The use of fish and herptiles in traditional folk therapies in three districts of Chenab riverine area in Punjab, Pakistan

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Abstract

Background: Like botanical taxa, various species of animals are also used in traditional and modern health care systems. Present study was intended with the aim to document the traditional uses of herptile and fish species among the local communities in the vicinity of the River Chenab, Punjab Pakistan.

Method: Data collected by semi-structured interviews and questionnaires were subsequently analyzed using relative frequency of citation (FC), fidelity level (FL), relative popularity level (RPL), similarity index (SI), and rank order priority (ROP) indices.

Results: Out of total 81 reported species, ethnomedicinal uses of eight herptiles viz. Aspideretes gangeticus, A. hurum, Eublepharis macularius, Varanus bengalensis, Python molurus, Erx johnii, Ptyas mucosus mucosus, Daboia russelii russelii and five fish species including Hypophthalmichthys molitrix, Cirrhinus reba, Labeo dero, Mastacembelus armatus, and Pethia ticto were reported for the first time from this region. Fat, flesh, brain, and skin were among the commonly utilized body parts to treat allergy, cardiovascular, nervous and respiratory disorders, sexual impotency, skin infections, and as antidote and anti-diabetic agents. Hoplobatrachus tigerinus, Duttaphrynus stomaticus, and Ptyas mucosus mucosus (herptiles), as well as Labeo rohita, Wallago attu, and Cirrhinus reba (fish) were top ranked with maximum informant reports, frequency of citations, and rank order priority. Uromastyx hardwickii, Ctenopharyngodon idella, H. molitrix, Cirrhinus mirgala, C. reba, L. rohita, L. calbasu, L. dero, and Pethia ticto were the species with 100% fidelity level. Furthermore, medicinal uses of Aspideretes gangeticus, Aspideretes hurum, Calotes versicolor, Daboia russelii russelii, Hypophthalmichthys molitrix, Cirrhinus reba, Labeo dero, Mastacembelus armatus, Pethia ticto, and Gagata cenia were reported for the first time.

Conclusion: About half of the reported species depicted zero similarity index with previously reported literature, which indicates strong associations of local inhabitants with animal species, particularly for therapeutic purpose. Inclusive studies on composition and bioactivities of the species with maximum use reports may contribute significantly in animal-based novel drugs discovery.

Keywords: Ethnozoology, Medicinal, Herptile, Fish, Punjab, Pakistan

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Introduction
The multipurpose usage of animal species, e.g., as food, medicine, entertainment, magic, music and religion, tools for art, and in trade, is well known [1–9]. It has been reported that loving, watching, and working with animal species is beneficial to lower heartbeat and control stroke [10]. Animal-based products are used as traditional medicines, and an estimated 8.7% of the vital chemicals used in modern healthcare systems are extracted from different animal species [11]. However, compared to plant species, animal-based products are widely neglected [12]. Inhabitants of rural areas are more compared to plant species, animal-based products are domesticated, are important to humans [13]. Wild animal species are often under threat due to anthropogenic activities like illegal hunting and trade for food, medicines, and ornamental purposes, deforestation, agriculture intensification, urbanization, and industrialization [3, 14–19].

Herptiles and fish are recognized as extremely fascinating and important animal species [20–22]. In many societies, different species of herptiles and fish are used in ethnomedicine and folklore to treat health disorders [16, 22, 23]. An estimated 10,450 species of reptiles and 7850 amphibian species have been reported [24] globally. In Pakistan, 195 species of reptiles [25] and 24 species of amphibians [26] have been documented so far. The Asian region has also a high diversity of marine and freshwater fish species (22907 and 10036 species, respectively) [24, 27]. An estimated 186 species of freshwater fish and 719 species of marine water fish have been reported so far in Pakistan [28]. However, traditional uses of animal species, particularly to treat diseases in humans and other animals, have rarely been documented in Pakistan [6, 7, 29–32]. To best of our knowledge, traditional uses of herptiles and fish species have never been reported before in Pakistan. Therefore, the present study was planned to document herptiles and fish species used to treat various diseases by the local communities residing along the Chenab riverine areas, i.e., Gujranwala, Gujrat, and Sialkot districts in the Punjab province of Pakistan. Qualitative indices were used to elucidate commonly utilized species with high fidelity level and frequency of citation. We hope the data provided will be of significant value for pharmaceutical industries to discover animal-based novel drugs to meet the recent challenges to human health.

