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BIODIVERSITY AND ECOLOGY OF THE HERPETOFAUNA OF CHOLISTAN DESERT, PAKISTAN

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Present studies are aimed to document the herpetofauna of Cholistan Desert and study its ecology. During the last three years from 2001 to 2003, attempts have been made to collect and observe the amphibians and reptiles in different parts of Cholistan Desert. More than four thousand specimens belonging to 44 species have so far been collected/observed from the study area. Among different collecting techniques adopted for these studies, "Pit-fall" traps and "Hand Picking" showed best results. The voucher specimens have been catalogued and are presently lying with Pakistan Museum of Natural History, Islamabad.

Keywords: Amphibians, Reptiles, ecology, Cholistan Desert, Pakistan.

INTRODUCTION

Lying on the eastern side of the Indus River and southern and southeastern side of Sutlej River, Cholistan Desert is the northwestern limit of Thar Desert or Great Indian Desert. This is a plain of gently undulating sand hills. Elevations are generally below 150 m. Archeological evidence shows that the region was better watered as recently, through the flow of historic Hakra River. The dry watercourse is still represented in Cholistan Desert (Map 1).

Cholistan Desert comprised of 2.6 million ha (FAO, 1993; Akbar et al., 1996). Cholistan desert has a length of about 480 km while the width varies from 32 to 192 km (Khan, 1987; Chaudhry, 1992). Based on the topography, parent material, soil and vegetation, the whole Cholistan desert is divided into two geomorphic regions. The northern region or "Lesser Cholistan" borders canal irrigated areas and covers about 7770 km^2 and the southern region or Greater Cholistan is comprised at 18,130 km^2 (Baig et al., 1980; Khan, 1987; Ahmed et al., 1992; Arshad and Rao, 1994). The lesser Cholistan consists of saline alluvial flats (locally called dahars) alternating with low sandy ridges. The clayey flats of lesser Cholistan are generally homogenous to a depth ranging from 30 to 90 cm. These soils are classified as either saline or saline-sodic, with pH ranging from 8.2 to 8.4 and from 8.8 to 9.6, respectively. The Greater Cholistan is a wind resorted sandy desert and comprised of river terraces, large sand dunes, ridges and depressions (Baig et al., 1980; Khan, 1987; Arshad and Rao, 1994). The dunes reach an average height of about 100 m (Arshad and Rao, 1994; Akbar et al., 1996).

Most of the herpetological studies carried out in Pakistan are either old or mainly restricted to the Sind and Balochistan provinces of Pakistan (Murray, 1884, 1886; Boulenger, 1920; Smith, 1933, 1935, 1943; Minton, 1966; Mertens, 1969). The other subsequent and relatively recent studies (Dubois and Khan, 1979; Khan, 1985, 1991, 1993a, 1993b; Khan and Baig, 1988, 1992; Baig, 1988a, 1988b, 1988c, 1989, 1990, 1992, 1996, 1997, 1998a, 1998b, 2004; Khan and Tasnim, 1990; Baig and Böhme, 1991, 1996) have been made to unveil the herpetological wealth of Pakistan. Except Khan (1985), unfortunately all others are related to the parts of Pakistan, other than Cholistan. Khan (1985) documented 15 species from the area. Present attempt is being made to explore the Cholistan Desert, a distinct and extremely important area of Pakistan.

MATERIAL AND METHODS

Extensive surveys of the study area have been made to observe and collect the amphibians and reptiles. Different collecting techniques were practiced for the procurement of voucher specimens from the area. To

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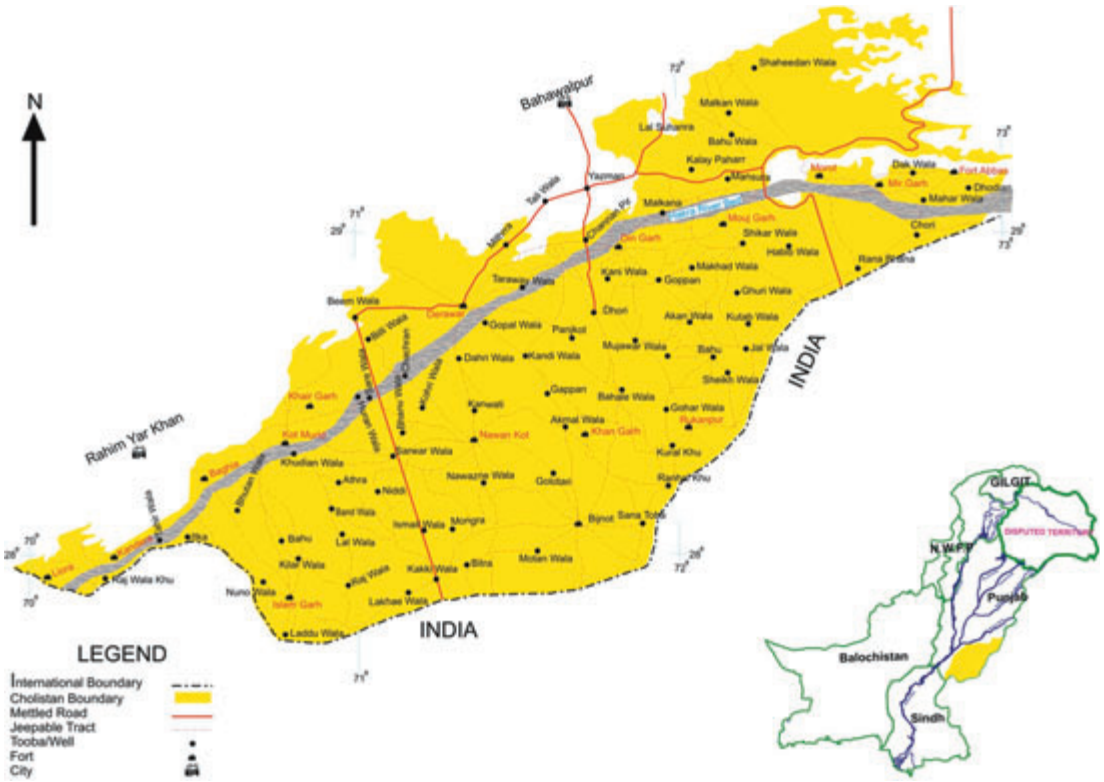

