8	8	28.5	7	7	25	7	7	25	6	6	21.5
2	Scarce	1	1	25	0	0	0	1	1	25	2	2	50
3	Rare	0	0	0	0	0	0	1	1	100	0	0	0

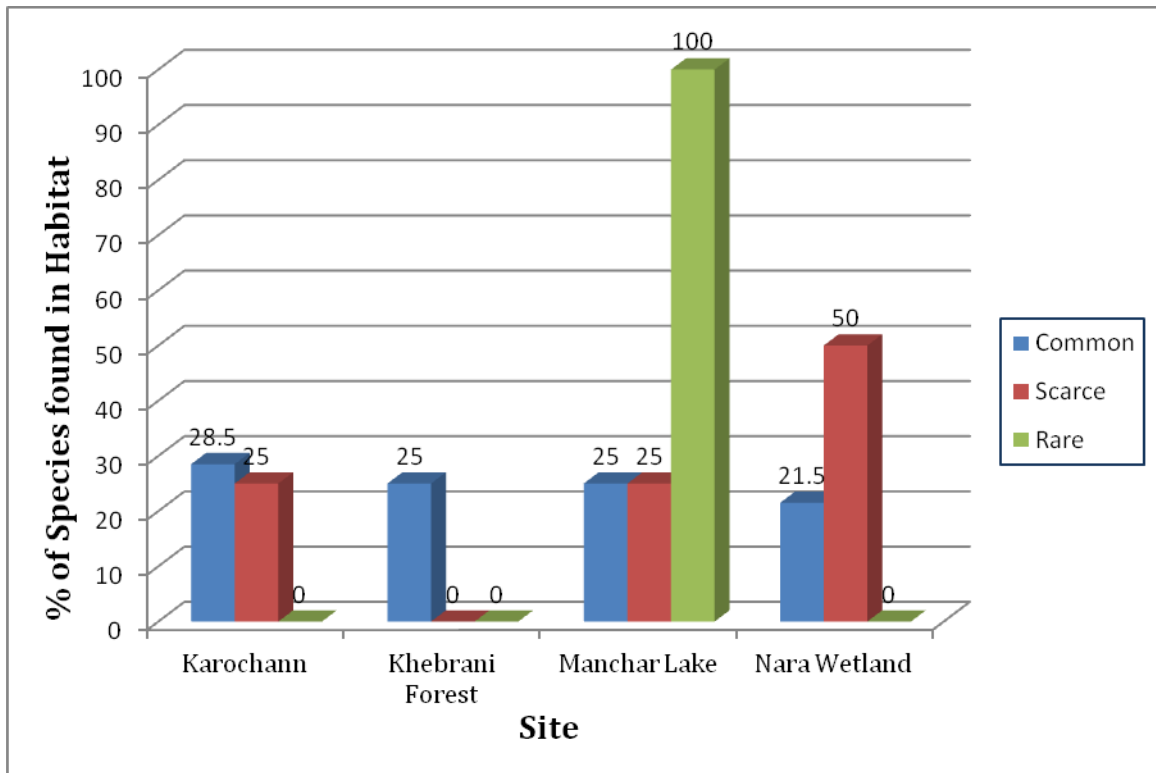
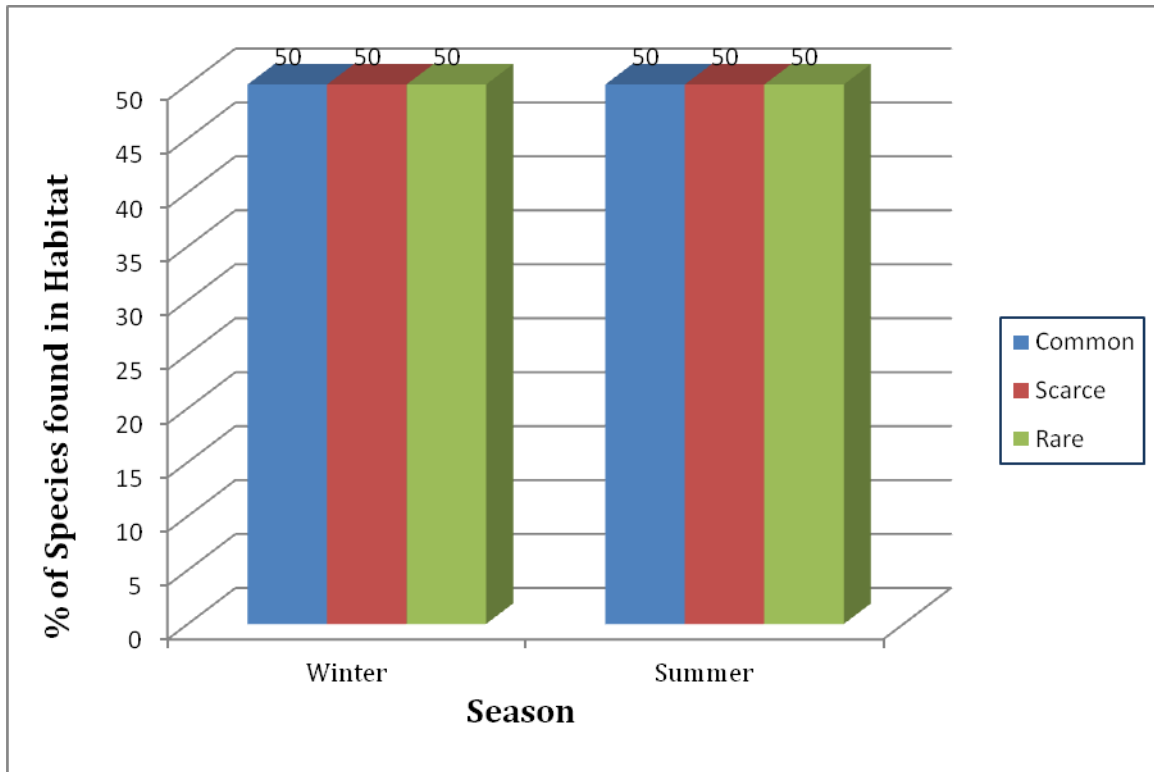


Figure 20 – Percentage of species recorded across sites against season categories



4.3 Reptiles and amphibians

4.3.1 Summary

During surveys, 38 species of reptiles and amphibians were observed. Among them, 27 species were recorded from Nara Wetland Complex, 20 from Manchar Lake, 14 from Kharochann and 11 from Khebrani forest. Even though this was a preliminary and brief survey, there is a possibility that more species might be observed during a future detailed ecological survey.

The detailed biological assessment with regard to the reptiles and amphibians were made on four sites *viz.* Chotiari Reservoir, Kinjhar Lake, Pai Forest and Keti Bunder by the Indus for All Programme in 2007 - 2008. Then, during the study 27 species of amphibians and reptiles were recorded from Keti Bunder, 23 species from Kinjhar, 31 from Chotiari Reservoir and 18 species from Pai Forest.

Being excellent biological indicators, the amphibians and reptiles respond quickly to weather or climate changes and take refuge into burrows in case of danger and unfavourable conditions. The amphibians and reptiles are mostly nocturnal species and therefore survey during night is more appropriate for study of reptiles. However due to some constraints, night survey could not be undertaken at few sites. Amphibian and reptilian activity is also restricted to specific time of the day and specific season of the

year. When proper time and habitat for survey is not considered then there is possibility of sighting of species become minimal.

There is always a need of consistent monitoring of amphibian and reptilian species during their activity period, over the months for several years to comprehensively record the potential herpeto-fauna. This was indeed the limiting factor in such short duration surveys. All these factors indicate the practical difficulties in the documentation of these species. There is a great need to carry out more work in order to add to the existing lists. The future studies need more time to effectively prepare herpeto-faunal inventory of the area.

4.3.2 Species recorded

A total of 37 species of reptiles and amphibians were recorded from the four sites during present study. Among them, 27 species of Amphibians and reptiles were recorded from Nara Wetland Complex, 20 species from Manchar Lake, 14 species from Kharo chann and 11 species from Khebrani Forest. There was no difference in number of species in winter and summer surveys, except one additional species from Manchar was recorded in summer.

Indian Garden Lizard, Bengal Monitor, Indian Cobra, Saw scaled Viper and Skittering Frog were the only species recorded from all the four sites. Mugger Crocodile, Brown River Turtle, Spotted Pond Turtle, Glossy bellied Racer and Checkered Keelback were only recorded from Nara Wetland Complex. Similarly, Brilliant Agama, Yellow-headed Rock Agama, Red throat Agama, Punjab Snake-eyed Lacerta and Indus valley Wolf Snake were only recorded from Manchar Lake. Warty Rock Gecko and Bronze Grass Skink were only observed at Khebrani Forest. There were not any exclusive species in Kharochann.