Materials and methods
Study area
The River Chenab is the combination of two main streams, i.e., Chandra and Bhaga originating from the Himalayan region of Himachal Pradesh in India. After passing through the Siwalik Range in the south, and the Lesser Himalayas in the north of Indian Jammu and Kashmir, it continues into Pakistan [33]. The present study was conducted in three districts of the Chenab riverine area, i.e., Gujranwala, Gujrat, and Sialkot (Fig. 1) from March 2016 to April 2017. The study area covers 9830 km², with temperature ranges from around 0 °C in December to 50 °C in June [34–36]. This region has a high diversity of wild fauna, comprising 150 species of birds, 47 herptiles, 34 fish, and 15 mammalian species [15, 37–39]. Demographically almost 52% of the population are male, and 48% are female. The major population is rural, and encompasses Arain, Gujjar, Jutt, Sheikh, Rana Butt, Malik, and Mughal casts. Punjabi is the common language spoken, although some people speak Sir- aiki and Urdu, while educated people can also speak English to some extent [34–36].

Data collection and analysis
Following the Nagoya Protocol, prior informed consent was taken from local informants for data collection and publication. In addition, the International Society of Ethnobiology Code of Ethics (http://www.ethnobiology.net/) was also followed. Ethnomedicinal uses of herptiles and fish species along with cultural importance were collected from local informants (n = 100) using semi-structured interviews and group discussions. Informants including farmers, fishermen, hunters, teachers, and health practitioners were selected based on their traditional knowledge of animal species, i.e., herptiles and fish. Animals were identified using “The Amphibian and Reptiles of Pakistan” [25], and “Freshwater Fish of Pakistan” were also consulted for correct classification and identification of fish of the study area [40]. Different indices, i.e., relative frequency of citation (RFC), fidelity level (FL), relative popularity level (RPL), rank order priority (ROP) and similarity index (SI), were used to analyze that data.

Relative frequency of mention (RFC) was calculated using formula as reported previously [41].

\[
\text{RFC} = \frac{FC}{N} \quad (0 \leq \text{RFC} \leq 1)
\]

Where FC is the frequency of citation for an ethnomedicinal or cultural use of a specific species and N is the total number of informants.

Fidelity level (FL) was obtained using the method explained earlier [42] based on formula

\[
\text{FL} (%) = \frac{N_p}{FC} \times 100
\]

where \(N_p\) indicates number of informants reporting major ailment for a specific species of herptiles or fish.
and FC is the frequency of citation for ethno-medicinal or cultural use of that species.

Relative popularity level (RPL) of the reported species was elucidated as reported by [43, 44]. Herptiles and fish species were classified into two groups (i) “popular” and (ii) “unpopular.” Popular herptiles and fish species were those having more than half of the maximum frequency of citation (FC), whereas the left-over herptiles and fish were documented as unpopular. For popular herptiles and fish species, a horizontal line was imaginary, namely the average number of uses per species is independent of the frequency of citation (FC), who recognizes the herptiles and fish; therefore, the average numeral of uses of a popular herptile and fish species does not enhance with the add to frequency of citations who cite a herptile and fish for any medical use. For the popular herptiles and fish, the RPL was chosen to one (1). For herptiles and fish in the unpopular group, the relative popularity level value is less than 1.0.

Rank order priority (ROP) is used to grade plants and animal species and was calculated as explained earlier [43, 44] and was analyzed by the following formula

$$\text{ROP}_{s} = \frac{\text{FL}}{\text{RPL}}$$

Similarity index (SI) was calculated as reported previously [3]

$$\text{SI} = \frac{M_s}{M_t} \quad (0 \leq \text{SI} \leq 1)$$

$M_s =$ Alike number of medicinal uses in the previous and present research records for a specific herptiles and fish species. $M_t =$ Total number of medicinal uses in the present research reports for a specific herptiles and fish species.