Map 1. Cholistan Desert.

achieve this goal several field station were set up in different parts of Cholistan Desert, mostly village schools. The day to day activities of the stations were monitored usually by the headmaster or science teacher of the school. The station also acted as specimen bank where students and rural folk deposited the specimens if they got any. Necessary data pertaining to specimen were also recorded for documentation and subsequent analysis.

Hand picking. It has always been the most efficient way of collecting small species of reptiles, especially, when the area to be traversed is large and time available in the field is short. Snake clutches were used for handling snakes, especially poisonous ones, and even for the lizards if they took refuge in the thorny bushes.

Noose traps. These traps were tried for agamids but unfortunately did not show any success.

Pit-falls. At few places "Pit–falls" were also fixed and monitored. These have also been proven as an effective method of collecting reptiles ranging from small lacertids to large snakes. The success of the "Pit-falls" is directly related to the overall activity of reptiles in the area.

Drag-nets/cast-nets. Aquatic species like turtles and frogs were collected with the help of these nets.

The species collected or sighted were photographed and necessary field data recorded. The voucher specimens collected were subsequently transported to PMNH laboratory to ascertain their taxonomic status and finally catalogued.

Preparation of inventory. The observed and collected specimens were either identified in the field and/or were brought in the laboratory for confirmation and future reference.

Data analysis. Observations regarding the presence of different species were made during the survey of the entire project area and its buffer zone. The latitude/longitude, elevation and habitat of the localities that were extensively surveyed were observed. The species collected or observed were recorded with reference to that locality. The detailed analyses indicating the evenness, richness and other criteria were carried out to understand the density and distribution pattern of Amphibians and Reptiles in the ecological zones of the study area.

To determine "**Most Productive Habitat**" Shannon Indices, Evenness and Richness of the communities present in the respective habitat have been calculated.

Fig. 1. Agriculture field in Cholistan showing canola crop.

It is calculated from the proportional abundances p_i of each species (abundance of the species/total abundances, noted here as $p_i = n_i/N$) according to the following formula

$$H = -\sum_{i=1}^{s} p_i \ln(p_i).$$

RESULTS

Vegetation of Cholistan is generally sparse, consisting of xerophytes and halophyte shrubs and grasses but there may be localized areas that represent green thick patches of shrubs like *Callotropis*, *Prosopis*, *Artemesia* etc.

Habitat types. Four types of microhabitats viz. dhars, sand dunes, tobas, and agriculture fields and human settlements have been identified in the study area. The first three represent the wild habitats of the area but where the water is available people also grow variety of crops, vegetables and fruits. These areas mostly lie along the desert canals.

It is not possible to restrict the movement of animals to a particular habitat as they frequently move everywhere in search of food. It is particularly difficult when the adjacent habitats are of smaller size. For example preferred habitat of snake, *Xenochrophis p. piscator* is water but it can practically go into any of the aforesaid habitats. Therefore animal species have been partitioned according to their preferred habitats (Table 1). Some representative species of a particular habitat have also been mentioned in the description of every habitat mentioned below.

Agriculture fields/human settlements (Fig. 1). As rainfall is too low (100 to 200 mm) in Cholistan desert for dry-land agriculture, the cropping is an option open to only those households who have irrigated lands. About 4% area of Cholistan desert is commanded by canals, fed from three barrages on the Sutlej and Chenab Rivers. The total area commanded by the irrigation system amounts to 113,500 ha. Because of water shortage, the actual area cultivated over two seasons of each year is about 52,600 ha, all of which falls within lesser Cholistan (FAO, 1993).

The principal crops grown are cotton and guar in the monsoon or "Kharif" season, and wheat, canola (rapeseed or "raya") and to a lesser extent, "berseem" (fodder crop) in the dry or "Rabi" season. Because of uncertain

TABLE 1. A Consolidated Alphabetic List of all the Species Collected, Showing Their "Preferred Habitat (PH)"

