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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 quadrate 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 Molur, 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, tens, 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

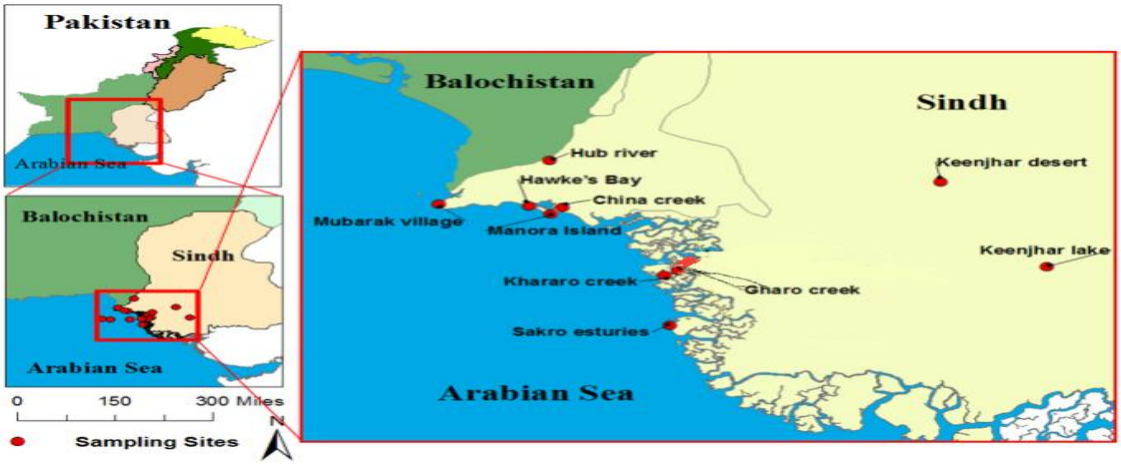

Fig. 1. Map showing study areas of Baluchistan and Sindh, Pakistan.

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 excayments), footprints, paths and the existence of fecal pallets, 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 ± 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 ± 4.62	33.70 ± 2.40	7.95 ± 0.81
2	Keenjhar Lake	27.35 ± 4.29	0.13 ± 0.15	8.41 ± 0.91.
3	China Creek	31.83 ± 2.63	36.51 ± 2.50	7.16 ± 1.30
4	SakroEsturies	29.44 ± 4.56	20.44 ± 10.60	7.88 ± 1.33
5	Hub River	28.55 ± 4.39	34.91 ± 4.15	7.63 ± 1.71
6	Khararo Creek	29.64 ± 4.17	34.08 ± 3.87	8.55 ± 1.36
7	Hawke's Bay	28.44 ± 4.17	36.04 ± 1.88	7.66 ± 1.88
8	Mubarak Village	30.82 ± 3.44	36.44 ± 2.40	7.66 ± 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	*Vulpes bengalensis*	Bengal Fox	√	x	x	√	X
	Vulpes bengalensis	Bengal Fox	√	x	x	√	X
	Vulpes vulpes	Desert Fox	√	√	x	√	√
Felidae	*Felis chaus*	Jungle Cat	√	√	x	√	X
	Felis silvestris	Indian Desert Cat	√	x	x	√	X
	Prionailurus viverrina	Fishing Cat	√	√	x	√	X
Herpestidae	*Herpestes edwardsi*	Grey Mongoose	√	x	x	x	X
	Herpestes javanicus	Small Indian Mongoose	√	√	x	√	X
Leporidae	*Lepus nigricollis*	Desert Hare	√	√	√	√	X
Megadernatidae	*Hipposideros fulvus*	Leaf-nosed Bat	√	√	√	√	X
Mustellidae	*Lutrogale perspicillata*	Smooth-coated Otter	√	x	x	√	X
Manidae	*Manis crassicaudata*	Indian Pangolin	√	x	x	√	X
Muridae	*Rattus rattus*	Roof Rat	√	√	√	√	X
	Mus musculus	House Mouse	√	√	√	√	√
	Hystrix indica	Porcupine	√	x	√	√	X
	Mus saxicola	Grey Spiny Mouse	√	√	√	√	X
	Nesokia indica	Short-tailed Mole Rat	√	√	√	√	√
	Meriones hurrianae	Indian Desert Jird	√	√	x	√	X
	Tatera indica	Indian Gerbil	√	√	x	√	X
	Gerbillus nanus	Balochistan Gerbil	x	√	x	x	X
	Bandicota bengalensis	Indian Mole Rat	√	√	√	√	X
Pteropidae	*Rhinopoma microphyllum*	Large Mouse-tailed Bat	√	√	x	√	√
Suidae	*Sus scrofa*	Indian Wild Boar	√	√	x	x	X
Viverridae	*Viverricula indica*	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	*Calotes versicolor*	Indian Garden Lizard	√	x	x	√	√
	Trapelus megalonyx	Afghan Ground Agama	√	√	√	√	√
	Trapelus agilis	Brilliant Agama	√	√	√	√	√
Boidae	*Eryx johnii*	Common Sand Boa	√	√	x	√	X
Colubridae	*Coluber fasciolatus*	Banded Racer	√	√	x	√	X
	Oligodon taeniolatus	Cliff Racer	√	x	x	√	X
	Platyceps ventromaculatus	Glossy-bellied Racer	√	x	x	√	x
	Platyceps rhodorachis	Streaked Kukri Snake	√	√	√	√	√
	Psammophis condanarus	Indian Sand Snake	√	√	x	√	√
	Psammophis leithii	Pakistan Ribbon Snake	√	√	√	x	X
	Psammophis schokari	Afro-Asian Sand Snake	√	√	x	x	X
	Ptyas mucosus	Dhaman	√	√	x	√	X
	Spalerosophis diadema	Royal Snake	√	√	x	√	√
	Oligodon taeniolatus	Cliff Racer	√	x	x	√	X
	Xenochrophis piscator	Checkered-keel Back	√	√	√	√	√

