

STUDY OF VERTEBRATE DIVERSITY AND ASSOCIATED THREATS IN SELECTED HABITATS OF SINDH AND BALUCHISTAN, PAKISTAN

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ABSTRACT

Vertebrate diversity is severely affected due to increased anthropogenic activities in aquatic and terrestrial habitats. Ecosystem changes result in changes to the habitats of vertebrate species and to water quality parameters. The present study was conducted from August 2017 to August 2019 for the evaluation of vertebrate fauna and associated threats in the selected areas of Sindh and Balochistan, Pakistan. Sampling was done twice per week in various fresh water, marine and terrestrial habitats of the study area. The variety of vertebrate fauna was determined by means of quadrat sampling, point count method, line transect method, counting of dung, footprints and other opportunistic methodologies. The fauna observed included 285 vertebrate species including 24 mammalian species belonging to 11 families, 30 reptilian species belonging to 12 families, 184 bird species belonging to 46 families. A total of 25 marine and euryhaline fish species belonging to 16 families were collected from Gharo Creek, China Creek, Khrararo Creek, and Hub River. 19 freshwater fish species belonging to 7 families were recorded from Keenjhar Lake. About 38.166 ± 5.9132 ppt of salinity was recorded in Hub River which is originally a freshwater habitat but has changed to saline water habitat. Accordingly, freshwater fish species have been declined due to high salinity. Some of the important fish species recorded during the present study included *Acanthopagrus latus*, *Acanthopagrus berda*, *Lutjanus argentimaculatus*, *Lutjanus johnii* and *Lates calcarifer*. Threats to vertebrate fauna recorded in the present study included habitat loss, pollution, deforestation, increased developmental activities in terrestrial and aquatic habitats and indiscriminate hunting. It has been concluded that changes in habitats and increased frequency of threats has caused a decline in the vertebrate diversity compared with the previous studies. Conservation measures should be taken to mitigate the influence of anthropogenic activities and protect vertebrate fauna from further decline.

Key words: Vertebrate fauna, diversity, fish, amphibians, reptiles, birds, mammals, threats.

INTRODUCTION

Biodiversity is a vital natural resource. It offers financial, cultural, scientific, educational and esthetic advantages to humans, both monetary and non-monetary (Leverington *et al.*, 2010; Kolahi *et al.*, 2012). Biodiversity covers genetic variety, species diversity, and ecological diversity (Gaston and Spicer, 2004; Meduna *et al.*, 2009; Chanie and Tesfaye, 2015).

The biological diversity of each ecosystem depends on the ecological services delivered. The land of Pakistan is made up of different zoogeographical and environmental combinations.

Diverse groups of flora and fauna is available which are supported by diverse habitats from Himalaya to the coastal areas and natural ecosystem of wetlands. Pakistan's ecosystems contain a broad variety of life and wealthy natural habitats. One hundred ninety eight species of mammals have been reported from Pakistan, 6 hundred seventy species of birds and one hundred eighty nine species of reptiles as well as nineteen species of amphibians (Sheik and Molar, 2004).

The coastal areas of Sindh and Baluchistan forests protect naturally the large populations of land fauna and provide shelter grounds for aquatic life (Khurshid *et al.*, 2004). This area harbors a great diversity of vertebrate fauna. The 90 km long coastal site of Karachi represent a valuable ecosystem that includes mangrove forests, tidal creeks, mud flats, salt pans, rocky shores, and pure sandy beaches (Afser *et al.*, 2013). Biological diversity faces severe threats, such as destruction of habitat, migration of fauna and changes in species composition, cutting of plants, introduction of exotic species, extreme weather changes, and interaction of local public (Bukhari and Bajwa, 2011; Bajwa and Waseem, 2013; Bajwa *et al.*, 2015). Pakistan is home to a fauna that is distinctive in the environment. Anthropogenic activities such as deforestation, species migration and habitat fragmentation pose

severe threats to biodiversity (Qasim *et al.*, 2017). Hunting, deforestation, wood logging, disturbance by anthropogenic activity and destruction of habitat are the major threats to vertebrate diversity (Khan *et al.*, 2018). Pakistan's coastline has supported both resident and migratory birds. The main reason for migration is the continuous unstable conditions of the environment in the region. Pakistan's coastal wetlands support a large population of migratory waders, egrets, herons, Gulls, terns, plovers and cormorants etc. (Tabassum and Gabol, 2005).

Khan *et al.* (2018) has reported fifteen species of mammals, one hundred thirty four species of birds, three species of amphibians, nineteen reptile species and twenty species of fish fauna in Korangi and Phitti creeks of Karachi. Based on field observations, 92 species of mammals, 373 species of birds, 127 species of herpetofauna were documented from Baluchistan (Ghalib *et al.*, 2019).

The vertebrate biodiversity is declining day by day due to the fluctuation in the climatic conditions. Pollution and industrialization are the fundamental reasons. The coastal line from Thatta district to Baluchistan is composed of different Creeks such as Kharo Creek, Khai Creek, Pitiani Creek, and Hub River. These Creeks are the homeland of varied groups of Birds, Reptiles, Amphibians, Mammals and Fish fauna. The objective of the present study was to evaluate vertebrate diversity and associated threats in selected habitats of Sindh and Baluchistan, Pakistan

MATERIALS AND METHODS

Study area

Surveys were conducted along the selected localities of Sindh and Baluchistan provinces of Pakistan. The studied habitats were visited for two years (August 2017 to August 2019) twice every week. The sites included Khararo Creek, Gharo Creek, Keenjhar Lake, China Creek, Hub River, Sakro Estuaries, Mubarak Village, Manora Island, and Hawks Bay. Each of these ten study sites (Table 1) represented important habitats for a variety of vertebrate life. The studied habitats included sandy flats, salt marshes, estuary pools, lagoons, smooth dunes, mangrove regions, gravel, rock-strewn beaches, cliffs, rocky islands, wastelands, and built-up regions. Various field methods have been employed to document vertebrate diversity.