No.	Species Name	Total	SND	AGH	DHR	TAQ	PH
1.	*Bufo stomaticus*	556	82	175	28	271	TAQ
2.	*Euphlyctis c. cyanophlyctis*	320	0	0	0	320	TAQ
3.	*Euphlyctis* sp.nov.	84	0	0	0	84	TAQ
4.	*Hoplobatrachus tigerinus*	142	0	0	0	142	TAQ
5.	*Lissemys punctata andersoni*	12	0	0	0	12	TAQ
6.	*Kachuga smithii*	22	0	0	0	22	TAQ
7.	*Kachuga tecta*	8	0	0	0	8	TAQ
8.	*Geoclemys hamiltonii*	46	0	0	0	46	TAQ
9.	*Aspideretes gangeticus*	16	0	0	0	16	TAQ
10.	*Calotes v. versicolor*	124	42	74	8	0	AGH
11.	*Trapelus megalonyx*	32	18	7	7	0	SND
12.	*Trapelus agilis pakistanensis*	68	32	14	22	0	SND
13.	*Uromastyx hardwickii*	324	113	35	176	0	DHR
14.	*Crossobamon orientalis*	184	184	0	0	0	SND
15.	*Cyrtopodion scaber*	112	67	39	6	0	SND
16.	*Hemidactylus brooki*	36	0	36	0	0	AGH
17.	*Hemidactylus flaviviridis*	176	0	176	0	0	AGH
18.	*Acanthodactylus cantoris*	432	256	94	82	0	SND
19.	*Mesalina watsonana*	10	10	0	0	0	SND
20.	*Eremias cholistanica*	84	62	16	6	0	SND
21.	*Novoeumeces* sp.nov.	28	6	22	0	0	SND
22.	*Eumeces t. taeniolatus*	24	10	14	0	0	SND
23.	*Eutropis dissimilis*	10	0	10	0	0	AGH
24.	*Eutropis macularia*	46	0	46	0	0	AGH
25.	*Ophiomrus tridactylus*	335	335	0	0	0	SND
26.	*Varanus bengalensis*	22	4	10	0	8	AGH
27.	*Varanus griseus koniecznyi*	8	7	1	0	0	SND
28.	*Leptotyphlops blanfordii*	26	12	14	0	0	AGH
29.	*Leptotyphlops macrorhynchus*	54	24	30	0	0	AGH
30.	*Typhlops porrectus*	46	0	46	0	0	AGH
31.	*Eryx johnii*	8	6	2	0	0	SND
32.	*Boiga t. trigonata*	18	4	14	0	0	AGH
33.	*Platyceps r. rhodorachis*	4	0	0	4	0	DHR
34.	*Platyceps v. ventromaculatus*	225	106	82	37	0	SND
35.	*Eirenis* sp.	1	0	1	0	0	AGH
36.	*Lytorhynchus paradoxus*	168	168	0	0	0	SND
37.	*Psamophis l. leithii*	8	2	4	2	0	AGH
38.	*Psamophis l. lineolatus*	5	2	2	1	0	DHR
39.	*Spalerosophis arenarius*	16	4	8	4	0	SND
40.	*Spalerosophis atriceps*	36	20	8	8	0	SND
41.	*Xenochrophis piscator piscator*	22	0	6	0	16	TAQ
42.	*Naja naja naja*	65	12	40	0	13	AGH
43.	*Bungarus sindanus sindanus*	10	0	8	0	2	AGH
44.	*Echis carinatus sochureki*	226	140	58	28	0	SND
	Total	4199	1728	1092	419	960	
	Richness	44	27	31	15	13	
	Evenness		0.488	0.549	0.438	0.462	
	Shannon Index		2.58	2.835	1.884	1.793	

DHR, Dhars; SND, sandy patches and associated areas with sparse vegetation; TAQ, tobas and other aquatic habitats; AGH, agriculture fields and human settlements.

Fig. 2. Flat stretch of land locally called "Dahars."

and inadequate water supplies crop yields are lower than those achieved in the rest of the Punjab. Cotton and wheat yields are about 590 and 1800 kg/ha, respectively, where water is received for 25 weeks. Where only ten weeks water supply is available, wheat yields reduces to 1100 kg/ha and canola 500 kg/ha (FAO, 1993).

In the scorching summer, agriculture fields provide better refuge for all kind of animal species. Chances of amphibians and other aquatic species are more for being close to aquatic bodies. Although all the species collected or observed have been grouped according to their preferred habitat in Table 2 but among lizards, some species of geckos, *Varanus bengalensis*, *Calotes v. versicolor*, and *Novoeumeces* sp.nov.; among snakes typhlopids, leptotyphlopids, elapids, and colubrids are more frequently seen in these areas. Chances of amphibians and turtles are more in this habitat than any other terrestrial habitat.

Dhars area (Fig. 2). It also represents a significant portion of the study area. It is flat stretch of land, hard in texture and saline in nature. The plants, which grow in the area, are halophytes and are represented by *Halloxylone grifitti* and *Suaeda fruiticosa*. The reptile species found in the area are mainly ground agama belonging to *Trapelus*, *Uromastyx hardwickii*, desert lacerta belonging to *Eremias cholistanica* and *Acanthodactylus cantoris*, some species of geckos and snakes.

Sand dunes or exclusive sandy patches (Fig. 3). Extensive and high sand dunes are frequently found in "Greater Cholistan" whereas they are lacking in "Lesser Cholistan" but sandy patches of reasonable size may be encountered all over the area. *Crossobamon orientalis*, *Ophiomrus tridactylus*, *Acanthodactylus cantoris*, *Lytorhynchus paradoxus*, and *Echis carinatus sochureki* are some of the representative species of this habitat and are frequently seen there.

Tobas/watercatchment area or irrigation channels (Fig. 4). There are no permanent natural water bodies or surface water in Cholistan. Factors like low rainfall, high rate of water infiltration into the sands, and high evaporation rate prevent the natural accumulation of surface water (FAO, 1993). Rainwater is collected and stored in small ponds, locally called "Tobas." Underground water is at a depth 30 – 40 m, which is mostly brackish, containing salts 9000 – 24,000 ppm (Baig et al., 1980; Akbar et al., 1996).