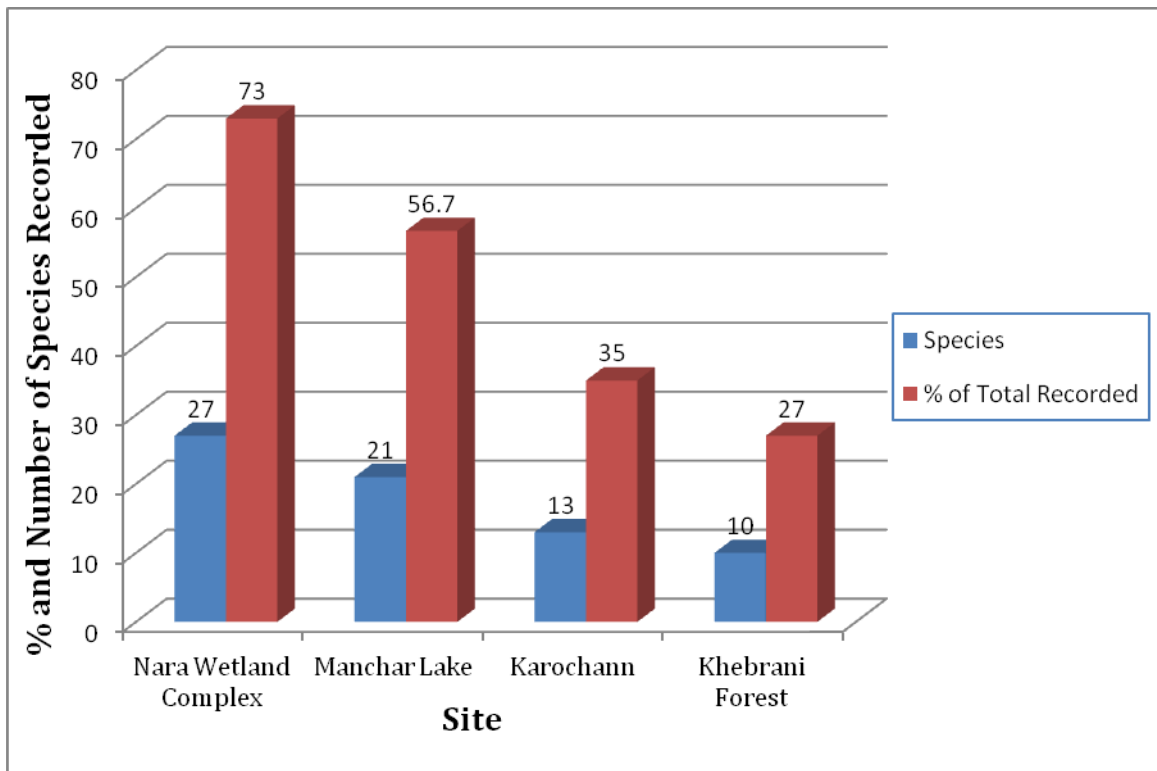
The list of species recorded from each site is given in the following Table.

Table 18 - LIST OF REPTILES AND AMPHIBIA SPECIES RECORDED FROM EACH SITE

	Common Name	Nara Wetland Complex		Manchar Lake		Kharochann		Khyberani Forest	
		W	S	W	S	W	S	W	S
1	Mugger Crocodile	+	+						
2	Saw-back Turtle	+	+			+	+		
3	Brown River Turtle	+	+						
4	Spotted Pond Turtle	+	+						
5	Indian Soft-shell Turtle	+	+						
6	Indian Flap-shell Turtle	+	+	+	+			+	+

7	Tree or Indian Garden Lizard	+	+	+	+	+	+	+	+
8	Afghan Ground Agama	+	+	+	+	+	+		
9	Brilliant Agama			+	+				
10	Yellow-headed Rock Agama			+	+				
11	Red throat Ground Agama				+				
12	Yellow-bellied House Gecko	+	+	+	+	+	+		
13	Spotted Indian House Gecko	+	+	+	+				
14	Keeled Rock Gecko	+	+	+	+				
15	Warty Rock Gecko							+	+
16	Three fingered Sand fish	+	+	+	+				
17	Indian Sand Swimmer	+	+						
18	Bengal Monitor	+	+	+	+	+	+	+	+
19	Indo-Pak Desert Monitor	+	+	+	+				
20	Bronze Grass Skink	+	+					+	+
21	Indian fringe-toed Sandy Lizard	+	+	+	+				
22	Punjab Snake-eyed Lacerta			+	+				
23	Indian Cobra	+	+	+	+	+	+	+	+
24	Saw scaled Viper	+	+	+	+	+	+	+	+
25	Indian or Common Krait					+	+		
26	Indian Sand boa	+	+	+	+				
27	Afro-Asian Sand Snake					+	+		
28	Rope Snake or Dhaman					+	+		
29	Indus valley Wolf Snake			+	+				
30	Sind Awl-headed Sand Snake	+	+						
31	Cliff Racer	+	+	+	+				
32	Glossy bellied Racer	+	+						
33	Checkered Keelback	+	+						
34	Marbled Toad	+	+	+	+			+	+
35	Bull frog	+	+			+	+	+	+
36	Skittering Frog	+	+	+	+	+	+	+	+
37	Indus valley Toad					+	+		

Figure 21 – Percentage of species and total species number recorded from each site



4.3.3 Species diversity

The following tables and figures examine the diversity of each site plus the evenness across the sites. This analysis incorporates both winter and summer season data.

The results in Table 47 show that Manchar Lake has the highest species account, followed by Nara Wetland Complex, Kharochann and Khebrani Forest. However the evenness analysis shows that Kharochann has more evenness followed by Nara Wetland Complex, Manchar Lake and Khyberani Forest.

Table 19 Species Diversity

S. No.	Type of index	Nara Wetland Complex	Manchhar Lake	Kharo chann	Khyberani Forest
1	Richness (number of species)	27	20	14	11
2	Evenness	1.29	0.92	1.41	0.75
3	Shannon Index	2.49	2.75	3.71	1.81
4	Mergalef Index	2.95	2.91	2.86	2.32

4.4 Avi-fauna

4.4.1 Summary

4.4.1.1 Nara Wetland Complex

The Nara Wetland Complex comprises of Nara Canal and a complex of about 225 small, medium and large wetlands or *dhands* on either side of the canal. These wetlands are either permanent or seasonal and are fresh water to brackish or saline. The majority of wetlands has an area of about 200 ha and is surrounded by sand dunes. Many dry out completely during winter and early spring. The area provides diverse habitat for a wide variety of birds which include lakes, marshes, desert, agriculture areas, fish ponds, wasteland and villages.

The wetlands of the Nara complex are the important wintering and staging ground of the migratory water birds that hosts a variety of rare and endangered bird fauna.

A total of 118 species of birds belonging to 13 orders and 37 families were recorded. Out of 118 species recorded, 53 are winter migrants, 59 resident, 4 passage migrants and two year round visitor birds. These include the vulnerable species, Marbled Teal (*Anas angustirostris*) and Near Threatened species of Ferruginous Duck (*Aythya nyroca*), and Indian Darter (*Anhinga rufa*). The trend of presence of rare and endangered species recognizes the ecological importance of the area.

Ghalib *et al.* (2008) recorded 78 species of birds from the wetlands of the adjoining Nara Desert Wildlife Sanctuary. These also included the threatened species *viz.* Indian white beaked vulture and Houbara Bustard. They also recorded breeding of red wattled lapwing, white tailed plover, black winged stilt and black headed myna from the area.

Bailley (2005) recorded the occurrence of large pied wagtail (*Motacilla maderaspatensis*) and rock bunting (*Emberiza cia*) from Nara area which is for the first time from Sindh province.

4.4.1.2 Manchhar Lake

It is the largest freshwater perennial lake formed in the natural depression. The lake is located in Dadu district of Sindh province. The lake is fed by two canals, the Aral Wah and the Danister from the river Indus. The lake also collects water from numerous small streams in the Kirthar Mountain.

There has been continuous environmental degradation of this wetland and water of the lake is becoming saline. The diversion of water from the Indus and run off from Kirthar mountains have contributed to the reduction in fresh water supplies. At the same time, saline drainage water from agricultural fields in the surrounding areas also flows in to the lake. Pollution through the Main Nara Valley Drain (MNVD) is the main threat to the lake. It brings agricultural, municipal, industrial and saline water which is the constant polluting sources of the lake. The lake is also facing eutrophication.

Manchhar Lake has multiple habitats, North East is plain and predominant agronomical and South west consists of hilly and range land. The lake has been an important wintering and staging ground of migratory birds and home to resident birds. As many as 45,000 birds were counted in winter of 1991 and 32,000 birds in 2000 at this lake. But due to lake degradation the population is declining gradually.

4.4.1.3 Kharochann

Kharochann is a coastal area situated at a distance of about 220 km SE of Karachi in Thatta district. The area mostly consists of mangroves, marshes, fallow land, and agricultural land, built up area, water channels, river bank, coastal area and the creek area. There are six major creeks in the area viz. Chann, Rohra, Ghora, Khichry, Mal and Wari creek.