Table 1. Study sites, coordinates.

S. No.	Sites	Latitude	Longitude
1	Gharo Creek	24.558766"N	67.466298"E
2	Keenjhar Lake	24.56276"N	68.34329"E
3	China Creek	24.834465"N	67.001129"E
4	Sakro Estuary	24.29588"N	67.30039"E
5	Hub River	25.049045"N	66.965427"E
6	Khararo Creek	24.523704"N	67.284475"E
7	Keenjhar Desert	24.56276 "N	68.34327"E
8	Hawke's Bay	24.840401"N	66.909821"E
9	Manora Island	24.794056, "N	66.977528 "E
10	Mubarak Village	24.52245"N	66.40081"E

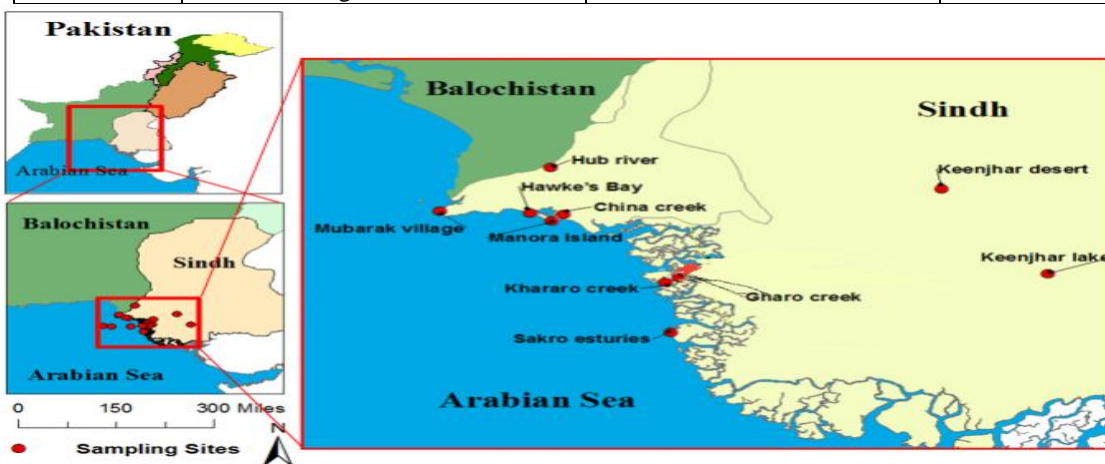


Fig. 1. Map showing study areas of Baluchistan and Sindh, Pakistan.

Techniques used for study of Mammals

Point Surveys, Line Transects, Track Counts, Roadside Counts, Strip Census and Pellet Count Methods were used for the evaluation of mammals' diversity.

In point counting, separate points were chosen as the wildlife observation points present at elevated altitude to record wildlife status. The time length for observation ranged from one hour to five hours. Dawn and dusk time have been discovered appropriate for implementing point count technique. Roadside count was used for observing large mammals (Brower *et al.*, 1990). L, T.M was used to study wild moving animals. Marine mammal surveys were conducted by small ships with a velocity below 12 knots. Pellet counts were used for the estimation of vertebrate species from fecal materials.

Survey method used for Reptiles and Amphibians

The vision examination technique is used to determine whether turtles are present at certain sites. The information was recorded using appropriate sampling regions and transaction steps. The plot search was done in reptiles and amphibians for demographic studies. In the indirect registers of individuals such as fishermen, wildlife representatives, traders, hunters and local authorities (egg-linked excavations), footprints, paths and the existence of fecal pellets, signs like paths, tunnels have been identified (Sutherland, 2006).

Survey of Birds

Comprehensive field studies were also used to document migratory and native birds, using techniques for surveying birds. Techniques of bird wildlife survey for bays, coastal, land and sandy deserts were used for line transects and point surveys. For bird species identification, field facilities and study books have been used. For the recording of bird fauna, DSLR camera, guide book and sound identification had been used (Khan and Khan, 2015; Buckland *et al.*, 2001; Sutherland, 2006).

Fish fauna and water Quality parameters

Fish from separate points were collected using various networks of different dimensions, loops, spell networks, gill networks, dragon and hook nets, and hand network. While collecting fish from various points, pH (through digital pH meter), Temperature with thermometer) and salinity (with the help of Refractometer) were determined on weekly basis according to the methods described by (Whitehead *et al.*, 1986; Saldanha *et al.*, 1995).

Identification

Different systemic and identification keys based on color design, particular spots, and signs of the surface of the body, body shape, composition of distinct fins have been primarily used to identify the fauna (Haseeb *et al.*, 2016).

RESULTS

Water parameter

Mean \pm SD values of water physical parameters including temperature, salinity and pH of the selected habitats are presented in Table 2.

Table 2. Physical parameters of surveyed areas.