There are also some small desert canals, which supply water to some selected areas for irrigation purposes. In addition to "tobas" at some places people have also fixed tube-wells and made small ponds where they store

TABLE 2. A Consolidated List of All the Species Collected During the Study Period Along with Their Museum Catalog Numbers

Species name	Material examined (PMNH No.)
Bufo stomaticus (Amphibia: Anura: Bufonidae)	947, 949–951, 1082, 1083, 1114–1117, 1119, 1120, 1122, 1123
Euphlyctis c. cyanophlyctis (Amphibia: Anura: Ranidae)	1133–1136, 1140–1144
Euphlyctis sp. (Amphibia: Anura: Ranidae)	1145–1152
Hoplobatrachus tigerinus (Amphibia: Anura: Ranidae)	945, 946, 948, 1081, 1118, 1125, 1131, 1132, 1137–1139
Tomopterna breviceps (Amphibia: Anura: Ranidae)	Reported on the basis of Khan (1985)
Geoclemys hamiltonii (Reptilia: Chelonia: Emydidae)	1424–1426
Kachuga smithii (Reptilia: Chelonia: Emydidae)	1637, 1641, 1646
Kachuga tecta (Reptilia: Chelonia: Emydidae)	1645
Lissemys punctata andersoni (Reptilia: Chelonia: Trionchidae)	1639, 1647
Aspideretes gangeticus (Reptilia: Chelonia: Trionchidae)	1638, 1640, 1642
Calotes versicolor versicolor (Reptilia: Sauria: Agamidae)	967, 968, 1134–1136, 1328, 1329, 1415, 1416, 1420, 1458, 1461–1463, 1486–1488, 1518
Trapelus agilis pakistanensis (Reptilia: Sauria: Agamidae)	1200, 1203–1215, 1340, 1400, 1401, 1417, 1421, 1467–1470, 1489–1491, 1511, 1569, 1570, 1693–1704, 1728–1730
Trapelus megalonyx (Reptilia: Sauria: Agamidae)	1485
Uromastyx hardwickii (Reptilia: Sauria: Agamidae)	951, 1418, 1560
Crossobamon orientalis (Reptilia: Sauria: Gekkonidae)	992, 1191, 1192, 1194–1197, 1334–1339, 1394, 1395, 1399, 1504, 1505, 1568, 1652, 1770–1844
Cyrtopodion scaber (Reptilia: Sauria: Gekkonidae)	993, 1359–1362, 1392, 1393, 1472, 1561–1564, 1572–1574, 1734–1738, 1741, 1743–1746, 1748–1750
Hemidactylus flaviviridis (Reptilia: Sauria: Gekkonidae)	1193, 1349, 1350, 1358, 1396–1398, 1579, 1580, 1742, 1747
Hemidactylus leschenaultii (Reptilia: Sauria: Gekkonidae)	with reference to Khan (1985)
Acanthodactylus cantoris (Reptilia: Sauria: Lacertidae)	976–982, 986, 994, 1137–1155, 1317, 1319–1323, 1345–1348, 1381–1389, 1492–1496, 1552, 1553, 1565–1567, 1666–1684, 1847, 1852, 1861, 1898
Eremias cholistanica (Reptilia: Sauria: Lacertidae)	1390, 1391, 1685, 1692, 1845, 1846, 1848–1851, 1853–1860, 1685–1692
Mesalina watsonana (Reptilia: Sauria: Lacertidae)	1351
Novoeumeces sp.nov (Reptilia: Sauria: Scincidae)	984, 1198, 1200, 1344, 1731
Eumeces t. taeniolatus (Reptilia: Sauria: Scincidae)	985, 1769
Ophiomrus tridactylus (Reptilia: Sauria: Scincidae)	983, 1369–1380, 1751–1767
Eutropis dissimilis (Reptilia: Sauria: Scincidae)	1365, 1497–1499, 1541, 1554
Eutropis macularia (Reptilia: Sauria: Scincidae)	1201, 1768
Varanus griseus koniecznyi (Reptilia: Sauria: Varanidae)	1419, 1540, 1708
Varanus bengalensis (Reptilia: Sauria: Varanidae)	1457, 1705–1707, 1727
Coluber v. ventromaculatus (Reptilia: Serpentes: Colubridae)	966, 969–971, 1121, 1122, 1307, 1308, 1447, 1483, 1484, 1709, 1710
Coluber r. rhodorachis (Reptilia: Serpentes: Colubridae)	1315
Lytorhynchus paradoxus (Reptilia: Serpentes: Colubridae)	972, 973, 1004, 1123–1130, 1412, 1413, 1508, 1549, 1550, 1711
Psamophis l. leithii Günther (Reptilia: Serpentes: Colubridae)	1311, 1531
Psamophis l. lineolatus (Reptilia: Serpentes: Colubridae)	974, 1306
Spalerosophis arenarius (Reptilia: Serpentes: Colubridae)	1115, 1116, 1133, 1524, 1721
Spalerosophis atriceps (Reptilia: Serpentes: Colubridae)	1001–1003, 1117, 1414, 1534, 1723, 1725, 1726
Naja n. naja (Reptilia: Serpentes: Elapidae)	995, 996, 1118–1120, 1313, 1314, 1718, 1722
Leptotyphlops macrorhynchus (Reptilia: Serpentes: Leptotyphlopidae)	1216, 1332, 1402–1404
Leptotyphlops blanfordii (Reptilia: Serpentes: Leptotyphlopidae)	965
Typhlops porrectus (Reptilia: Serpentes: Typhlopidae)	1333
Eryx johnii (Reptilia: Serpentes: Boidae)	1526
Boiga trigonata (Reptilia: Serpentes: Colubridae)	975, 1507, 1720
Eirenis sp. (Reptilia: Serpentes: Colubridae)	1409
Xenochrophis p. piscator (Reptilia: Serpentes: Colubridae)	1312, 1506, 1724
Bungarus sindanus sindanus (Reptilia: Serpentes: Elapidae)	1527, 1528
Echis carinatus sochureki (Reptilia: Serpentes: Viperidae)	997–1000, 1108–1111, 1131, 1304, 1305, 1309, 1310, 1316, 1406–1408, 1411, 1509, 1510, 1525, 1532, 1533, 1559, 1714–1717

Fig. 3. A medium sized sand dune at Chai Wala (Greater Cholistan).

canal water or water pumped through tube-well. The aquatic fauna that comprises mainly turtles and anurans, may reach to different places in Cholistan through the desert canals.