Principal component analysis (PCA). Data were statistically analyzed with the help of principal component analysis by using Past software Version 3 [45].
Results and discussion

Demography
Data were collected from 100 informants of an age between 18 and 75 years (Fig. 2). About 70% informants were literate, and participants had finished having primary, matric, intermediate, bachelors, and master levels (23, 24, 21, 8, and 3, respectively). The majority of the informants (76%) were from rural areas with agricultural background.

Local nomenclature
Vernacular names of animal species are usually based on environment, myths, morphological characteristics, habitat, and social associations of species with humans. As mentioned in Table 1, “daddo” is used as suffix in six animals (13%) of the reported herpetiles such as Bufotes latastii (chitkbra daddo), Duttaphrynus stomaticus (ghariallo daddo), Microhyla ornata (bona daddo), Fejervarya limnocharis (pidda daddo), Hoplobatrachus tigerinus (wada daddo), and Sphaerotheca breviceps (chota dahri daddo). Variations in the vernacular names of these animals are due morphological differences, e.g., H. tigerinus has a larger size and was called “wada daddo.” Similarly, M. ornata has a smaller size and was called “bona daddo.” A very small frog was called “pidda daddo,” while B. latastii, which has patches on body, was called “chitkbra daddo,” and S. breviceps, Amphiesma stolatum, and Ophisops jerdonii, which all have lines on the body, were named as “chota dahri daddo.” Likewise, 14 species of lizards had the suffix “kirli” such as Laudakia melanura melanura (kali kirli), Eublepharis macularius (korh kirli), Cyrtopodion montiumsalorum (sahrai kirli), Cyrtopodion Scabrum (toor Kirli), Hemidactylus flaviviridis (gharailo kirli), Hemidactylus persicus (Irani kirli), Acanthodactylus cantorius (neeli poosh kirli), Ophisops jerdonii (safaid dahari kirli), Ablepharus grayanus (bahri kirli), Ablepharus pannonicus (surakh posh kirli), Eutropis macularia (bore kirli), Euryalepis taeniolatus taeniolatus (maidani kirli), Ophiomorus tridactylus (tray ungl kirli), and Scincella himalayana (pahari kirli). Fifteen species of snakes had the suffix “sap,” e.g., Leptotyphlops macrorhynchus (dhaga sap), Ramphotyphlops braminus (dhaga sap), Python molurus (azdha sap), Amphiesma stolatum (lakeer dhari sap), Boiga trigonata (bili sap), Lytorhynchus paradoxus (ollu sap), Oligodon arnensis arnensis (kukri sap), Oligodon taeniolatus taeniolatus (kukri sap), Platyceps rhodorachis (Pheesi sap), Psammophis leithii leithii (teer maar sap), Psammophis schokari schokari (saharai sap), Ptyas mucosus mucosus (chohay-maar sap), Xenochrophis piscator piscator (chitra sap), Daboia russelii russelii (dabian wala sap), and Echis carinatus sochureki (pathar sap). Only two local names included “kukri sap” in the vernacular name (Oligodon arnensis arnensis and O. taeniolatus taeniolatus), and “dhaga sap” was the local name of Leptotyphlops macrorhynchus and Ramphotyphlops braminus. Local nomenclature of snakes was also based on their external morphology.
| S# | Scientific, common and local name | Parts used | MA | Diseases Code IMA ND FC FL RPL ROP | Reported use                                                                                                                                                                                                 | References | SI |
|----|----------------------------------|------------|----|-------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|----|
| 1  | Duttaphrynus stomaticus (Lütken,1864), Indus Valley toad, Ghariallo daddo | Skin       | T  | BF1 3 1 30 0.667 6.67               | Allergy, pneumonia, dermatitis, ripened abscess, wounds                                                                                                                                                    | [46–48]    | 0  |
| 2  | Hoplobatrachus tigerinus (Daudin, 1802), Indian Bullfrog, Wada daddo     | Fat, oil   | T  | HT1 2 3 40 0.889 4.44               | Acidity, burn, cold, cough, diarrhea, dysentery, wound                                                                                                                                                      | [49–52]    | 0  |
| 3  | Aspideretes gangeticus Ernst and Barbour, 1989, Indian soft shell, Plather | Flesh ash, fat, oil | O, T | AG1 2 3 8 25.0 0.178 4.44, AG2 2 25.0 4.44, AG3 4 50.0 8.89 | Skin diseases, Piles, Sexual potency                                                                                                                                                                          | 0          |    |
| 4  | Aspideretes hurum Ernst and Barbour, 1989, Peacock soft shell, Kachokuma | Fat, oil   | T  | AH1 2 4 8 50.0 0.178 8.89, AH2 2 25.0 4.44, AH3 4 25.0 4.44 | Sexual potency, Backbone pain, Joint Pain                                                                                                                                                                   | 0          |    |
| 5  | Lissemys punctata andersoni Webb, 1980, Indian Flap-shelled Turtle, Harakochopa | Carapace Ash, fat, oil | O, T | LP1 1 4 7 14.3 0.156 2.22, LP2 1 14.3 2.22, LP3 2 28.6 4.45, LP4 4 57.2 8.90 | Internal injuries, Allergy, Cough, Sexual potency, Foot and toes injuries, Allergy, acne, piles, arthritis, asthma, bronchitis, burn, cough, dermatitis, epilepsy, backbone pain, diabetes, urinary obstruction, diarrhea, indigestion, lung diseases, malaria fever, menorrhaga, rashes, sexual dysfunction, wounds, tuberculosis | [48, 53–55] | 0.75 |
| 6  | Calotes versicolor (Daudin, 1802), Oriental garden lizard, Girgit          | Flesh ash  | T  | OV1 2 1 12 16.7 0.267 4.45           | Arthritis, burn, cough, fever, jaundice, malaria, sexual stimulant, skin disease                                                                                                                                 | [47, 48, 50, 52, 56–58] | 0.5 |