S. No.	Sites	Temperature °C	Salinity (ppt)	pH
1	Gharo Creek	28.83 \pm 4.62	33.70 \pm 2.40	7.95 \pm 0.81
2	Keenjhar Lake	27.35 \pm 4.29	0.13 \pm 0.15	8.41 \pm 0.91.
3	China Creek	31.83 \pm 2.63	36.51 \pm 2.50	7.16 \pm 1.30
4	SakroEsturies	29.44 \pm 4.56	20.44 \pm 10.60	7.88 \pm 1.33
5	Hub River	28.55 \pm 4.39	34.91 \pm 4.15	7.63 \pm 1.71
6	Khararo Creek	29.64 \pm 4.17	34.08 \pm 3.87	8.55 \pm 1.36
7	Hawke's Bay	28.44 \pm 4.17	36.04 \pm 1.88	7.66 \pm 1.88
8	Mubarak Village	30.82 \pm 3.44	36.44 \pm 2.40	7.66 \pm 1.20

The identified species are categorized into their respective families and the data of each group has been tabulated separately. Recorded species of mammals were 24 belonging to 11 families (Table 3)

Table 3. List of mammal species recorded during the present study.

Family	Scientific name	Common name	Khararo Creek	Hub River	China Creek	Keenjhar Lake	Gharo Creek
Canidae	<i>Vulpes bengalensis</i>	Bengal Fox	√	x	x	√	X
	<i>Vulpes bengalensis</i>	Bengal Fox	√	x	x	√	X
	<i>Vulpes vulpes</i>	Desert Fox	√	√	x	√	√
Felidae	<i>Felis chaus</i>	Jungle Cat	√	√	x	√	X
	<i>Felis silvestris</i>	Indian Desert Cat	√	x	x	√	X
	<i>Prionailurus viverrina</i>	Fishing Cat	√	√	x	√	X
Herpestidae	<i>Herpestes edwardsi</i>	Grey Mongoose	√	x	x	x	X
	<i>Herpestes javanicus</i>	Small Indian Mongoose	√	√	x	√	X
Leporidae	<i>Lepus nigricollis</i>	Desert Hare	√	√	√	√	X
Megadermatidae	<i>Hipposideros fulvus</i>	Leaf-nosed Bat	√	√	√	√	X
Mustellidae	<i>Lutrogale perspicillata</i>	Smooth-coated Otter	√	x	x	√	X
Manidae	<i>Manis crassicaudata</i>	Indian Pangolin	√	x	x	√	X
Muridae	<i>Rattus rattus</i>	Roof Rat	√	√	√	√	X
	<i>Mus musculus</i>	House Mouse	√	√	√	√	√
	<i>Hystrix indica</i>	Porcupine	√	x	√	√	X
	<i>Mus saxicola</i>	Grey Spiny Mouse	√	√	√	√	X
	<i>Nesokia indica</i>	Short-tailed Mole Rat	√	√	√	√	√
	<i>Meriones hurrianae</i>	Indian Desert Jird	√	√	x	√	X
	<i>Tatera indica</i>	Indian Gerbil	√	√	x	√	X
	<i>Gerbillus nanus</i>	Balochistan Gerbil	x	√	x	x	X
	<i>Bandicota bengalensis</i>	Indian Mole Rat	√	√	√	√	X
	Pteropidae	<i>Rhinopoma microphyllum</i>	Large Mouse-tailed Bat	√	√	x	√
<i>Sus scrofa</i>		Indian Wild Boar	√	√	x	x	X
Viverridae	<i>Viverricula indica</i>	Small Indian Civet	√	√	x	√	√

Reptiles: There were 30 species of reptiles reported in the current survey (Table 4).

Table 4. Checklist of reptile species collected during the current survey.

Family	Scientific name	Common name	Khararo Creek	Hub River	China Creek	Keenjhar Lake	Gharo Creek
Agamidae	<i>Calotes versicolor</i>	Indian Garden Lizard	√	x	x	√	√
	<i>Trapelus megalonyx</i>	Afghan Ground Agama	√	√	√	√	√
	<i>Trapelus agilis</i>	Brilliant Agama	√	√	√	√	√
Boidae	<i>Eryx johnii</i>	Common Sand Boa	√	√	x	√	X
Colubridae	<i>Coluber fasciolatus</i>	Banded Racer	√	√	x	√	X
	<i>Oligodon taeniolatus</i>	Cliff Racer	√	x	x	√	X
	<i>Platyceps ventromaculatus</i>	Glossy-bellied Racer	√	x	x	√	x
	<i>Platyceps rhodorachis</i>	Streaked Kukri Snake	√	√	√	√	√
	<i>Psammophis condanarus</i>	Indian Sand Snake	√	√	x	√	√
	<i>Psammophis leithii</i>	Pakistan Ribbon Snake	√	√	√	x	X
	<i>Psammophis schokari</i>	Afro-Asian Sand Snake	√	√	x	x	X
	<i>Ptyas mucosus</i>	Dhaman	√	√	x	√	X
	<i>Spalerosophis diadema</i>	Royal Snake	√	√	x	√	√
	<i>Oligodon taeniolatus</i>	Cliff Racer	√	x	x	√	X
<i>Xenochrophis piscator</i>	Checkered-keel Back	√	√	√	√	√	