SPECIES ACCOUNT

The numbers of species collected/observed during the study period represent a significant component of the total herpetofauna present there. The efforts are being made to unveil the hidden wealth of the Cholistan Desert with particular reference to the amphibians and reptiles.

A consolidated list of all the species so far collected and observed in the study area during the last three years, lying in the Pakistan Museum of Natural History with their museum catalog numbers, has been given in Table 2 and species richness, evenness and Shannon index of associated habitats in Table 1. The relative abundance of the species collected is also depicted in Fig. 5. Two of the species *Tomopterna breviceps* and *Hemidactylus leschenaultii** although are not represented in our collection but have been reported by Khan (1985) and are very likely to be there.

Amphibia

Anura (Frogs and Toads)

The amphibian fauna of Pakistan consists of 24 species of anurans falling in four families, viz., Ranidae, Bufonidae, Microhylidae, and Megophryidae; only the first two are represented in the study area.

Ranidae

Skittering frog, *Euphlyctis cyanophlyctis cyanophlyctis* (Schneider, 1799)

Diagnosis. The interorbital space is narrower than the upper eyelid; tympanum is indistinct, about two third the size of the eye; fingers slender, pointed or slightly swollen at the tips, first not extending beyond second; toes are completely webbed; dorsum with numerous scattered small smooth tubercles, sides of body rugose, ventrum smooth; male is smaller than females; insectivorous.

Tiger frog/Bull-frog, *Hoplobatrachus tigerinus* (Daudin, 1802)

Diagnosis. Tympanum distinct, almost as large as eye; fingers obtusely pointed, first longer than second; dorsum smooth or granular, with 6 – 14 longitudinal broken folds, occasionally interspersed with smooth tubercles, ventrum smooth; forelimbs of breeding male are thick, first finger is swollen, blue vocal sacs area located on sides of the throat; insectivorous.

Indian burrowing frog, *Sphaeroteca breviceps* '*' (Schneider, 1799)

Diagnosis. Habitus short, stocky, toad-like; Head broader than long, top flat; first finger longer than second, tips swollen;

Fig. 4. "Toba" at Shadi Wala Dar containing stored rainwater.

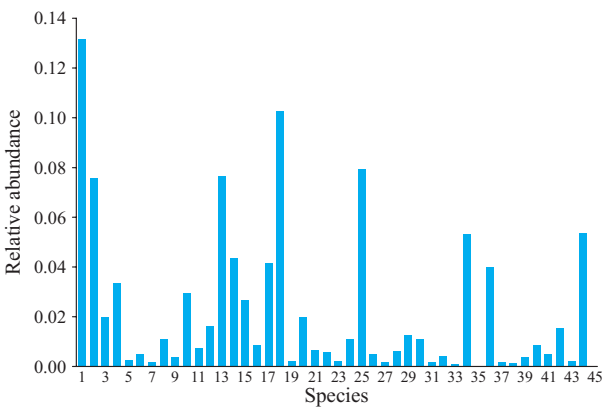

Fig. 5. A graph representing relative abundance of species in the study areas, the species numbers corresponds to Table 1.

skin smooth, with feeble longitudinal dorsal folds; tympanum distinct, as large as eye; insectivorous.

Bufonidae

Indus valley toad/Marbelled toad, *Bufo stomaticus* (Lütken, 1862)

Diagnosis. No cranial crests; interorbital space a little broader than the upper eyelid; tympanum distinct, round, its diameter two thirds that of eye; first and second fingers subequal; parotid gland is longer than the broad; a distinct tibial gland is present; insectivorous.

Reptilia

In Pakistan, 15 turtles/tortoises, 2 crocodilian, 103 lizards, and 79 snake species represent the reptilian fauna. Out of this, an overall 39 species are represented in the study area.

Testudines (turtles/tortoises)
Trionchidae

Indian softshell turtle, *Aspideretes gangeticus* (Cuvier, 1825)

Diagnosis. Carapace low, oval; coastal 8 pairs, the eighth meeting at midline, first separated by preneural and first neural plate; plastral bones strongly rugose in adults; plastron much shorter than carapace, with 5 callosities; sexually dimorphic, male with longer and thicker tail; omnivorous (mostly herbivore).

Indian flapshell turtle, *Lissemys punctata andersoni* (Webb, 1980)

Diagnosis. Shell low, oval, scutes with the granulation and covered with soft skin; coastal 8 pairs, last pair meet medially each other; callosities on plastron 7; plastron with hinged pectoral and femoral valves, under which hind-limbs are withdrawn; limbs with three claws, fingers webbed; tail short, does not extend beyond shell; omnivorous.

Fig. 6. Marbled toad, *Bufo stomaticus*.

Fig. 7. Spotted pond turtle, *Geoclemys hamiltonii*.

Emydidae

Spotted pond turtle, *Geoclemys hamiltonii* (Gray, 1831)

Diagnosis. Carapace oblong, widest near midpoint, margin not flared or serrate; 24 marginals; plastron rigidly joined to carapace; digits webbed to bases of claws; tail short in both sexes but portion anterior to vent thicker in males; carnivorous (meat, snails, fish, insects).

Brown roofed turtle/Brown river turtle, *Kachuga smithi* (Gray, 1863)

Diagnosis. Carapace ovoid, strongly arched, margins not serrate; third central lamina quadrangular to pentagonal; fourth central lamina with narrow anterior projection that just touches third; plastron broadly and rigidly articulated with carapace; digits webbed to beyond bases of nails; tail of adult male more fleshy than that of female; omnivorous (prefer insects).