The area is facing environmental degradation, particularly facing acute scarcity of fresh water and sea water intrusion. The intrusion is causing high salinity of the soil.

The area has great ecological significance and is the wintering ground of many species of waterbirds. Karochann is an important area for a variety of bird species. The area has significant biodiversity value, especially the wintering activities of avifauna. The migratory birds particularly the shorebirds, egrets and herons, gulls and terns, pelicans and flamingos that stopover for feeding, resting and roosting purpose. As many as 85 species of birds have been recorded from the area.

4.4.1.3 Khyberani Forest

Khebrani Forest is in Matiari District. It was a riverine forest which depended on Indus river water prior to the construction of Sukkur Barrage. It has been declared as a reserve forest by the Sindh Forest Department. The forest consists of 25 compartments and the total area of forest is about 3,000 acres.

A total of 61 species of birds belonging to 11 Orders and 30 Families were recorded. The Grey and Black Partridges are the key species of the area. Among the total recorded species 43 were resident and 18 migrants. Some less known species were recorded from the area such as Oriental Honey Buzzard, Northern Goshawk, Eurasian Sparrow Hawk and Long billed Pipit. Lot of open area is being converted into agriculture fields and thus habitat degradation is continued.

4.4.2 Species recorded

The total number of bird species recorded on each site is shown below.

Table 20 – Total number of bird species recorded at each site

S. No.	Total No. of Species recorded on each site	No. of Species
1.	Nara Wetland Complex	118
2.	Manchhar Lake	75
3.	Kharochann	85
4.	Khyberani Forest	61

The total number of birds species recorded from all the 4 sites is 149 species. A total of 80 species of birds were recorded in summer and 146 species in winter. The total numbers of birds recorded in winter was 15,248 and in summer 6,824.

Table 21 : LIST OF BIRD SPECIES RECORDED FROM EACH SITE

	Common Name	Nara Wetland Complex		Manchhar Lake		Kharochann		Khyberani Forest	
		W	S	W	S	W	S	W	S
1	Black necked Grebe	+							
2	Little Grebe	+		+	+				
3	White Pelican			+					
4	Large Cormorant	+	+	+					
5	Little Cormorant	+	+	+	+	+	+		
6	Indian Darter	+							
7	Grey Heron	+				+	+		
8	Purple Heron	+							
9	Indian Pond Heron	+	+	+	+	+	+	+	+
10	Cattle Egret	+	+	+	+	+	+	+	+

11	Large Egret	+		+		+			
12	Intermediate Egret	+	+	+		+		+	
13	Little Egret	+	+	+	+	+	+	+	+
14	Reef Heron	+	+	+	+	+	+		
15	Painted Stork					+			
16	Spoonbill			+					
17	Yellow Bittern	+							
18	Black Bittern		+				+		
19	Little Bittern	+	+						
20	Spoonbill			+					
21	Ruddy Shelduck	+							
22	Common Shelduck			+					
23	Marbled Teal		+						
24	Common Teal	+		+					
25	Mallard	+							
26	Gadwall	+							
27	Shoveller	+		+					
28	Common Pochard	+							
29	Ferruginous Duck	+							
30	Tufted Duck	+							
31	Common Kite	+	+	+	+	+	+	+	+
32	Blackwinged Kite	+		+	+	+			
33	Brahminy Kite	+		+		+	+		
34	Oriental Honey Buzzard							+	
35	Northern Goshawk							+	
36	Shikra	+		+	+	+	+	+	+
37	Eastern Sparrow Hawk							+	
38	Long legged Buzzard			+				+	
39	White eyed Buzzard	+					+		
40	Marsh Harrier	+	+	+		+			
41	Osprey	+				+			
42	Merlin							+	
43	Common Kestrel	+		+				+	
44	Grey Partridge	+	+	+	+	+	+	+	+
45	Black Partridge	+	+			+		+	
46	White breasted waterhen	+				+	+		
47	Indian Moorhen	+	+	+	+				
48	Purple Moorhen	+	+						
49	Common Coot	+		+					
50	Oystercatcher					+			
51	White tailed Plover	+		+					
52	Redwattled Lapwing	+	+	+	+	+	+		+
53	Yellow wattled			+	+				

	Lapwing								
54	Little Ringed Plover	+		+		+	+		
55	Kentish Plover	+		+		+	+		
56	Lesser Sand Plover	+				+			
57	Greater Sand Plover	+							
58	Whimbrel	+				+			
59	Curlew	+		+		+			
60	Bartailed Godwit	+				+	+		
61	Common Redshank	+		+		+			
62	Marsh Sandpiper	+				+			
63	Greenshank	+				+			
64	Wood Sandpiper	+							
65	Common Sandpiper	+		+		+			
66	Common Snipe	+							
67	Little Stint	+		+		+			
68	Dunlin	+	+						
69	Ruff	+		+					
70	Black winged Stilt	+	+	+	+	+	+	+	+
71	Crab Plover	+				+			
72	Heuglin's Gull	+		+	+	+			
73	Brown headed Gull	+		+		+			
74	Black headed Gull	+	+	+		+	+		
75	Slenderbilled Gull	+	+	+		+	+		
76	Caspian Tern	+		+	+	+	+		
77	Gull billed Tern	+							
78	River Tern	+	+	+	+	+	+	+	+
79	Black bellied Tern	+				+			
80	Little Tern	+	+	+	+	+	+		
81	Sandwich Tern	+				+			
82	White cheeked Tern						+		
83	Chestnut bellied Sandgrouse			+	+				
84	Blue Rock Pigeon	+	+	+	+	+	+	+	+
85	Ring Dove	+	+	+	+	+	+	+	+
86	Little brown Dove	+	+	+	+	+	+	+	+
87	Crow Pheasant	+	+			+	+	+	+
88	Common Koel		+				+		
89	Rose ringed Parakeet		+				+		
90	Lesser Golden Woodpecker								+
91	Sykes's Night jar	+							+
92	Barn Owl	+							
93	Spotted Owlet	+	+						+
94	Pied Kingfisher	+	+	+	+	+	+		
95	Common Kingfisher	+	+	+		+		+	

96	White breasted Kingfisher	+	+	+	+	+	+	+	+
97	Green Bee eater	+	+	+	+	+	+	+	+
98	Blue-cheeked Bee eater		+						
99	Indian Roller	+	+	+	+	+		+	+
100	Common Hoopoe	+	+	+	+			+	
101	Desert Lark	+	+	+		+			
102	Greater Short toed Lark	+	+			+			
103	Crested Lark	+	+	+	+	+	+	+	+
104	Pale Martin	+		+		+		+	
105	Crag Martin	+	+			+			
106	Common Swallow	+		+		+		+	
107	Wire tailed Swallow		+				+		
108	Rufous tailed Shrike	+		+		+		+	
109	Southern Grey Shrike	+	+	+		+			
110	Bay backed Shrike	+							
111	Striated Shrike		+						
112	Black Drongo	+	+	+	+	+	+	+	+
113	Rosy Pastor			+	+				
114	Bank Myna			+	+		+	+	+
115	Indian Myna	+	+	+	+	+	+	+	+
116	Common Starling	+		+	+				
117	Tree Pie	+						+	+
118	House Crow	+	+	+	+	+	+	+	+
119	White Cheeked Bulbul	+	+	+	+	+	+	+	+
120	Red vented Bulbul	+	+					+	+
121	Common Babbler	+	+	+	+	+	+	+	+
122	Jungle Babbler	+	+					+	+
123	Striated Babbler	+							
124	White-browed Fantail Flycatcher	+				+		+	
125	Common Chiffchaff	+				+			
126	Clamarous Reed Warbler	+						+	
127	Yellow bellied Prinia	+	+					+	
128	Rufous vented Prinia	+	+	+				+	
129	Tailor Bird							+	+
130	Lesser Whitethroat	+						+	
131	Common Chiffchaff	+		+				+	
132	Greenish Warbler	+							
133	Bluethroat							+	
134	Black Redstart	+		+				+	
135	Pied Bushchat	+	+	+	+	+	+	+	+
136	Isabelline Wheatear	+				+		+	
137	Desert Wheatear	+		+		+			

138	Hume's Wheatear	+	+	+	+	+			
139	Indian Robin	+	+			+		+	+
140	Paddyfield Pipit							+	+
141	Longbilled Pipit							+	
142	White wagtail	+	+	+		+		+	
143	Yellow wagtail	+		+		+			
144	White browed Wagtail		+						
145	Purple Sunbird	+	+			+	+	+	+
146	House Sparrow	+	+	+	+	+	+	+	+
147	Jungle Sparrow	+	+			+		+	+
148	Streaked Weaver Bird		+						
149	House Bunting			+	+				