Elapidae	*Bungarus caeruleus*	Indian Krait	√	√	√	√	√
	Naja naja	Indian Cobra	√	√	x	√	√
Emydidae	*Geoclemys hamiltonii*	Spotted Pond Turtle	√	x	x	x	X
Elapidae	*Bungarus caeruleus*	Indian Krait	√	√	√	√	√
	Naja naja	Indian Cobra	√	√	√	√	√
Gekkonidae	*Cytodactylus kachhensis*	Warty Rock Gecko	√	√	√	√	√
	Cyrtopodion scaber	Keeled Rock Gecko	√	√	√	√	X
	Hemidactylus flaviviridis	Yellow-bellied House	√	√	√	√	√
Lacertidae	*Acanthodactylus cantoris*	Indian Fringe-toed Lizard	√	√	√	√	√
Scincidae,	*Ophiomorus tridactylus,*	Three-toed Sand Swimmer	√	√	√	√	√
Varanidae,	*Varanus griseus,*	Desert Monitor Lizard	√	√	√	√	√
	Varanus bengalensis	Indian Monitor lizard	√	x	x	x	X
Viperidae	*Echis carinatus*	Saw-scaled Viper	√	√	√	√	√
	Daboia russelii	Russell's Viper	√	√	√	√	√
Uromastycidae**,**	*Saara hardwickii*	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	*Bufo stomaticus*	Indus or Marbled Toad	√	√	√	√	√
Ranidae	*Euphlyctis cyanophlyctis*	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	*Ixobrychus sinensis*	Yellow Bittern	x	√	X	√	X
	Ardea alba	Great White Egret	x	x	√	√	√
	Ardea cinerea	Grey Heron	√	√	X	√	X
	Ardea purpurea	Purple Heron	√	x	X	√	X
	Ardeola grayii	Pond Heron	√	x	X	√	X
	Bubulcus ibis	Cattle Egret	√	x	X	√	X
	Egretta gularis	Western Reef Heron	√	x	X	√	√
	Egretta garzetta	Little Egret	√	√	x	√	√
	Egretta intermedia	Intermediate Egret	√	√	√	√	X
	Ixobrychus cinnamomeus	Chestnut Bittern	x	x	x	√	X
	Dupetor flavicollis	Black Bittern	√	√	x	√	X
	Nycticorax nycticorax	Night Heron	x	x	√	x	X
Accipitridae	*Elanus caeruleus*	Black-winged Kite	x	√	√	√	X
	Aegypius monachus	Cinereous Vulture	√	x	x	x	X
	Milvus migrans	Black Kite	x	x	x	√	+
	Haliastur Indus	Brahminy Kite	x	√	x	√	X
	Haliaeetus albicilla	White-tailed Sea Eagle	√	√	x	√	√

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

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

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

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

Alaudidae	*Mirafra erythroptera*	Indian/Red-Winged Bush	x	x	x	√	X
	Eremopterix grisea	Ashy-crowned Finch	x	√	x	√	X
	Eremopterix nigriceps	Black-crowned Finch	x	x	x	√	X
Nectariniidae	*Nectarinia asiatica*	Purple Sunbird	√	x	√	√	X
Timaliidae	*Turdoides caudatus*	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.

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

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

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

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

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 no compress even for many year 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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