Indian saw-back turtle, *Kachuga tecta* (Gray, 1831)

Diagnosis. Shell higher and less tapering than *K. smithi*: third central lamina pentagonal, pointed posteriorly; keel of third central projecting posteriorly as short, blunt spine, keels of first and second centrals high; anterior projection of fourth central very narrow; herbivorous.

Sauria (lizards)

Agamidae

Indian garden lizard, *Calotes versicolor versicolor* (Daudin, 1802)

Diagnosis. Body compressed; forehead concave, head with unequal, smooth, or feebly keeled scales; a pair of well separated supraorbital spines; dorsals 35 – 52 around mid-body, all pointing backward and upward, larger than ventrals; ventrals keeled; median row of dorsals elongated, sharp tipped, forming dorsal crest which extends from nuchal to the level of vent; males are longer in snout-vent length and tail length and a prominent gular region; insectivorous.

Pakistan's ground agama, *Trapelus agilis pakistanensis* (Rastegar-Pouyani, 1999).

Diagnosis. It is distinguished mainly on the morphology of male, which has compressed head and body, head distinctly pointed; usually a single row of callose preanal scales (females without this character); dorsal scales relatively flat, subequal to homogeneous, distinctly keeled and mucronate, 67 – 83 around body; ventrals distinctly keeled; insectivorous.

Fig. 8. Sind sand gecko, *Crossobamon orientalis*.

Afghan ground agama/Ocellate ground agama, *Trapelus magalonyx* (Günther, 1864).

Diagnosis. Dorsals heterogeneous, larger are arranged in groups, some scales smooth, other feebly or strongly keeled or mucronate, strongly imbricate or less rhomboidal; ventrals as large as small dorsals, feebly keeled; dorsum metallic bronze in male, with a vertebral series of 6 large light dark-edged cross-bars, enclosing a reddish ocellus, throat cobalt blue, a dark streak along nape; insectivorous.

Uromastycidae

Indian spiny-tailed lizard, *Uromastyx hardwickii* (Gray, 1827)

Diagnosis. Body depressed; a transverse gular fold; tympanum distinct; head and body with uniform granular scales; caudal spines squarish at their bases, 20 – 24 in a row at the middle; herbivorous (juveniles occasionally feed on insects).

Fig. 9. Spiny-tailed lizard, *Uromastyx hardwickii*.

Fig. 11. Saw-scaled viper, *Echis carinatus sochureki*.

Fig. 10. Sind awl-headed snake, *Lytorhynchus paradoxus*.

Gekkonidae

Keeled rock gecko/Common tuberculated ground gecko, *Cyrtopodion scaber* (Heyden *in* Rüpell, 1827).

Diagnosis. Subcaudals in a single series of broad scales; scales across mid-abdomen nor more than 25; insectivorous.

Yellow-bellied house gecko, *Hemidactylus flaviviridis* (Rüpell, 1840)

Diagnosis. Dorsum with granular scales, no distinct tubercles; supralabials 12 – 15, infralabials 10 – 14; Lamellae under first toe 7 – 10, under fourth toe 12 – 15; tail indistinctly segmented, caudal tubercles small and conical; preano-femoral pores 8 – 15; insectivorous.

Bark gecko, *Hemidactylus leschenaultii* '*' (Duméril and Bibron, 1836)

Diagnosis. Round feebly keeled tubercles are scattered among granular dorsal scales which are much smaller than the interspaces, few on anterior, numerous on posterior half on the body; supralabials 10 – 12, infralabials 8 – 10; Lamellae under first toe 6 – 7, and under fourth toe 9 – 11; tail strongly depressed, segmented, with a median series of enlarged subcaudals; 6 rows of dorsal pointed subcaudal tubercles; male with 10 – 17 femoral pores, medially separated by several scales; insectivorous.

Spotted Indian house gecko/Spotted barn gecko, *Hemidactylus brookii* (Gray, 1845)

Diagnosis. Dorsum granular, interspersed with small sub-trihedral tubercles; supralabials 8 – 10, infralabials 7 – 9; lamellae under fourth toe 8 – 10; tail cylindrical, distinctly segmented, with three dorso-lateral rows of small flat caudal tubercles, a single row of broad subcaudals; male with preanal and femoral pores, separated medially by 2 – 3 scales; insectivorous.

Sind sand gecko, *Crossobamon orientalis* (Blanford, 1876)

Diagnosis. Head of moderate size, snout bluntly pointed; no postmental; all digits with fringe of small, pointed scales; dorsal scales small, sub-imbricate, inter-mixed with round, flattened tubercles; ventral scales small; caudal scales in annuli; insectivorous.

Lacertidae

Indian fringed-toed sand lizard/Blue-tail sand lizard, *Acanthodactylus cantoris* (Günther, 1864)

Diagnosis. Dorsals 26 – 36 across midbelly, gulars 26 – 38; hind-limb reaches between ear and collar in male, between collar and axilla in female; femoral pores 16 – 23; subocular does not border mouth, separated from it by fifth and sixth supralabials; tail bluish gray; insectivorous.

Cholistan striped lacerta, *Eremias cholistanica* (Baig and Masroor, 2006)

Diagnosis. Dorsals 52 – 63; ventrals in 13 – 15 oblique longitudinal series; subocular touching mouth; frontal and supraciliaries separated from supraoculars by row(s) of granules; occipital absent; 14 – 18 femoral pores on each side, separated by 2 – 4 scales; toes fringed encircled by 3 scales and with 23 – 29 double series of unicarinate scales underneath; dorsum with 6 or 7 black longitudinal stripes without any sign of vermiculation; insectivorous.