Bibliography

- Abaturov, B. D. 1968 Importance of the digging activity of the mole (*Talpa europea* L.) on soil cover and vegetation in broad leaf fir forest, *Pedobiologia* 8:239-264.
- Abbasi, S. A. (1998). *Water Quality sampling and Analysis*. 1st Ed., Discovery Publishing House, New Dehli.
- Ahmed, M. F. and Ghalib, S. A. 1986. Field guide to the Ducks, Geese and Swans of Pakistan with illustrated keys to their identification. *Rec. Zool. Surv. Pakistan*. 9: 1-138
- Ahmed, M. F. and M.S. Niazi. 1988. Important edible fishes of Pakistan. *Zool. Surv. Deptt. Govt. of Pakistan*. 31 pp
- Ahmed, M. F. 1983. Vertebrate Fauna of the Mangrove Swamps. *Mangroves of Pakistan. Proceeding of National Workshop on Mangroves. Pakistan Agricultural Research Council* Pp 45 – 47
- Ahmed, M. F. 1988. Wildlife Estimation Techniques. *Records Zoological Survey of Pakistan*. Vol. XI: 115 – 123
- Ahmed, M. F. 1997. Ungulates of Pakistan. *Biodiversity of Pakistan* (ds. Mufti, S. A., Woods, C. A., Hasan, S. A). Pakistan Museum of Natural History, Islamabad and Florida Museum of Natural History, Gainesville, USA.
- Ahmed, M. F. and Ghalib, S. A. 1975. A checklist of Mammals of Pakistan. *Rec. Zool. Surv. Pakistan*. VII (1&2): 1 – 34.
- Ahmed, M. F., Ghalib, S. A., Naizi, M. S. and Hasan, S. A. 1988. Vertebrate Fauna of Mangroves of Pakistan, PARC Islamabad and Zoological Survey Department. (Unpublished Report)
- Ahmed, M., Khanum, Z and Ahmed, M. F. 1986. Wild Hoofed Mammals of Pakistan (in Urdu). *Zoological Survey of Pakistan*.
- Ahmed, M. F. and Ghalib, S. A. 1979. A checklist of Mammals of Pakistan. *Records Zoological Survey of Pakistan*. 7: 1 – 34
- Ali, S. and Ripley, S.D. 1971 – 81. *Hand books of the Birds of India and Pakistan*. 10 volumes. Oxford University Press, Bombay.
- Ali, S. and Ripley, S.D. 1987 *Compact handbook of the birds of India and Pakistan*. Oxford University Press, Bombay

- Ali, S. S., Jafri, S.I. H., Leghari, S.M. and Tebow, S., 1983. Studies on the flora and fauna of a hot sulphur spring at Lakki (District Dadu) Sindh, Pakistan. Karachi Univ. Sci. 11 : 185 – 197
- Amjad, S. and Kidwani, S. 2003. Freshwater, Brackish water and Coastal Wetlands of Sindh. 80pp (Unpublished report)
- Amjad, S., Khan, S. H. and Saleem, M. 1998. Overview of marine pollution and its impact on coastal environment. Biosphere, vol. 1 (11)
- Anderson, S.C. and Minton, S.A. 1963 Two noteworthy herpetological records from the Thar Parker Desert, West Pakistan. Herpetologica, 19:152
- Anthony, H. E., 1950. The capture and preservation of small mammals for study. American Museum of Natural History Sciences Guide No. 61, New York.
- APHA, 1985. Standard methods for the examination of water and waste water. Am. Pub. Health. Ass. Washington D.C. 14th ed: 1 – 1268
- Arain, M. B., Kazi, T. G., Jamali, M. K., Afridi, H. I., Baig, J. A., Jalbani, N. and Shah, A. Q. 2008. Evaluation of Physico- Chemical Parameters of Manchhar lake Water and their Composition with other Global Published Values. Pak. J. anal. Environ. Chem. 9 (2): 101 – 109.
- Auffenberg, W. and Rehman, H. 1993. Studies on Pakistan Reptiles. Pt.3 *Calotes versicolor*. Asiatic Herpetological Res., 5: 14 – 30
- Azam, M.M., Khan, S. A. and Qamar, S. 2002. Distribution and Population of Hog Deer in District Sanghar, Sindh. Rec. Zool. Surv. Pak. Vol. XIV: 5 – 10
- Becher, E. F. 1886. A Sind Lake. JBNHS: 1 (5): 91 – 96
- Baig, K. J. 1988a. Anurans (Amphians) of northern Pakistan with special references to their distribution. Pak. J. Sci. Ind. Res., 31 (9): 651 – 655
- Baig, K. J. 1988b. An unusual tail regeneration in Agama. Pak. J. Sci. Ind. Res., 31 (10): 731 – 732
- Baig, K. J. 1988c. New record of Agama nuristanica (Sauria: Aamidae) from Pakistan. Biologia, 34 (1): 199 - 200
- Baig, K. J. 1990. Japalura kumaonensis: A new record of the genus and species from Pakistan. Herpetological Review (USA), 21 (1): 22
- Baig, K. J. 1992. Systemic studies of the Stellio group of Agama (Sauria: Agamidae). Ph.D. Diss., Q.A. Uni. Islamabad.

- Baig, K. J. 1996. Herpeto-fauna of the sub Himalayan region of Pakistan including Islamabad area. Proc.DAAD 4th Follow- up Seminar, Islamabad: 35 – 42.
- Baig, K. J. 2001a. Annotated Checklist of amphibians and reptiles of the northern mountain region and Potwar Plateau of Pakistan. Proc. Pakistan Acad. Sci. 38 (2): 121 – 130.
- Baig, K. J. 2001b. Threatened Herpetofauna of Pakistan, pp 82 – 90.
- Baig, K. J. and Bohme, W. 1991. Callous scalation in female agamid lizards (Stellio group or Agama) and its functional implications. Bonn. Zool. Beitr. (Germany), 42 (3 - 4): 275 – 281
- Baig, K. J. and Bohme, W. 1996. Description of two new subspecies of *Laudakia pakistanica* (Sauria Agamidae). Russian J. Herpetology, 3 (1): 1 – 10
- Baig, K. J. and Gvozdik, L., 1998. Uperodon systoma: record of a new microhylid frog from Pakistan. Pak. J. Zool., 30 (2): 155 – 156.
- Baig, K. J., Mehmood, A. & Arslan, M. 1986. Seasonal changes in reproductive organs and androgen levels of the Musk Shrew, *Suncus murinus*. Pak.J. Zool., 18 (3): 229 – 237
- Baig, N.A. and M. Y. Khan. 1976. Biological and Chemical Conditions of Manchar Lake (Distt: Dadu). Pak. J. Sci. 28: 33 – 40.
- Bailey, H. 2005 Baseline Study of Nara Desert Wildlife Sanctuary (Unpublished Report)
- Baneriji, A. 1995. The family life of five – striped Squirrel (*Funambulus pennanti*), JBNHS, Vol. 53, No 2, Misc. Notes No. 10, pp 261 – 4
- Baqui, I.U., Zubari, V. A, and Iqbal, M. 1974. Limnological studies of Kalri Lake. Agriculture Pakistan 25 (2): 119 – 135
- Beg, M. A., Kausar, S., Hassan, M. M. & Khan, A. A. 1986. Some Demographic and Reproductive parameters of the House Shrews in Punjab, Pakistan. Pak. Jour.Zool.Vol.8, No 2, pp. 201 – 208.
- Beg, M. A., Khan, A. A. and Zaman, R. 1975. Age determination in Indian gerbil. Pak. Jour. Zool., Vol. 7 (1): pp 93 – 96
- Beg, A. R. 1975 Wildlife Habitats of Pakistan, Bulletin No.50. Biological Sciences Research Division, Pakistan Forest Institute, Peshawar
- Beg, Mirza, A. & Shahnaz, A. Rana 1978. Ecology of Field Rat, *Rattus meltada pallidior* in Central Punjab, Pakistan. Pakistan Jour, Zool., Vol. 10, no. 2 pp 163 – 168