| 7  | Laudakia agrorensis (Stoliczka, 1872), Agor agama lizard, Goh              | Fat, oil, bile | T  | LA1 2 4 20 10.0 0.444 4.44, LA2 3 15.0 6.67, LA3 4 20.0 8.89, LA4 2 10.0 4.44 | Joint pain, Sexual potency, Snake, spider, wasp and scorpion sting, Body pain                                                                                                                                 | [47, 48]    | 0  |
| 8  | Eublepharis macularius (Blyth, 1854), Common leopard                        | Fat        | T  | EM1 1 1 6 16.7 0.133 2.23           | Arthritis, burn, cough, fever, jaundice, malaria, sexual stimulant, skin disease                                                                                                                                 | [47, 48]    | 0  |
| #  | Scientific, common and local name | Parts used | MA | Diseases | Code | IMA | ND | FC | FL | RPL | ROP | Reported use                                                                 | References | SI |
|----|-----------------------------------|------------|----|----------|-------|-----|----|----|----|-----|-----|--------------------------------------------------------------------------------|------------|----|
| 9  | Uromastyx hardwickii Smith, 1935, Indus spiny-tailed lizard, Sanda | Fat, oil   | T  | Joint pain | UH1   | 20  | 4  | 24 | 83.3 | 0.533 | 44.44 | Enhance sexual power, treat earache, backbone pain, joint pain, headache       | [48, 59]   | 0.5 |
|    |                                   |            |    |          | UH2   | 20  |    |    | 83.3 |        | 44.44 |                                                                      |            |    |
|    |                                   |            |    |          | UH3   | 4   |    |    | 16.7 |        | 8.89  |                                                                      |            |    |
|    |                                   |            |    |          | UH4   | 24  |    |    | 100  |        | 53.33 |                                                                      |            |    |
| 10 | Varanus bengalensis (Daudin, 1802), Bengal Monitor, Bengali goh, Goh | Fat, oil   | T  | Joint pain | VB1   | 3   | 4  | 20 | 15.0 | 0.444 | 6.67  |                                                                      |            |    |
|    |                                   |            |    |          | VB2   | 2   |    |    | 10.0 |        | 4.44  |                                                                      |            |    |
|    |                                   |            |    |          | VB3   | 4   |    |    | 20.0 |        | 8.89  |                                                                      |            |    |
|    |                                   |            |    |          | VB4   | 3   |    |    | 15.0 |        | 6.67  |                                                                      |            |    |
| 11 | Python molurus (Linnaeus, 1758), Rock python, Azdha sap | Fat, oil   | T  | Wound    | PM1   | 3   | 3  | 5  | 60.0 | 0.111 | 6.67  |                                                                      |            |    |
|    |                                   |            |    |          | PM2   | 3   |    |    | 60.0 |        | 6.67  |                                                                      |            |    |
|    |                                   |            |    |          | PM3   | 3   |    |    | 60.0 |        | 6.67  |                                                                      |            |    |
| 12 | Eryx johnii (Russell, 1801), Indian Sand boa, Do moi | Oil        | T  | Leucoderma | EJ1   | 2   | 2  | 22 | 9.1  | 0.489 | 4.44  |                                                                      |            |    |
|    |                                   |            |    |          | EJ2   | 2   |    |    | 9.1  |        | 4.45  |                                                                      |            |    |
| 13 | Ptyas mucosus mucosus (Linnaeus, 1758), Indian rat snake, Chohay-maar sap | Skin       | T  | Eyesight | PMM1  | 3   | 1  | 25 | 12.0 | 0.556 | 6.67  |                                                                      |            |    |
| 14 | Naja naja naja (Linnaeus, 1768), Indian cobra, Kala naag | Fat, skin, oil | T  | Sciatica | NNN1  | 2   | 4  | 17 | 11.8 | 0.378 | 4.44  | Arthritis, cancer, eye sight, leprosy, muscular pain, sexual weakness, sciatica, snakebite | [48, 51, 52, 59] | 1 |
|    |                                   |            |    |          | NNN2  | 4   |    |    | 23.6 |        | 8.92  |                                                                      |            |    |
|    |                                   |            |    |          | NNN3  | 7   |    |    | 41.2 |        | 15.56 |                                                                      |            |    |
|    |                                   |            |    |          | NNN4  | 2   |    |    | 11.8 |        | 4.46  |                                                                      |            |    |
| 15 | Daboia russelii russelii (Shaw and Nodder, 1797), Russel’s chain viper, Dabian wala sap | Fat, oil   | T  | Urine problem | DRR1  | 1   | 2  | 8  | 12.5 | 0.178 | 2.22  |                                                                      |            |    |
|    |                                   |            |    |          | DRR2  | 1   |    |    | 1.5  |        | 0.27  |                                                                      |            |    |