Elapidae	<i>Bungarus caeruleus</i>	Indian Krait	√	√	√	√	√
	<i>Naja naja</i>	Indian Cobra	√	√	x	√	√
Emydidae	<i>Geoclemys hamiltonii</i>	Spotted Pond Turtle	√	x	x	x	X
Elapidae	<i>Bungarus caeruleus</i>	Indian Krait	√	√	√	√	√
	<i>Naja naja</i>	Indian Cobra	√	√	√	√	√
Gekkonidae	<i>Cytodactylus kachhensis</i>	Warty Rock Gecko	√	√	√	√	√
	<i>Cyrtopodion scaber</i>	Keeled Rock Gecko	√	√	√	√	X
	<i>Hemidactylus flaviviridis</i>	Yellow-bellied House	√	√	√	√	√
Lacertidae	<i>Acanthodactylus cantoris</i>	Indian Fringe-toed Lizard	√	√	√	√	√
Scincidae,	<i>Ophiomorus tridactylus,</i>	Three-toed Sand Swimmer	√	√	√	√	√
Varanidae,	<i>Varanus griseus,</i>	Desert Monitor Lizard	√	√	√	√	√
	<i>Varanus bengalensis</i>	Indian Monitor lizard	√	x	x	x	X
Viperidae	<i>Echis carinatus</i>	Saw-scaled Viper	√	√	√	√	√
	<i>Daboia russelii</i>	Russell's Viper	√	√	√	√	√
Uromastycidae,	<i>Saara hardwickii</i>	Indian Spiny-tailed Lizard	√	√	√	√	√

Amphibians: Skittering frog and marbled toad were reported during field surveys (Table 5).

Table 5. List of amphibian species recorded during the present study.

Family	Scientific name	Common name	Khararo Creek	Hub River	China Creek	Keenjhar Lake	Gharo Creek
Bufonidae	<i>Bufo stomaticus</i>	Indus or Marbled Toad	√	√	√	√	√
Ranidae	<i>Euphlyctis cyanophlyctis</i>	Skittering Frog	√	x	√	√	√

Birds: The recorded species of birds are 184 from Keenjhar Lake and different coastal areas including aquatic birds, raptors, passerines birds and game birds (Table 6).

Table 6. Checklist of bird species.

Family	Scientific name	Common name	Khararo Creek	Hub River	China Creek	Keenjhar Lake	Gharo Creek
Ardeidae	<i>Ixobrychus sinensis</i>	Yellow Bittern	x	√	X	√	X
	<i>Ardea alba</i>	Great White Egret	x	x	√	√	√
	<i>Ardea cinerea</i>	Grey Heron	√	√	X	√	X
	<i>Ardea purpurea</i>	Purple Heron	√	x	X	√	X
	<i>Ardeola grayii</i>	Pond Heron	√	x	X	√	X
	<i>Bubulcus ibis</i>	Cattle Egret	√	x	X	√	X
	<i>Egretta gularis</i>	Western Reef Heron	√	x	X	√	√
	<i>Egretta garzetta</i>	Little Egret	√	√	x	√	√
	<i>Egretta intermedia</i>	Intermediate Egret	√	√	√	√	X
	<i>Ixobrychus cinnamomeus</i>	Chestnut Bittern	x	x	x	√	X
	<i>Dupetor flavicollis</i>	Black Bittern	√	√	x	√	X
	<i>Nycticorax nycticorax</i>	Night Heron	x	x	√	x	X
Accipitridae	<i>Elanus caeruleus</i>	Black-winged Kite	x	√	√	√	X
	<i>Aegypius monachus</i>	Cinereous Vulture	√	x	x	x	X
	<i>Milvus migrans</i>	Black Kite	x	x	x	√	+
	<i>Haliastur Indus</i>	Brahminy Kite	x	√	x	√	X
	<i>Haliaeetus albicilla</i>	White-tailed Sea Eagle	√	√	x	√	√

	<i>Haliaeetus leucoryphus</i>	Pallas's Fishing Eagle	√	√	√	√	√
	<i>Gyps bengalensis</i>	White-backed Vulture	√	√	√	√	X
	<i>Gyps fulvus</i>	Griffon Vulture	√	x	x	√	X
	<i>Aquila clanga</i>	Greater Spotted Eagle	√	x	x	√	X
	<i>Aquila nipalensis</i>	Steppe Eagle	x	x	x	√	X
	<i>Aquila rapax</i>	Tawny Eagle	x	x	x	√	X
	<i>Aquila heliaca</i>	Imperial Eagle	x	x	x	√	X
	<i>Circus gallicus</i>	Short-toed Eagle	x	x	x	√	X
	<i>Circus aeruginosus</i>	Marsh Harrier	x	x	x	√	X
	<i>Circus macrourus</i>	Pallid Harrier	x	x	x	√	X
	<i>Accipiter badius</i>	Shikra	√	x	x	√	X
	<i>Butastur teesa</i>	White-eyed Buzzard	x	x	x	√	X
	<i>Buteo buteo</i>	Desert Buzzard	x	√	x	√	X
	<i>Buteo rufinus</i>	Long-legged Buzzard	√	x	x	√	X
	<i>Hieraetus pennatus</i>	Booted Eagle	√	x	x	x	X
	<i>Hieraetus fasciatus</i>	Bonelli's Eagle	x	x	x	√	X
Anatidae	<i>Dendrocygna javanica</i>	Lesser Whistling Teal	√	√	√	x	√
	<i>Dendrocygna bicolor</i>	Greater Whistling Teal	√	x	x	√	X
	<i>Cygnus columbianus</i>	Bewick's Swan	√	x	√	√	√
	<i>Anser erythropus</i>	Lesser White-fronted Goose	√	x	√	√	√
	<i>Tadorna ferruginea</i>	Ruddy Shelduck	√	√	x	x	X
	<i>Tadorna tadorna</i>	Common Shelduck	x	√	x	√	X
	<i>Anas acuta</i>	Pintail	x	x	√	√	X
	<i>Anas Penelope</i>	Wigeon	√	x	x	√	√
	<i>Anas crecca</i>	Common Teal	√		x	√	-
	<i>Anas Strepera</i>	Gadwall	-	√	x	√	√
	<i>Anas platyrhynchos</i>	Mallard	√	x	√	√	X
	<i>Anas querquedula</i>	Garganey	x	x	x	√	X
	<i>Anas poecilorhyncha</i>	Spotbill Duck	√	√	x	√	√
	<i>Anas clypeata</i>	Shoveller	√	√	x	√	-
	<i>Aythya ferina</i>	Common Pochard	√	√	x	√	√
	<i>Aythya nyroca</i>	White-eyed Pochard	√	x	x	√	√
	<i>Aythya fuligula</i>	Tufted Duck	x	√	x	x	X
	<i>Aythya marila</i>	Scaup	√	x	x	x	X
	<i>Netta rufina</i>	Red-crested Pochard	√	x	x	√	X
	<i>Natta puscoromandelianus</i>	Pygmy Cotton Teal	x	x	x	√	X
	<i>Marmaronetta angustirostris</i>	Marbled Teal	√	√	x	√	X
Apodidae	<i>Apus affinis</i>	House Swift	√	√	√	√	√
Alcedinidae	<i>Ceryle rudis</i>	Lesser Pied Kingfisher	√	√	√	√	√
	<i>Alcedo atthis</i>	Common	√	√	x	√	X