- Bhaagat, H. B. 1999. Introduction, distribution, conservation and behavioural ecology of Indus blind dolphin (*Platanista indi*) in River Indus (Dolphin Reserve), Sindh, Pakistan. *Tigerpaper* 26: 11- 16
- Blanford, W.T. 1881 *Fauna of British India, Mammalia*. Taylor and Francis, London
- Boulenger, G. A. 1890 *Fauna of British India including Ceylon and Burma. Reptilia and Batrachia*, London.
- Boulenger, G.A., 1920. A monograph of the south-Asian Papuan, Melanesian and Australian frogs of the genus *Rana*, *Rec. Ind.Mus.*, Calcutta, 20: 1 – 20
- Brain, C.K., Fourie, I. and Shiel, R. J. 1995. Rotifers of the Kalahari Gemsbok National Park, South Africa. *Hydrobiologia*, 313/ 314, 319 – 324
- Braulik, G. T. 2006. Status and Assessment of the Indus River Dolphin, *Platanista gangetica minor*, March – April 2001. *Biological Conservation* 129: 579 – 590.
- Brower, J., Zar, J. and Ende, C., 1990. *Field and Laboratory Methods for General Ecology*. Wm.C.Brown Publishers, 2460 Kerper Boulevard, Dubuque, 1A 52001.
- Buckner, C. H. 1964. Metabolism, food capacity and feeding behavior in four species of shrews. *Can.J.* 42: 259 – 279.
- Burke, L., Y, Kura; K. Kassem; C. Revenga; M. Spaulding and D. McAllister. 2002. *Pilot Analysis of Global Ecosystems: Coastal Ecosystems*. World Resources Institute, Washington DC.
- Clerk, F. W. 1972. Influence of jackrabbit density on coyote population change. *J. Wildl. Manage.* 36: 343 – 356.
- David Reby, D., Hewison, A. J., Cargnelutti, B., Angibault, J. M. and Vincent, J. P. 1998. Use of Vocalizations to Estimate Population Size of Roe Deer. *The Journal of Wildlife Management.* 62: 4, pp 1342 – 1348.
- Davidson, F. F. 1959. Poisoning of wild and domestic animals by a toxic water bloom of microcystis, Nostoc and Rivularia. *Kuetz J. Amer Water Works Assoc* 51: 1277.
- Dewani, V. K., I. A. Ansari and M.Y. Khuhawar. 2002. Determination and transport of metal ions in river Indus at Kotri Barrage. *J. Chem. Soc. Pak.* 24 (3): 190 – 194.
- Dickman, M.. 1969. Some effects on lake renewal of phytonplanktons productivity and species composition. *Limnol. Oceang.* 14: 660 – 666.
- Din, M., Hussain, F. H., Naila, A., Shabbir, H., Rana, N. N., Anwar, K., Saeed, D. and

- Zumra, S. 1997. The Quality Assessment of Drinking Supplied to Islamabad, Environmental Pollution, Proceedings of the Third National Symposium on Modern Trends in Contemporary Chemistry, Islamabad, Pakistan.
- Drickamer, L.C. and Vessey, S. H. 1992. Animal Behaviour-mechanisms, ecology and evolution. W.c. Brown Publishers, 2460 Kerper Boulevard, Dubuque, 1A 52001 USA, pp 479.
- Dubois, A. and Khan, M.S. 1979. A new species of frog (genus Rana subgenus paa) from northern Pakistan (Amphibia: Anura). Jour. Herpetol., 13: 403 – 410.
- EIAO Guide Note No. 10/2004. Methodologies for Terrestrial and Freshwater Ecological Baseline Surveys
- Ellerman, J. R. 1961. The fauna of India – Mammalia, Zoological Survey of India.
- Ellerman, J. R. and Morrison _ Scot, T.C. 1951. Checklist of Palaearctic and Indian Mammals 1758 to 1946. British Museum(Natural History), England.
- Feldhamer, G. A., Drickamer, L.C., Vessey, S. H. and Merritt, J. F. 2004. Mammalogy: Adaptation, Diversity, and ecology. The McGraw-Hill Companies, Inc., 1221. Avenue of the Americas, New York, NY 10020
- Fogel, R. and Trappe 1978 Fungus consumption (mycophagy) by small animals, Northw. Sci 52:1-31
- Forever Indus: The WWF proceeding of “Indus Delta Eco-region Workshop” held in Karachi from Dec. 16 – 19, 2002.
- Foster, J. and Gent, T. 1996 Reptile Survey Method, English Nature.
- Frantz, Stephen C. 1973. ‘Behavioural’ Ecology of the Lesser Bandicoot Rat, *Bandicota bengalensis* (Gary) in Calcutta, John Hopkins University, Ph.D. Thesis, Baltimore, Maryland.
- French, N. R., Grant, W. E., Grodzinski, W. and Smith. D. 1976. Small mammals energetic in grassland ecosystems. Ecol. Mongr. 46 : 201 – 220.
- Fulk, G. W. and A. R. Khokhar. 1981. ‘Movements of *Bandicota bengalensis* and *Nesokia indica* in Rice Fields in Sind’. JBNHS. Vol. 78 No. 1, pp. 107 -112.
- Fulk, G. W., S. B. Lathiya & A. R. Khokhar. 1981. ‘Rice Field Rate of Lower Sind: Abundance, Reproduction and Diet.’ Journ. Zool. Pp. 193.
- Gachal, G.S., Memon, Z., Qadir, A.H., Yusuf, S.M. and Siddiqui, M. 2007 Ecological

- Impact on the status of Otter (*Lutrogale perspicillata*). Sindh Univ. Res. Jour., 39:19-26
- Ghalib, S. A., Rahman, H., Iffat, F. and Hasnain, S. A. 1976 A Checklist of the Reptiles of Pakistan. Rec. Zool. Suev. Pak. 8:37-57
- Ghalib, S. A., Hasnain, S. A. and Khan, A. R. 1999. Observations on the birds of Chotiari Wetland Complex, District Sanghar, Sindh. Proc. Pakistan Congr. Zool. Vol 19: 57 – 66
- Ghalib, S. A. and Bhaagat, H. B. 2004. The Wetlands of Indus Delta Ecoregion: in Ahmed, E., Omer, S. and Rasool, F. (editors). Proceedings of Consultative Workshop on Indus Delta Ecoregion. (IER). WWF- Pakistan : 117 - 142.
- Ghalib, S. A., Hasnain, S. A., Parveen, S. and Khan, A. R. 2002. Current Status of the Birds of Sindh. Journal of Natural History and Wildlife 33 – 55
- Ghalib, S. A., Khan, M. Z. and Abbas, D. 2006. An Overview of the Asian Waterbird Census in Pakistan. J. Nat. Hist. Wildl. 5 (1): 181 – 189.
- Ghalib, S. A., Khan, A. R., Zehra, A. and Abbas, D. 2008. Bioecology of Nara Desert Wildlife Sanctuary, district Ghotki, Sukkur and Khairpur, Sindh. Pak. Jour. Of Zool. Vol. 40 (1): 37 – 43.
- Golley, F. B., K. Petruszewicz, and L. Ryszkowski (eds). 1975. Small mammals: their productivity and population dynamics. Cambridge University Press, London.
- Gregory, R. D., Gibbons, D. W. and Donald, P. F. 2004. Birds census and survey techniques in Bird ecology and Conservation; a Handbook of Techniques. Ed W.J. Sutherland, I. Newton and R. E. Green, Oxford, Oxford University Press. Pp 17 – 56
- Grimmett, R., Inskipp, C. and Inskipp, T. 1998. Birds of the Indian Sub- continent. Oxford University Press, Dehli.
- Gross, J. E. 1969. The role of small herbivorous mammals in the functioning of the grassland ecosystem. P 268 – 278. In R. L. Dix and R. G. Biedeman (eds). The grassland ecosystem: A preliminary synthesis. Range Sci. Dept. Sci. Ser. No. 2, Colorado State University, Fort Collins, CO.
- Haq, S. M. Ali – Khan, J. and Chughtai, S., 1973. The Distribution and abundance of zooplankton along the coast of Pakistan during post monsoon and premonsoon period. Eco. St.Anl. and Syn: 257 – 272.
- Harris, L. D. 1971. A précis of small mammal studies and results in the grassland

- biome.p. 213 – 240. In N. r. French(ed). Preliminary analysis of structure and function in grasslands, Range Sci, Ser. No. 10. Co. State Univ., Fort Collins, CO.
- Halcrow 2002 Nara Game Reserve Baseline Environmental Study Report, Halcrow Pakistan (unpublished report).
- Hasan, A., Khan, S.A. and Ahmed, S.I. 2005. Fish and birds in Keti Bandar, Shah Bandar and other parts of Indus Delta. Records Zoological Survey of Pakistan Vol.16: 33 – 39.
- Hasan, M. 2001. Birds of the Indus. Oxford University Press, Karachi, 346 pages.
- Hasan, S. A. 1964 Birds of Manchar Lake. Agriculture Pakistan 15(3):259-283
- Hasnain, S. A. and Parveen, S. 1988 A report – Birds in Indus Delta. Sahil, National Institute of Oceanography 1:48-51
- Hayek, L. C. 1997 Surveying natural populations, Columbia University Press, New York, 563 pp.
- Hayward, G. F., and J. Phillipson. 1979. Community structure and functional role of small mammals in ecosystem. P. 136 – 211. In Stoddard, D. M. (ed). Ecology of small mammals. Chapman and Hall, London. Hist., 134 (2): 28 – 184.
- Hole, F. D. 1981. Effects of animals on soil. Geoderma 25: 75 – 112.
- Howes, J. and Backwell, D. 1989. Shorebird studies Manual. AWB Publications No. 55, Kuala Lumpur.
- HMSO, 1996. Biodiversity Assessment. A Guide to Good Practice. HMSO, London.
- Hussain, 1961. Manchar Lake, How to improve and judiciously exploit. J.Agric. Pakistan 12 (2): 222 – 237.
- IFAP. 2007. Preliminary Environmental Baseline Study Report. Indus for All Programme Sites: Keti Bundar, Kinjhar, Chotiari Reservoir and Pai Forest, Sindh, Pakistan (Unpublished Report).
- IFAP 2006 Preliminary Environmental Baseline Study Report – Keti Bunder, Kinjhar Lake, Chotiari Reservoir and Pai Forest, Sindh. Indus for All Programme, WWF Pakistan. 399 pp.
- IFAP 2008 Detailed Ecological Assessment of Fauna, including Limnology Studies at Chotiari Reservoir, 2007 – 2008. Indus for All Programme, WWF Pakistan. 195 pp.