| 16 | Echis carinatus sochureki Stemmler, 1969, Sind Valley saw snake viper, Pathar Sap | Fat, oil   | T  | Snake bite | EC1   | 2   | 3  | 7  | 28.6 | 0.156 | 4.44  | Snake bite                                                                     | [48, 59]   | 0.25 |
|    |                                   |            |    |          | EC2   | 2   |    |    | 28.6 |        | 4.45  |                                                                      |            |    |
| #  | Scientific, common and local name | Parts used | MA | Diseases | Code | IMA | ND | FC | FL | RPL | ROP | Reported use                                                                 | References | SI |
|----|----------------------------------|------------|----|----------|------|-----|----|----|----|-----|-----|-----------------------------|------------|----|
|    | Fishes                           |            |    |          |      |     |    |    |    |     |     |                                            |            |    |
| 17 | Ctenopharyngodon idella (Valenciennes, 1844), Grass carp, Grass carp | Brain, oil O, T |    | Eyesight | Q1  | 51  | 5  | 51 | 100| 1.000| 100  | Treat cold, enhance memory, energy and sexual power, joint pain | [31, 48]   | 0.20 |
|    |                                  |            |    | Night blindness | Q2  | 6   |    | 11.8| 11.8|     |     |                                            |            |    |
|    |                                  |            |    | Fever     | Q3  | 44  |    | 86.3| 86.3|     |     |                                            |            |    |
|    |                                  |            |    | Cold      | Q4  | 51  |    | 100 | 100 |     |     |                                            |            |    |
|    |                                  |            |    | Joint pain | Q5  | 3   |    | 5.9 | 5.9 |     |     |                                            |            |    |
| 18 | Cyprinus carpio Linnaeus, 1758, Common carp, Gulf carp               | Brain, oil O, T |    | Eyesight | C1  | 5   | 5  | 62 | 8.1 | 1.000| 8.1  | CNS, erysipelas, lumbago, enhance memory, energy and sexual power, reduce overweight, and treat cold | [48, 60]   | 0.20 |
|    |                                  |            |    | Night blindness | C2  | 5   |    | 6.8 | 6.8 |     |     |                                            |            |    |
|    |                                  |            |    | Fever     | C3  | 60  |    | 96.8| 96.8|     |     |                                            |            |    |
|    |                                  |            |    | Cold      | C4  | 3   |    | 4.1 | 4.1 |     |     |                                            |            |    |
|    |                                  |            |    | Joint pain | C5  | 3   |    | 4.1 | 4.1 |     |     |                                            |            |    |
| 19 | Hypophthalmichthys molitrix (Valenciennes, 1844), Silver carp, Silver carp | Brain, oil O, T |    | Eyesight | H1  | 5   | 5  | 60 | 8.3 | 1.000| 8.3  |                                            |            |    |
|    |                                  |            |    | Night blindness | H2  | 5   |    | 8.3 | 8.3 |     |     |                                            |            |    |
|    |                                  |            |    | Fever     | H3  | 60  |    | 100 | 100 |     |     |                                            |            |    |
|    |                                  |            |    | Cold      | H4  | 60  |    | 100 | 100 |     |     |                                            |            |    |
|    |                                  |            |    | Joint pain | H5  | 3   |    | 5.0 | 5   |     |     |                                            |            |    |
| 20 | Cirrhinus mrigala (Hamilton, 1822), Mrigal carp, Mori               | Brain, oil O, T |    | Eyesight | O1  | 5   | 5  | 50 | 10.0| 1.000| 10  | Reduces weight, joint pain, enhance memory, sexual power, provide energy, against cold | [48, 59]   | 0.40 |
|    |                                  |            |    | Night blindness | O2  | 5   |    | 10.0| 10  |     |     |                                            |            |    |
|    |                                  |            |    | Fever     | O3  | 50  |    | 100 | 100 |     |     |                                            |            |    |
|    |                                  |            |    | Cold      | O4  | 44  |    | 88.0| 88  |     |     |                                            |            |    |
|    |                                  |            |    | Joint pain | O5  | 3   |    | 6.0 | 6   |     |     |                                            |            |    |
| 21 | Cirrhinus reba (Hamilton, 1822), Reba carp, Reba Machhali           | Brain, oil O, T |    | Eyesight | R1  | 5   | 5  | 67 | 7.5 | 1.000| 7.5  |                                            |            |    |
|    |                                  |            |    | Night blindness | R2  | 5   |    | 7.5 | 7.5 |     |     |                                            |            |    |
|    |                                  |            |    | Fever     | R3  | 67  |    | 100 | 100 |     |     |                                            |            |    |
|    |                                  |            |    | Cold      | R4  | 55  |    | 82.1| 82.1|     |     |                                            |            |    |
|    |                                  |            |    | Joint pain | R5  | 3   |    | 4.5 | 4.5 |     |     |                                            |            |    |
### Table 1
Comparative assessment of present and previously reported ethnomedicinal uses of herptiles and fishes (Continued)