		Kingfisher					
	<i>Halcyon smyrnensis</i>	White-breasted Kingfisher	√	x	x	√	X
Ciconiidae	<i>Anastomus oscitans</i>	Openbill Stork	√	√	√	√	X
Charadriidae	<i>Charadrius leucurus</i>	White-tailed Lapwing	√	√	x	x	√
	<i>Charadrius dubius</i>	Little Ringed Plover	√	√	x	√	X
	<i>Charadrius alexandrinus</i>	Kentish Plover	√	x		√	X
	<i>Pluvialis squatarola</i>	Black-bellied Plover	√	x	x	√	X
	<i>Pluvialis dominica</i>	Eastern Golden Plover	x	x	x	√	X
	<i>Vanellus vanellus</i>	Green Plover	x	√	x	√	X
	<i>Vanellus indicus</i>	Red-wattled Lapwing	√	x	√	√	X
	<i>Vanellus malabaricus</i>	Yellow-wattled Lapwing	√	x	x	√	X
Corvidae	<i>Corvus splendens</i>	House Crow	√	√	√	√	√
Caprimulgidae	<i>Caprimulgus asiaticus</i>	Indian Little Night jar	x	x	√	√	X
	<i>Caprimulgus mahrattensis</i>	Syke's Nightjar	x	√	x	√	X
Cuculidae	<i>Clamator jacobinus</i>	Pied-crested Cuckoo	x	x	x	√	X
	<i>Eudynamis scolopacea</i>	Koel	x	x	x	√	X
	<i>Centropus sinensis</i>	Greater Coucal or Crow	x	x	√	√	X
Columbidae	<i>Columba livia</i>	Blue Rock Pigeon	√	x	√	√	√
	<i>Columba eversmanni</i>	Eastern Rock Pigeon	√	x	√	√	√
	<i>Treron phoenicoptera</i>	Yellow-legged Green	x	x	√	√	√
	<i>Streptopelia decaocto</i>	Collared Turtle Dove	x	x	x	x	√
	<i>Streptopelia tranquebarica</i>	Red Turtle Dove		x	x	√	X
	<i>Streptopelia senegalensis</i>	Little Brown Dove	√	x	x	√	X
Dicruridae	<i>Dicrurus macrocercus</i>	Black Drongo/ King crow	√	√	√	√	√
Estrildidae	<i>Lonchura malabarica</i>	White-throated Munia	√	x	x	√	X
Fringillidae	<i>Fringilla montifringilla</i>	Brambling	√	x	x	√	X
	<i>Bucanetes githagineus</i>	Trumpeter Finch	√	x	x	x	√
Falconidae	<i>Falco tinnunculus</i>	Kestrel	x	x	x	√	X
	<i>Falco chicquera</i>	Red-headed Merlin	x	x	x	√	X
Gruidae	<i>Grus grus</i>	Common Crane	√	√	x	√	√
	<i>Grus virgo</i>	Demoiselle Crane	√	√	x	x	X
Hirundinidae	<i>Riparia paludicola</i>	Plain Martin	x	x	x	√	X
	<i>Hirundo rustica</i>	Barn Swallow	√	x	x	√	X
	<i>Hirundo smithii</i>	Wire-tailed Swallow	x	x	x	√	X
	<i>Hirundo daurica</i>	Red-rumped Swallow	√	√	√	√	X
Jacaniidae	<i>Hydrophasianus chirurgus</i>	Pheasant-tailed	x	√	x	√	X