- IFAP 2008 Detailed Ecological Assessment of Fauna, including Limnology Studies at Pai Forest, 2007 – 2008. Indus for All Programme, WWF Pakistan. 201 pp.
- IFAP 2008 Detailed Ecological Assessment of Fauna, including Limnology Studies at Kinjhar Lake, 2007 – 2008. Indus for All Programme, WWF Pakistan. 186 pp.
- IFAP 2008 Detailed Ecological Assessment of Fauna, including Limnology Studies at Keti Bunder, 2007 – 2008. Indus for All Programme, WWF Pakistan. 210 pp.
- Iffat, F. 1994 Notes on the collection of amphibians in the Zoological Survey Department. Rec. Zool. Surv. Pak. 12:120-124
- IUCN 2011 IUCN Redlist of Threatened Species. www.icunredlist.org
- Jafri, S. I., Mahar, M.A. and Laghari, S. M. 1999. Diversity of fish and plankton in Manchar Lake (Dist. Dadu) Sindh, Pakistan. In: Proce. Symp. Aquatic Biodiversity of Pakistan (Q.B. Kazmi and M.A. Kazmi eds.). Marine References Collection and Resoures Centre. 63 – 70.
- Javed, M. and Hayat,S. 1996. Planktonic productivity of river water as bio- indicator of fresh water contamination by metals. Proc. Pak. Congr. Zool. 16: 283 – 298.
- Jehangir, M. 2002. Bacteriological Contamination and upward Trend in Nitrate Contents, observed in Drinking Water of Rawalpindi and Islamabad. The Network Consumer Protection in Pakistan (Un published)
- Kahlowan. M. A., Tahir, M. A. and Sheikh, A. A. 2004. Water Quality Status in Pakistan: Second Report 2002 – 2003, Pakistan Council of Research in Water Resources, Islamabad, ISBN: 969 – 8469 – 13 – 3
- Karim, S. I. 1986 Avifauna of Sindh mangroves. Proceedings of the International Conference on Marine Sciences of Arabian Sea. Pp:457-465.
- Khan, A. A. and Ali, S.B. 2003. Effect of erosion on Indus river. Biodiversity in Pakistan. Pak. J. Biol. Sci., 6(12): 1035 – 1040.
- Khan, M. W. 2002. Use of Statistic Stock. Presented in Regional Seminar on “Utilization of Marine Resources” organized by National Institute of Oceanography in collaboration with ISESCO member countries from 20 – 22 December 2002 at Karachi.
- Khan, M. S. 1972 The commonest toad of West Pakistan and a note on *Bufo melanostictus* Schneider. Biologia 18:131-133
- Khan, M.S. 1978 An annotated checklist and key to amphibians of Pakistan. Biologia 22:200-210

- Khan, M. S. 1979. On a collection of amphibians and reptiles from northern Punjab & Azad Kashmir, with ecological notes. *Biologia*, 25 (1-2): 37 – 50.
- Khan, M. S. 1980. A new species of gecko from northern Pakistan. *Pak. J.Zool.* 12 (1): 11 – 16
- Khan, M. S. 1993. A checklist and key to the gekkonid lizards of Pakistan. *Hamadryad* 18: 35 – 41.
- Khan, M. S. 1994 Key for identification of amphibians and reptiles of Pakistan. *Pak Jour of Zool* 26(3): 225 - 249
- Khan, M. S. 1997. A new toad of genus *Bufo* from the foot of Siachin Glacier, Baltistan. *Pak. Jour. of Zool.* 29(1):23-48
- Khan, M. S. 1998. *Typhlops ductuliformers* a new species of blind snakes from Pakistan and a note on *Typhlops porrectes* Stoloczka, 1871 (Squamata: Serpentes: Scolocophidia). *Pak. J. Zool.*, 31 (4): 385 – 390.
- Khan, M.S. 2004 Annotated Checklist of Amphibians and Reptiles of Pakistan. *Asian Herpetological Research*, Vol. 10:191-201
- Khan, M. S. 2006. Amphibians and reptiles of Pakistan. Krieger Publishing Company, Malabar, Florida. Pp 311.
- Khan, M. S. and Baig, K. J. 1988. Checklist of the amphibians and reptiles of district Jhelum, Punjab, Pakistan. *The snake*, 20: 156 – 161.
- Khan, M. S. and Tasnim, R. 1989. A new frog of the genus *Rana*, Subgenus *Paa*, from southwestern Azad Kashmir. *J. Herpetology.*, 23 (4): 419 – 423.
- Khan, W. A. and Qasim. 2010. Otter Surveys in Indus Ecoregion: Otter Population Estimation. WWF- Pak, Internal Report 167 pp.
- Khan, W. A., Qasim, M., Ahmed, E., Akber, G., Habib, A. H. Ali, H., Qamar, F. M., Chaudhary, A.A., Iqbal, S., Bhagat, H. B., Akhtar, M. and Ahmed, M.S. 2009. A survey of Smooth coated Otter (*Lutrogale perspicillata sindica*) in Sindh Province of Pakistan. *IUCN Otter Specialist Group Bulletin*.
- Khan, W. A., Qasim, M., Ahmed, E., Chaudhary, A.A., Bhagat, H. B. and Akhtar, M. 2010. Status of Smooth coated Otter (*Lutrogale perspicillata sindica*) in Pakistan. *Pak. J. Zool.* 42 (6): 817 – 824.
- Khan, M. Z. and Ghalib, S. A. 2006. Birds Population and Threats to some Selected Important Wetlands in Pakistan. *J. Nat. Hist. Wildl.* 5(2): 209 – 215.

- Khanum, Z., Ahmed, M. F. and Ahmed, M. 1980. A checklist of birds of Pakistan with illustrated keys to their identification. *Rec. Zool. Surv. Pakistan* vol. 9 (1): 1 – 138.
- Khurshid, N. 1996 Marbled Teal - A species in danger (Leaflet), World Wide Fund for Nature Pakistan.
- Khurshid, N. 2000. Pakistan's Wetland Action Plan. WWF P and NCCW, Islamabad. 80pp.
- Khurshid, N. and Qureshi, R. 1996. White – headed Duck - a species in danger WWF-Pakistan.
- LBOD Consultants 1993. LBOD Stage 1 Project: Resettlement Plan and EIA of Chotiari Reservoir and Nara Remodelling. Sir M. MacDonald & Partners Ltd., National Engineering Service Pakistan (Pvt.). Ltd. and Associated Consulting Engineers (Pvt) Ltd.
- LBOD Consultants 1998 LBOD Stage 1 Project:Envoirnmental Management and Monitoring Plan. Sir M. MacDonald & Partners Ltd., National Engineering Service Pakistan (Pvt.). Ltd. And Associated Consulting Engineers (Pvt)Ltd.
- Li, Z. W. D. and Mundkur, T. 2004. Numbers and distribution of waterbirds and wetlands in the Asia – Pacific region. Results of the Asian Waterbird Census: 1997 – 2001. WETLANDS International, Kuala Lumpur, Malaysia.
- Lopez, A. and Mundkur.T. 1997. The Asian Waterfowl Census 1994 – 1996. Results of the coordinated Waterbirds Census and an overview of the status of Wetlands in Asia . Wetlands International, Kuala lumpur.
- Mahar, M. A. 2003. Ecology and Taxonomy of Planktons of Manchhar Lake (Distt.Dadu.), Sindh, Pakistan. A Thesis submitted to the University of Sindh for the Degree of Ph.D., Dept of Fresh Water Biology and Fisheries, University of Sindh, Jamshoro.
- Mahar, M. A., S. I.H. Jafri, S. M. Leghari and M. Y. Khuhawar. 2002. Studies on Water Chemistry and fish production of Manchar lake, Dadu, Sindh, Pakistan. *Pak.J. Biol. Sci*, 3 (12): 2151 – 2153.
- Mallon, D., 1991. Biodiversity Guide to Pakistan. IUCN, Gland, Switzerland. 32 pp.
- McInville, W. B., Jr., and L. B. Keith. 1974. Predator-prey relations and breeding biology of the great – horned owl and red-tailed hawk in central Alberta. *Can. Field Nat.* 88: 1 – 20.
- Mehmood, A., Baig, K. J. & Arslan, M. 1996. Studies on seasonal changes in the