Long-tailed desert lacerta/Spotted lacerta, *Mesalina watsonana* (Stoliczka, 1872)

Diagnosis. Ventrals distinctly broader than long, in 8 – 10 straight longitudinal series across midabdomen; occipital scale in

contact with the interparietal; lower nasal scale rests only on first supralabials; no lateral fringe on fourth toe; dorsal and lateral scales of body granular; insectivorous.

Scincidae

Yellow-bellied mole skink, *Eurylepis t. taeniolatus* (Blyth, 1854)

Diagnosis. 21 – 23 scales around mid-body; postnasal scale is present; two median rows of dorsal scales fused into a broad median row; insectivorous.

Indian sand-swimmer/3-toed sand-swimmer, *Ophiomorus tridactylus* (Blyth, 1853)

Diagnosis. Supranasals usually narrowly in contact, partially separated from one another by the posterior tip of the rostral scale; prefrontals in contact with upper labials; parietal in contact with anterior temporal; scales around midbody 22; fingers and toe 3; a distinct ventro-lateral ridge from snout to groin; insectivorous and decomposing organic matter.

Striped grass skink, *Eutropis dissimilis* (Hallowell, 1857)

Diagnosis. Supranasals in contact with each other; frontonasal almost as broad as long; no postnasal scale; An undivided transparent disc in lower eyelid; dorsal and lateral body scales subequal; dorsals with 2 or 3 and laterals with 3 keels; insectivorous.

Bronze grass skink, *Eutropis macularia* (Blyth, 1853)

Diagnosis. Supranasals are separated from each other; frontonasals about as long as broad; a postnasal may or may not be present; scaly lower eyelid; dorsal and lateral body scales are subequal, with 5 – 9 keels; insectivorous.

Varanidae

Indian desert monitor, *Varanus griseus koniecznyi* (Mertens, 1954)

Diagnosis. Tail round throughout, without a dorsal crest; body with 4, tail with 10 – 15 transverse bands; naris much nearer to orbit than the end of snout; supraoculars small, subequal; carnivorous.

Bengal monitor/Indian monitor, *Varanus bengalensis* (Daudin, 1802)

Diagnosis. Naris a little nearer to orbit than tip of snout; scales on head longer than nuchals, which are round, not keeled; abdominals smooth, in 90 – 110 transverse rows; digits elongate; tail strongly compressed with a double toothed dorsal crest; carnivorous.

Serpentes (snakes)

Leptotyphlopidae

Large-beaked thread snake, *Leptotyphlops macrorhynchus* (Jan *in* Jan and Sordelli, 1861)

Diagnosis. Rostral very large, projecting well beyond lower jaw, hooked; ocular large separating two supralabials; 14 scales around body; total length of body 80 – 110 times its diameter; tail length approx. 10 percent of total length; scale rows from occiput to base of tail 300 – 359; it feeds on decompose organic matter.

Sind thread snake, *Leptotyphlops blanfordii* (Boulenger, 1890)

Diagnosis. Rostral not concave below, normal, round; scale rows 268 – 272 from occiput to base of tail and 37 – 39 from vent to tail spine; total length 55 – 70 times its diameter; it feeds on decompose organic matter.

Typhlopidae

Slender blind snake, *Typhlops porrectus* (Stoliczka, 1871)

Diagnosis. Nasal suture touching second labial; 18 scales round body; scales from vent to tail spine 6 to 9; diameter of the body 86 times in total length; it feeds on decompose organic matter.

Boidae

Indian sand boa/Red sand boa, *Eryx johnii* (Russell, 1801)

Diagnosis. Head not distinct from neck; mental grove present; body scales keeled, 51 – 61 body scales at midbody; premaxilla not toothed; head with small scales; subcaudals in a single row; carnivorous.

Colubridae

Black-headed royal snake, *Spalerosophis atriceps* (Fischer, 1885)

Diagnosis. A subocular scale is present; prefrontal fragmented; dorsal scales at midbody in 29 rows; ventrals 230 – 252; subcaudals 100 – 112; prefrontals 02; anal undivided; carnivorous.

Red-spotted royal snake, *Spalerosophis arenarius* (Boulenger, 1890)

Diagnosis. A subocular scale is present; prefrontal fragmented; dorsal scales at midbody in 25 – 27 rows; ventrals 228 – 247; subcaudals 75 – 86; prefrontals 04; anal undivided; carnivorous.

Sind awl-headed snake, *Lytorhynchus paradoxus* (Günther, 1875)

Diagnosis. Rostral large, projecting, strongly concave below, pointed; subcaudals in double rows; fifth labial touching eye; scale rows at midbody 19; ventrals 178 – 184; subcaudals 40 – 48; carnivorous.

Indian gamma snake/common cat snake, *Boiga trigonata* (Schneider *in* Bechstein, 1802)

Diagnosis. Head triangular, flat, very distinct from neck; eyes large, protruding, with vertically elliptical pupil; body slender, laterally compressed; body scales smooth, with apical pits, 21 at midbody; ventrals 212 – 239; subcaudals 76 – 92; anal not divided; carnivorous.

Pakistan ribbon snake, *Psamophis leithii leithii* (Günther, 1869)

Diagnosis. Body slender, tail long with divided subcaudals; eye large with round pupil; scale rows 17 at midbody, smooth; ventrals 167 – 187; subcaudals 98 – 109; anal scale not divided; carnivorous.

Steppe ribbon snake, *Psamophis lineolatus lineolatus* (Brandt, 1838)

Diagnosis. Nasal scale completely divided; Fourth, fifth and sixth upper labials touching eye; scale rows at midbody 15 – 16; ventrals 180; subcaudals 81; anal divided; carnivorous.