		Jacana					
	<i>Metopidius indicus</i>	Bronze-winged Jacana	x	x	x	√	X
Laridae	<i>Larus argentatus</i>	Herring Gull	x	x	x	√	X
	<i>Larus heuglini</i>	Heuglin's Gull	x	x	x	√	X
	<i>Larus ichthyaetus</i>	Great Black-headed Gull	√	x	x	√	X
	<i>Larus brunnicephalus</i>	Brown-headed Gull	√	x	√	√	X
	<i>Larus ridibundus</i>	Black-headed Gull	x	x	√	√	X
	<i>Larus genei</i>	Slender-billed Gull	x	x	√	√	X
	<i>Larus canus</i>	Common Gull	x	x		√	X
Laniidae	<i>Lanius isabellinus</i>	Isabelline Shrike	x	x	√	√	X
	<i>Lanius schach</i>	Rufous-backed Shrike	x	x	x	√	X
Meropidae	<i>Merops persicus</i>	Blue-cheeked Bee-eater	√	x	√	√	X
	<i>Merops orientalis</i>	Green Bee-eater	√	x	√	x	X
Motacillidae	<i>Anthus trivialis</i>	Tree Pipit	x	x	√	√	√
	<i>Motacilla flava</i>	Yellow Wagtail	√	x	x	x	X
	<i>Motacilla citreola</i>	Yellow-headed Wagtail	x	x	√	x	X
Podicipedidae	<i>Podiceps cristatus</i>	Great Crested Grebe	x	x	x	√	√
	<i>Tachybaptus ruficollis</i>	Little Grebe	x	x	x	√	√
Phalacrocoracidae	<i>Phalacrocorax carbo</i>	Great Cormorant	√	x	x	√	√
	<i>Anhinga melanogaster</i>	Snake Bird	x	x	x	x	√
	<i>Phalacrocorax fuscicollis</i>	Indian Shag	√	x	√	√	X
	<i>Phalacrocorax niger</i>	Little Cormorant	x	x	x	√	X
Pelecanidae	<i>Pelecanus onocrotalus</i>	White Pelican	x	x	x	√	X
	<i>Pelecanus crispus</i>	Dalmatian Pelican	x	x	x	√	√
Phoenicopteridae	<i>Phoenicopterus roseus</i>	Greater Flamingo	√	x	x	√	X
Pandionidae	<i>Pandion haliaetus</i>	Osprey	x	x	x	√	√
Phasianidae	<i>Francolinus francolinus</i>	Black Partridge	x	x	x	√	X
	<i>Francolinus pondicerianus</i>	Grey Partridge	x	√	x	√	√
	<i>Coturnix coturnix</i>	Common Quail	x	√	√	√	X
Psittacidae	<i>Psittacula krameri</i>	Rose-Ringed Parakeet	x	x	√	√	X
Picidae	<i>Dinopium bengalensis</i>	Lesser Golden-backed	x	x	x	√	X
	<i>Picoides ssimillis</i>	Woodpecker	√	√	x	x	X
Pycnonotidae	<i>Pycnonotus leucogenys</i>	White-cheeked Bulbul	√	√	√	√	√
	<i>Pycnonotus cafer</i>	Red-vented Bulbul	√	√	√	√	√
Passeridae	<i>Passer domesticus</i>	House Sparrow	√	√	√	√	√
	<i>Passer hispaniolensis</i>	Spanish Sparrow	√	√	√	√	√
	<i>Passer pyrrhonotus</i>	Sindh Jungle Sparrow	√	√		√	
	<i>Petronia xanthocollis</i>	Yellow-throated Sparrow	√	√	√	√	√
Ploceidae	<i>Ploceus philippinus</i>	Baya/Weaver Bird	√	x	x	√	X
	<i>Ploceus manyar</i>	Streaked Weaver	x	x	x	√	X
Rhynchopidae	<i>Rynchops albicollis</i>	Indian Skimmer	√	x	x	√	X

	<i>Pterocles exustus</i>	Chestnut-bellied	x	x	x	√	X
Rallidae	<i>Porzana porzana</i>	Spotted Crane	x	x	x	√	X
	<i>Amaurornis phoenicurus</i>	White-breasted Waterhen	x	√	x	√	X
	<i>Gallinula chloropus</i>	Indian Moorhen	x	x	x	√	√
	<i>Gallicrex cinerea</i>	Water cock	√	x	x	√	X
	<i>Rallus aquaticus</i>	Water Rail	√	x	x	√	√
	<i>Fulica atra</i>	Coot					
Recurvirostridae	<i>Himantopus himantopus</i>	Black-winged Stilt	√	√	x	√	X
	<i>Glareola pratincola</i>	Collared Pratincole	x	x	x	√	X
Sturnidae	<i>Sturnus vulgaris</i>	Common Starling	√	x	x	√	X
	<i>Sturnus roseus</i>	Rosy Pastor	√	x	x	√	X
	<i>Acridotheres tristis</i>	Indian Myna	√	x	x	√	X
	<i>Acridotheres ginginianus</i>	Bank Myna	√	x	x	√	X
Sylviidae	<i>Sylvia nana</i>	Desert Warbler	√	x	x	√	√
	<i>Sylvia hortensis</i>	Orphean Warbler	√	x	x	√	√
	<i>Sylvia curruca</i>	Lesser Whitethroat	x	x	√	√	X
	<i>Sylvia communis</i>	Common White throat	+	x	√	√	X
	<i>Cettia cetti</i>	Cetti's Warbler	x	x	√	√	√
Strigidae	<i>Otus bakkamoena</i>	Collared Scops Owl	x	√	x	x	X
	<i>Bubo bubo</i>	Eagle Owl	x	√	x	√	√
Sternidae	<i>Chlidonias hybridus</i>	Whiskered Tern	x	x		x	X
	<i>Chlidonias leucoptera</i>	White-winged Black Tern	x	√	x	√	X
	<i>Gelochelidon nilotica</i>	Gull-billed Tern	√	√	√	√	√
	<i>Hydroprogne caspia</i>	Caspian Tern	√	x	x	√	X
	<i>Sterna aurentia</i>	River Tern	√	x	x	√	X
	<i>Sterna albifrons</i>	Little Tern	√	x	x	√	X
	<i>Sterna acuticauda</i>	Black-bellied Tern	x	x	x	√	X
	<i>Sterna bergii</i>	Large Crested Tern	x	x	x	√	X
Scolopacidae	<i>Calidris minuta</i>	Little Stint	√	x	x	√	X
	<i>Calidris temminckii</i>	Temminck's Stint	x	√	x	√	X
	<i>Calidris alpina</i>	Dunlin	x	x	x	√	X
	<i>Philomachus pugnax</i>	Ruff	√	x	x	√	X
	<i>Capella gallinago</i>	Common Snipe	√	x	x	x	X
	<i>Limosa limosa</i>	Black-tailed Godwit	x		x	√	X
	<i>Numenius arquata</i>	Curlew	√	x	x	√	X
	<i>Numenius phaeopus</i>	Whimbrel	x	x	x	√	√
	<i>Tringa erythropus</i>	Spotted Redshank	√	√	x	√	X
	<i>Tringa tetanus</i>	Redshank	x	x	x	√	X
	<i>Tringa stagnatilis</i>	Marsh Sandpiper	√	x	x	√	X
	<i>Tringa nebularia</i>	Greenshank	x	x	√	√	√
	<i>Tringa ochropus</i>	Green Sandpiper	x	x	x	√	X
	<i>Tringa glareola</i>	Wood Sandpiper	√	x	x	√	X
	<i>Tringa hypoleucos</i>	Common Sandpiper	x	x	x	√	X
Turdidae	<i>Phoenicurus ochruros</i>	Black Redstart	x	√	√	√	X
Threskiornithidae	<i>Plegadis falcinellus</i>	Glossy Ibis	√		√	√	√
	<i>Threskiornis melanocephalus</i>	White Ibis	√	√	√	√	X
	<i>Platalea leucorodia</i>	Spoonbill	√	x	x	√	X