- reproductive tract of female Musk Shrew. *Suncus murinus*. Pak. J. Zoo., 18: (3): 263 – 272.
- Memon, N. Birwani, Z. and Nizamani, N. 2008. Degradation of Manchhar Lake- A Case of Human Disaster. Shirkatgah – Women’s Resources Centre, Karachi. 38pp.
- Mertens, R. 1969 Die Amphibien und Reptilien West Pakistans. Stuttgart Beitrag Naturkundi 197:1-96.
- Mertens, R. 1970 Die Amphibien und Reptilien West Pakistans. Stuttgart Beitrag Naturkundi 216:1-5.
- Mertens, R. 1974 Die Amphibien und Reptilien West Pakistan. Senckenb. Boil. 55(1-3):35-38
- Mian, Afsar. 1986. Some Notes on Field Biology of *Rhombomys opimus*, *Meriones persicus* and *Mus musculus bartrianus* with reference to Orchard of Baluchistan, Pakistan. JBNHS. Vol . 83, No. 3, pp. 654 – 656
- Ministry of Health GDP. 2005. Quality Drinking Water Guidelines and Standards for Pakistan.
- Minton, S. A. 1966. A contribution to the herpetology of West Pakistan. Bull. Am. Mus. Nat. Hist 134(2):31-184
- Minton, S. A. and Anderson, S. 1965 A new dwarf gecko (*Tropicolotes*) from Baluchistan. Herpetological 2:59-61
- Miracle, M. R. and Serra, M. 1989. Salinity and temperature influence in rotifer life history characteristics. Hydrobiologia, 186/187, 81 – 102.
- Mirza, Z. B. 1969. The Small Mammals of West Pakistan, Vol. 1, Rodentia, Chiroptera, Insectivora, Lagomorpha, Primates and Pholidota, Central Urdu Board, Lahore (in Urdu)
- Mirza, Z. B. 1998 Illustrated Handbook of Biodiversity of Pakistan., CERC, BHC, Islamabad.
- Mirza, Z. B. 2002. A Pocket guide to Khirthar National Park and it adjoining protected areas. Premier- Kufpee Pakistan B. V, Islamabad. 177 pages.
- Mirza, Z. B. 2007. A Field Guide to the Birds of Pakistan., Bookland, Lahore.
- Mitcheal, A. A. 1967. The Indus rivers, Yale Uni. Press, London.
- Monawwar, S. A. Rehman and s. Amjad. 1999. Impact of industrial pollution on Gizri

- Creek area. Sem.Aq. Biodiv.Pakistan. (Kazmi, Q.B. and M. A. Kazmi eds.) MRCRC, Dept. of Zool. Univ. Karachi.pp. 159 – 170
- Mountfort, G. 1969 The Vanishing Jungle – The Story of the World Wildlife Expeditions to Pakistan. London Collins 100
- Mueggler, W. F. 1967. Voles damage big sagebrush in southwestern Montana. *J. Range Manage.* 20: 88 – 90.
- Mundkar, T. and Taylor, V. 1993. Asian Waterfowl Census 1993. AWB, Kuala Lumpur and IWRB, Slimbridge.
- Murray, J. A. 1984. Vertebrate Zoology of Sind: A systematic account. Richardson & Co., London. 415pp.
- Murray, J. A. 1986. The Zoology of Sind, London and Bombay. Pp 92.
- Prater, S. H. 1971 The book of Indian animals. Bombay Natural History Society, 3rd Edition. Pp 324.
- Richard & Co., London. National Park. *Proc. Pakistan Acad. Sci.* 39 (2) : 261 – 262
Museum, Calcutta.
- Nazneen, S. 1995. State of Limnology in Pakistan. In: *Limnology in Developing countries* (Gopal, B. and Witzel, R. G. eds.) *Intrn. Assoc. Limnology, India* pp. 191 229. Nepal, Bangladesh and Sri Lanka. BNHS, Bombay.
- Nybakken, J.W. 2003. *Marine Biology: An ecological approach*, 6th ed. Benjamin Cummings.
- Pakistan. 1973 The Presidential Proclamation of March 20, 1973; *Gazette of Pakistan*, March 20, 1973.
- Pakistan. 1975. The Exclusive Fishery Zone (Regulation of Fishing) Act; Act No. XXXII of 1975 as amended in 1993.
- Pakistan. 1976 The Territorial waters and Maritime Zone Act, 1976; Act No. LXXXII of 1976.
- Pakistan. 1976a. The Exclusive Fishing Zone (Regulation of Fishing) Rules 1976, promulgated under section 16 of the Exclusive Fishing Zone (Regulation of Fishing) Act 1975. Pakistan. Oxford University Press, Karachi.
- Panwhar, M. 1995. Manchhar Lake: An untapped asset of the lower Indus Valley. *Sindh Univ. Res. J. (Arts - Ser)*, 30: 91 – 103.
- Perennou, C. and Mundkur, T. 1992. Asian Waterfowl Census 1992. IWRB, Slimbridge.

- Perennou, C., Mundkur, T. Scott, D. A, Follested, A. and Kvenild, L. 1993. The Asian Waterfowl Census 1987 – 91. Distribution and Status of Asian Waterfowl. Asian Wetland Bureau, Kuala Lumpur and IWRB, Slimbridge.
- Pescod, M. B. 1977. Surface water quality criteria for developing countries, in water, wastes and health in hot climates, Feachern, R., McGarry, M. and Mara, D. (eds) London: John Wiley, pp 52 – 77.
- Philpote, M. T. 1967. Chlorococcales pub. I.C.A.R. Krishan Bhawan New Delhi: 1 – 365.
- Pillari, G. 1970. Observations on the behavior of *Platanista gangetica* in the Indus and Brahmaputra rivers. Investigations on Cetacea 2, 27 – 59.
- Pillari, G. 1977. Indus dolphin ecological study. WWF- Pakistan, Lahore.
- Prasad, B. and Mukherjee, D. D. 1930. On the fishes of Manchhar Lake (Sind). J.B. N.H.S. 34 (1): 164 – 169.
- Prater, S. H. 1965. The Book of Indian Animals. Bombay Natural History Society, India.
- Prasad, B. and Mukerji, D.D. 1930. On the fishes of the Manchhar Lake (Sindh). J.B.N.H.S. 34 (1): 164 – 169.
- Prescott, G. W. 1961. Algae of the western Great Lake Area Monograph. Michigan State University, 1 – 975.
- Qureshi, Z. 1964 – 66. Kati Lake development Geographia 3 -5: 39 – 42.
- Rahman, H. and Javed, H. I. 2004 Revised Checklist of Amphibians of Pakistan. Rec. Zool. Surv. Pak. 12:120-124
- Reeves, R. R. & Chaudhry, A. A. 1998. Status of the Indus River dolphin *Platanista minor*. Oryx 32 : 35 – 44.
- Ripley, S. D. 1961. A Synopsis of the Birds of India and Pakistan together with those of Nepal, Sikkim, Bhutan and Ceylon., Bombay Natural History Society.
- Roberts, T. J. 1972. 'A brief Examination of Ecological changes in the province of Sind and their consequences on the Wildlife Resources of the region', Pakistan Journal of Forestry, Vol. 22, April, pp. 33 – 6.
- Roberts, T. J. 1973. 'Conservation problems in Baluchistan with particular references to wildlife preservation, Pakistan Journal of Forestry', Vol. 23(2):117 - 27

- Robert, T. J. 1997. Mammals of Pakistan. Revised edition. Ernest Benn Ltd., London.
- Roberts, T. J. 2005. Field Guide to the Large and Medium Sized Mammals of Pakistan. Oxford University Press
- Roberts, T. J. 2005. Field Guide to the Small Mammals of Pakistan. Oxford University Press
- Roberts, T. J., Passburg, R. and Zalinge, N. P. V. 1986. A Checklist of Birds of Karachi and Lower Sindh., Pakistan. WWF Pakistan, 37 pp.
- Roberts, T. J. 1991 – 92. The Birds of Pakistan. Vols 1 and 2. Oxford University Press, Karachi.
- Roberts, T. J. 1967. Epilogue on a Sind lake 4. JBNHS: 64: 13 – 21.
- Rodgers, W. A. 1991. Techniques for Wildlife Census in India, Wildlife Institute of India, New Forest, Dehra Doon, India.
- Russel, P., 1803. Description and figures of two hundred fishes collected at Vizagapatam on the coast of Coromandal. London, W. Bulmer and Co., 77 – 78pp.
- Sajjad, M. and Rahim, S. 1998. Chemical Quality of Ground Water of Rawalpindi/ Islamabad. Proceedings of the 24th WEDC Conference: Sanitation and Water for All. Islamabad, Pakistan.
- Salam, A., Chaudhary, A.A. and Bukhari, S.S. 1998. Studies on biodiversity and water quality parameters of Indus river, Punjab, Pakistan, Pak. Jour. Zool. Abstract, Series No 18.
- Samarasekera, V. N. (eds). An Overview of the Threatened Herpetofauna of South Asia. IUCN, Sri Lanka. 118pp.
- Sandy Cairncross 1993. Environment Health Engineering in the Tropics, John Wiley & Sons.
- Sathasivam, K. 2004. Marine Mammals of India. Universities Press (India) Private Ltd., Hyderabad.
- Schemnitz, S. D. 1980. Wildlife Management Techniques Manual. The Wildlife Society, Inc. 5410 Grosvenor Lane, Bethesda, Maryland 20814.
- Scott, D. A (ed) 1989. A Directory of Asian Wetlands, IUCN, Gland, Switzerland and Cambridge, U.K.
- Scott, D. A. and Poole, C. M. 1989. A Status Overview of Asian Wetlands, based on “A