Glossy-bellied racer, *Platyceps ventromaculatus ventromaculatus* (Gray, 1834)

Diagnosis. Top of head with large symmetrical plates; eyes large with round pupil; fifth and sixth supralabials touching eye; dorsal scales smooth; scale rows at midbody 19; dorsal pattern of light brown rhombs; ventrals 195 – 213; subcaudals 82 – 119, divided; anal divided; carnivorous.

Cliff racer, *Platyceps rhodorachis rhodorachis* (Jan *in* De Flippi, 1865)

Diagnosis. Dorsal scales smooth, 19 at midbody; ventrals 205 – 244; subcaudals 110 – 144; anal divided; dorsal pattern of dark spots or unicolor; carnivorous.

Checkered keelback, *Xenochrophis piscator piscator* (Schneider, 1799)

Diagnosis. Dorsals keeled, in 19 rows at midbody; a pair of anterior temporals; fourth and fifth supralabials touching eye; ventrals 135 – 152; subcaudals 62 – 78; anal divided; a pair of oblique orbitolabial dark stripes; carnivorous.

Elapidae

Indian cobra/Black cobra, *Naja naja naja* (Linnaeus, 1758)

Diagnosis. Medium-sized snake; Head not distinct from body, neck dilatable into an expanded hood; loreal absent; no maxillary teeth; body scales smooth, in rows 21 – 23 at midbody; ventrals 182 – 196; subcaudals 53 – 67, divided; carnivorous.

Sind krait, *Bungarus sindanus sindanus* (Boulenger, 1897)

Diagnosis. Medium-sized snake, head barely distinguishable from neck; Loreal absent; median dorsal scale row distinctly enlarged; subcaudals not divided; dorsal scales at midbody 17; ventrals 220 – 237; subcaudals 49 – 52; anal entire; first light transverse band appears at the level of eleventh to fifteenth ventrals; carnivorous.

Viperidae

Sochurek's saw-scaled viper, *Echis carinatus sochureki* (Stemmler, 1969)

Diagnosis. Body of moderate to somewhat slender built, slightly flattened dorsolaterally; all dorsal scales keeled but only keels of strongly oblique lateral rows serrate; scale rows at midbody 29 – 31; ventrals 156 – 181; subcaudals 27 – 35, undivided; anal undivided; carnivorous.

DISCUSSION

Khan (1985) reported 15 species of amphibians and reptiles from a small area of Cholistan desert, of which *Brachysaura minor* (Sauria: Agamidae) is presumably a misperception. The other authors (Minton, 1966; Mertens, 1969) although did not specifically studied Cholistan Desert but indicated the presence of some species there. Present study has significantly increased the list of herpetofauna found in this desert ecosystem.

Amphibian fauna in the study area is represented by 5 species belonging to two families and 4 genera. One of the species belonging to *Euphlyctis* is expected new to the science while the remaining three are widely distributed in Pakistan. Amphibians are although associated with water but bufonids may be seen in the gardens and other habitats too. Hand-picking and drag nets are the most effective methods of collecting amphibians. Hand-picking is mostly effective in case of bufonids whereas ranids are mostly collected with the help of drag-nets, as they live in water and occasionally come out of it.

The turtle species mentioned above have been mostly collected from the desert canals run in the study area, mainly along the Lal Sohanra National Park. There are many small tributaries of these canals, which supply water to the different areas of Cholistan Desert. As the main canal and these small water channels are part of the same aquatic system, the presence of these turtles is therefore very likely in different areas of Cholistan Desert. Turtles are exclusively aquatic species but frequently come out for basking and also for egg laying. In the shallow water where they cannot dive deeper, they are collected with the help of drag-nets but in deeper water the collection has been made with the help of cast-nets.

Lizards (Sauria) are represented by 16 species belonging to 6 families viz. Gekkonidae, Agamidae, Scincidae, Lacertidae, Varanidae, and Uromastycidae. Of these, *Cyrtopodion scaber*, *Crossobamon orientalis*, *Uromastyx hardwickii*, and *Acanthodactylus cantoris* are the most common species of the area. One of the lacertid species, i.e., *Eremias cholistanica*, is newly described (Baig and Masroor, 2006) as a result of these studies while another scincid lizard belonging to genus *Novoeumeces* is expected to be new to science. Hand-picking and the pit-falls are the most effective methods of collecting lizards. The agama species identified by Khan (1985) as *Agama minor* could be *Trapelus agilis pakistanensis*. In my collection there are several specimens who according to Khan (2002) are *Novoeumeces indothalensis* but I believe more work is required to prove or disapprove the validity of this species. Presence of *Eurylepis t. taeniolatus* in the desert is contrary to the observation made by Minton (1966).

Seventeen species of snakes belonging to 6 families have so far been collected from the study area. Most of the collected specimens belong to family colubridae of which *Lytorhynchus paradoxus* and *Platyceps v. ventromaculatus* are found the most. A species belonging to genus *Eirenis* exhibits the set of characteristics that does not correspond to any of the reported taxa of Pakistan. Among the poisonous snakes *Echis carinatus sochureki* is the most common species of desert. Snakes are active and agile species of reptiles and frequent almost every habitat. They are mostly nocturnal and therefore come out of the burrows at night in search of food. Despite that 90% of snakes are non-venomous they are generally considered enemies of mankind and are therefore mercilessly killed by the rural folk whenever encountered. A significant component of the snakes have been collected by the rural folk, which chase and kill them because of fear. This component has been considered as hand picking.

Among the five different collecting techniques "Noose Trap" did not show any significant results whereas "Hand Picking" and "Pit-falls" have been proven as the most efficient ways of collecting in case of almost every reptile species.

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