Alaudidae	<i>Mirafra erythroptera</i>	Indian/Red-Winged Bush	x	x	x	√	X
	<i>Eremopterix grisea</i>	Ashy-crowned Finch	x	√	x	√	X
	<i>Eremopterix nigriceps</i>	Black-crowned Finch	x	x	x	√	X
Nectariniidae	<i>Nectarinia asiatica</i>	Purple Sunbird	√	x	√	√	X
Timaliidae	<i>Turdoides caudatus</i>	Common Babbler	√	√		√	√

Status of the avifauna: The status of birds recorded was as native eighty two, Winter Visitors seventy three, Summer Visitors eight, Summer Breeding Visitors eight and Migrants thirteen (Table 7).

Table 7. Status of avifauna during 2019 at selected areas of Sindh and Baluchistan.

No.	Category	Species
1	R	82
2	WV	73
3	SV	08
4	SBV	08
5	M	13
Total		184

R=Residents WV=Winter Visitors SV=Summer Visitors SBV=Summer Breeding Visitors' M=Migrants

Fishes: During the present survey, 4241 individuals of different fish species were captured belonging to 25 species and 16 families. Best represented was family Lutjanidae (3 species), distantly followed by Sparidae, Serranidae, and Ariidae (3 species), the remaining 12 families were represented by one species each. Freshwater fish captured in Keenjhar lake including 6 order 7 Family and 19 species. The most important and rare fish species were *Acanthopagrus latus*, *Acanthopagrus malabaricus*, *Lutjanus argentimaculatus*, *Lutjanus johnii*, *Lates calcarifer*, *Acanthopagrus berda*, *Acanthopagrus bifasciatus* and freshwater *Labeo rohita*, *Catla catla*, *Rita rita*, *Ctenopharyngodon idella*, *Cyprinus carpio*, *Oncorhynchus mykiss* (Table 8, 9).

Table 8. Recorded fish from selected habitats of the study area.

Species	Khararo Creek	Hub River	Gharo Creek	China Creek to Manora point
	N	N	N	N
<i>Mugil cephalus</i>	-	400	-	10
<i>Lutjanus argentimaculatus</i>	8	4	-	-
<i>Lutjanus malabaricus</i>	2	-	-	-
<i>Lates calcarifer</i>	120	-	-	-
<i>Chanos chanos</i>	400	-	-	-
<i>Ilisha melastoma</i>	200	-	-	6
<i>Sillago sihama</i>	10	-	8	-
<i>Arius arius</i>	20	12	-	-
<i>Netuma thalassina</i>	50	-	70	20
<i>Arius maculatus</i>	60	-	-	-
<i>Pomadasys kaakan</i>	2	-	-	-
<i>Lutjanus johnii</i>	10	-	2	-
<i>Nemipterus japonicus</i>	6	-	-	-
<i>Epinephelus coioides</i>	5	-	-	4
<i>Epinephelus tauvina</i>	20	18	-	4
<i>Epinephelus diacanthus</i>	10	-	12	-
<i>Acanthopagrus berda</i>	120	40	42	6
<i>Acanthopagrus latus</i>	40	80	-	-
<i>Acanthopagrus bifasciatus</i>	36	-	10	-
<i>Otolithes ruber</i>	-	-	6	-
<i>Terapon jarbua</i>	40	-	50	-

<i>Rastrelliger kanagurta</i>	6	8	-	4
<i>Nematalosa nasus</i>	800	200	-	-
<i>Liza subviridis</i>	900	200	30	-
<i>Platycephalus indicus</i>	10	120	-	-

Table 9. List of freshwater fishes recorded in Keenjhar Lake.