- Directory of Asian Wetlands. Pakistan Section (pp. 295 - 365). IUCN, Gland.
- Scott, D. A. and Rose, P. M. 1989 Asian Waterfowl Census, 1989. International Waterfowl and Wetlands Research Bureau, Slimbridge, England
- Shamsi, S. 2005. Rare Birds found breeding in Nara Sanctuary, The Daily Dawn August 27, 2005.
- Sial, J. K. and Mehmood, S. 1999. Water Pollution from Agricultural and Industry. Proceedings: Water Resources Achievements and Issues in 20th Century and Challenges for Next Millennium. June 28 – 30. 1990. Pakistan Council of Research in Water Resources, Islamabad, Pakistan.
- Siddiqui, M. S. U. 1970. 'Notes on a Collection of some Shrews from West Pakistan and Kashmir', Records. Zool. Survey of Pakistan, Vol. 2 , No. 1, Karachi.
- Siddiqui, M. S. U. 1969. Fauna of Pakistan. Agricultural Research Council, Government of Pakistan, Karachi.
- Siddiqui, P.A. 1982. Bioecological of avifauna in the province of Sind. Final Technical Report PL- 480. Department of Zoology, University of Karachi, Karachi.
- Siddiqui, P. A., Saqib, T. A. and Kazmi, M. A. 2001. Birds Population in Different Coastal Areas of Sindh. Pakistan Journal of Marine Science, Vol. 10 (1): 49 – 60.
- Smith, S. A. 1933. The Fauna of British India Including Ceylon and Burma, vol. 1 Taylor & Francis, London.
- Smith, S. A. 1935. The Fauna of British India Including Ceylon and Burma, vol. 1 Taylor & Francis, London.
- Smith, S. A. 1943. The Fauna of British India Ceylon and Burma Including the whole of Indo – Chinese sub-region, vol. III, Taylor & Francis, London.. 240pp.
- Snedaker, S. C., 1993. "Impact on mangroves", pp. 282 – 305, In G.A. Maul(ed). Climatic Changes in the Intre-Americas Sea, Edward Arnold, Hodder and Sloughton Publishers, Kent, UK, 389p.
- Sonobe, K. and Usui, S (editors) 1993 A Field Guide to the Waterbirds of Asia. Wild Bird Society of Japan, Tokyo
- Southern, H, N. 1970. The Natural control of a population of Tawny owls (*Strix aaluco*). J. Zoology: 147: 197 – 285.
- Spalding M. D., F. Blasco; C. D. Field., eds. 1997. World Mangroves Atlas. Oki-nawa,

- Sufi, S. M. K. 1962. Checklist of fishes of Manchar Lake (West Pakistan), with a note on the effect of the effect of Sukkur Barrage and canalization of the feeding channels on the fish fauna of the lake. *Agri. Pak.*, 13(2):499 – 503.
- Sun-Ok HER, Shin-Ho CHUNG, Nasir J. A. and Noor- us- Saba. 2001. Drinking Water Quality Monitoring in Islamabad, National Institute of Health & Korea International Cooperation Agency, Islamabad.
- Sutherland, W. J., Newton, I. and Green, R. E. (editors). *Bird Ecology and Conservation*, Oxford University Press, Oxford.
- SWD 2003. The Sindh Wildlife Protection Ordinance 1972, with Amendments up to the June 01, 2001. Sindh Wildlife Department, Government of Sindh.
- Tahir, M. A. 2000. Arsenic in Ground Water of Attock and Rawalpindi Districts. Joint Venture PCRWR & UNICEF, Islamabad (Un published).
- Tahir, M. A., Chandio, B. A., Abdullah, M. and Rashid, A. 1998. Drinking Water Quality Monitoring in the Rural Areas of Rawalpindi. National Workshop on Quality to Drinking Water. March 7, 1998. Pakistan Council of Research in Water Resources. Islamabad, Pakistan.
- Thomos, O. 1920. 'Some new mammals from Baluchistan and north-west India', *Scientific Results from the Mammal Survey No. 21, JBNHS, Vol. 26, No. 4*, pp 933 – 8.
- Thomas, O. 1923. 'The Distribution and Geographical Races of the Golundi Bush Rats (*Golunda ellioti*)', *JBNHS, Vol. 29, No. 2*, pp. 372 – 6
- Ticehurst, C. B. 1923 *The Birds of Sind, Ibis* 5(2);253-261
- Tripathy, A. K. and Oandy, S.N.1990. *Water pollution*. New Delhi, Ashish Publishing House, pp 326.
- U.N.E.P. 1994 *The pollution of Lakes and Reservoirs*. UNEP Environment Library No. 12, United Nations Environment Programme, Nairobi
- Ven, J. Van der 1987 *Asian Waterfowl Census, 1987*. International Waterfowl and Wetlands Research Bureau, Slimbridge, England
- Ven, J. Van der 1988 *Asian Waterfowl Census, 1988*. International Waterfowl and Wetlands Research Bureau, Slimbridge, England
- Wagle, P. V. 1927. 'The Rice Rats of Lower Sind and their control', *JBNHS, Vol. 32, No. 2*, pp. 330 – 8.

- Walton, G. M. & D. W. Walto. 1973. 'Notes on Hedgehogs of the Lower Indus Valley'. Korean Journ. Zoology. Vol. 16, pp. 161 – 170.
- Ward, H.B. and Whipple, G.C. 1959. Fresh water Biology, Zool. Ed., John Willey and Sons, London.
- WHO. 1985. Guidelines for Drinking water quality, Vol 3: drinking water quality control in small community supplies, (Geneva: World Health Organization).
- Wilson, D. E., F. R. Cole, J. D. Nichols, R. Rudran and M. S. Foster. 1996. Measuring and Monitoring Biological Diversity: Standard Methods for Mammals. Smithsonian Institute Press, Washington.
- Woodcock, M. 1993. Collins Handguide to the Birds of the Indian Subcontinent Collins.
- Woods, C. A. and Kilpatrick. 1997. Biodiversity of small mammals in the mountains of Pakistan (high or low): 437 – 467. In: Mufti, S. A., Woods, C. A. & S. A. Hasan (eds), Biodiversity of Pakistan. PMNH, Islamabad (Pakistan)& FMNH, Gainesville (USA).
- Woods, C. A. and Kilpatrick, C. W., Rafique, A. Shah, M. and Khan, W. 1997. Biodiversity and Conservation of Deosai Plateau, Norther Areas. Pakistan: 33 – 61. In: Mufti, S. A., Woods, C. & S. A. Hasan (eds). Biodiversity of Pakistan . PMNH, Islamabad & FMNH, Gainesville. 537pp.
- Wroughton, R.C. 1920. 'Mammals Survey Report', No. 32, Baluchistan, JBNHHS, Vol. 27, No 2, pp. 314 – 22
- Wroughton, R.C. 1911. 'On a Small Collection of Rodents from Lower Sind'. JBNHS. Vol. 20, No. 4, pp. 1000 – 1001.
- WWF. 1999. Protection and Management of Pakistan Wetlands project funded by UNDP.
- WWF – Pakistan 2004. Study on Knowledge Attitude & practice of Fisherfolk Communities about Fisheries and Mangroves Resources – Keti Bunder Report. Tackling Poverty in Pakistan.
- WWF – Pakistan 2010 Position Paper on Manchhar Lake. Friends of Indus Forum, Indus for All Prog, WWF (6pp).
- Yahya, M. 2008. The Lost Paradise (Manchhar Lake). In: Sengnpta, M. and Dalwani, R. (editors). Proceedings of Taal 2007: The 12th. World Lake Conference: 1397 – 1407.
- Zlotin, R. E. and Kodashova, K. S. 1974 The role of animals in the biological cycle of the

forest-steppe ecosystem. Science Publ. House, Moscow. 92 pp.