Order	Family	Scientific name
Beloniformes	Belonidae	<i>Xenentodon cancila</i>
Cypriniformes	Cyprinidae	<i>Catla catla</i>
=	=	<i>Cirrhinus mrigala</i>
=	=	<i>Labeo bata</i>
=	=	<i>Ctenopharyngodon idella</i>
=	=	<i>Cyprinus carpio</i>
=	=	<i>Labeo rohita</i>
Perciformes	Chandidae	<i>Ambassis nama</i>
=	=	<i>Ambassis ranga</i>
Siluriformes	Bagridae	<i>Rita rita</i>
=	Siluridae.	<i>Ompok pabda</i>
=	Siluridae	<i>Wallago attu</i>
=	Bagridae	<i>Mystus bleekeri</i>
=	=	<i>Mystus cavasius</i>
=	=	<i>Mystus vittatus</i>
=	=	<i>Sperata seenghala</i>
=	=	<i>Clarias batrachus</i>
Salmoniformes	Salmonidae	<i>Oncorhynchus mykiss</i>
Synbranchiformes	Mastacembelidae	<i>Macrognathus oral</i>

DISCUSSION

The present survey on of vertebrate fauna was carried out from August 2017 to August 2019 in the selected areas of Sindh and Baluchistan, Pakistan. A total of twenty four 24 mammalian species included to 11 families, 30 reptilian species belonging to 12 families, 184 bird species belonging to 46 families, 19 freshwater fishes belonging to 7 families and 25 marine and euryhaline fish species belonging to 16 families were recorded . In a previous study, Khan *et al.* (2018) reported 134 species of avifauna and three species of amphibians, 19 species of reptiles, 15 mammal species, and twenty species of fishes were reported in two Creeks, Korangi Creek and Phitti Creek, Sindh, Pakistan. Ghalib *et al.* (2018) has reported 76 species of avifauna from Bhambore area, Gharo Creek, Thatta, Sindh, Pakistan. In another study by Ghalib *et al.* (2017), a total of 160 species of avifauna has been documented from the creeks of Sindh but in the current study, we have reported 184 species of avifauna from the Creeks and Keenjhar lake of Sindh and Baluchistan, Pakistan. Some of the species of vertebrate fauna were reported by previous authors but have not been recorded in the present study. The difference may be due to climate change, habitat loss, deforestation, pollution and increased developmental activities in the coastal areas that may have caused the difference in the vertebrate fauna. Ghalib *et al.* (2019) has reported 92 species of mammals, 373 birds, 120 reptiles and 7 species of amphibians from Baluchistan.

Khan *et al.* (2010) has recorded 3 marine turtle’s species from Karachi Coast. During the current study, these fauna were not recorded as there were no appropriate habitats available in the study region for marine turtles. This shows the impact of habitat loss since 2010 till 2019 that has caused disappearance of various vertebrate species from the study area. Zahidullah *et al.* (2016) has reported that human activities transform the habitats and the species finally transfer from their native habitats. Korai *et al.* (2008) has recorded 51 fish species in Keenjhar Lake. In the present study, only 19 species of fishes were recorded from Keenjhar Lake. The decline again is associated with anthropogenic activities. Ahmed *et al.* (1999) has reported 4 freshwater fish species and 9 marine water species collected from Khararo Creek. They reported salinity from 3 to 20 ppt in Gharo Creek. In the present study, salinity was recorded from 7 to 40 ppt at Khararo Creek. The increase in salinity has caused a decline in the freshwater vertebrate fauna. In the present study, the larger number of marine fishes compared with fresh water fishes shows the increased salinity in the freshwater habitats that have resulted in the decline of freshwater fauna and an increase in the marine and saline fauna.

In a recent study by Khan *et al.* (2018) at Lal Suhanra National Park, Pakistan, the decline in vertebrate fauna was attributed to hunting, deforestation, wood logging, and disturbance by anthropogenic activities and destruction of habitats.

Mubarak Village, Hawks bay which is one of the only beaches in Pakistan where *Chelonia mydas* come to lay eggs. Some industrial effluents in Mubarak village have many organic and inorganic contaminants, petroleum hydrocarbons, pesticides, antifouling agents and heavy metals. These particles are non-biodegradable and very slow rate of elimination results in the decline of associated fauna.

THREATS

Changes in the environment and climate and natural disasters are also significant threats to the survival of vertebrate biodiversity. Pollution, water contamination with industrial, agricultural, or domestic waste, sprays of pesticides, fertilizers, global warming, and pathogens all threaten the current of aquatic biota. There is a main reduction of aquatic avifauna visit to Sea, Creeks areas due to hunting, habitat degradation, habitat loss hunting/trapping/ bird poaching, vegetation cutting/clearance (Sindh and Baluchistan coastal region) and disturbance and unsustainable fishing methods. Diversity of species and their numbers have decreased significantly over the past few years primarily owing to habitat crush owing to land reclaim on the coastal region. One of the most prominent threats to frogs and toads in Pakistan is rapid urbanization and industrialization. Suitable reptile and amphibian breeding habitats have been destroyed by rapid construction of vast industrial fields and housing systems. Because of habitation obliteration and company use, the species of bull frog has declined. The main threats to biodiversity are human activities, pollution, oil leakage, industrialization, over-exploitation, electric current and boat repairing. Polythene bags do not compress even for many years and result in the decline of vertebrate fauna.

Conclusion: The present study shows that coastal areas of Sindh and Baluchistan have a rich diversity of vertebrate fauna. The fluctuations in the diversity of vertebrate fauna are due to increased salinity, habitat loss, industrial effluents, illegal hunting and increased anthropogenic activities. It is recommended that conservation measures should be adopted on top priority to protect biodiversity from further decline and extinction.

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