| #  | Scientific, common and local name | Parts used | MA | Diseases     | Code | IMA | ND | FC | FL | RPL | ROP | Reported use                                                                 | References | SI |
|----|----------------------------------|------------|----|---------------|------|-----|----|----|----|-----|-----|--------------------------------------------------------------------------------|------------|----|
| 22 | *Labeo rohita* (Hamilton, 1822), Rohu, Raho | Brain O      |    | Joint pain   | LR1  | 55  | 8  | 61.1 | 1.000 | 61.1 | Urine problem, stomachache, weakness, rheumatic pain, enhance memory, energy and sexual power, treat cold | [47, 48, 59, 61] | 0.25 |
|    |                                  |            |    | Body pain    | LR2  | 3   | 3.3 | 3.3  |       |     |                                                                                 |            |    |
|    |                                  |            |    | Sexual potency | LR3  | 7   | 7.8 | 7.8  |       |     |                                                                                 |            |    |
|    |                                  |            |    | Eye sight     | LR4  | 5   | 5.6 | 5.6  |       |     |                                                                                 |            |    |
|    |                                  |            |    | Depression    | LR5  | 2   | 2.2 | 2.2  |       |     |                                                                                 |            |    |
|    |                                  |            |    | Diabetes      | LR6  | 2   | 2.2 | 2.2  |       |     |                                                                                 |            |    |
|    |                                  |            |    | Alzheimer     | LR7  | 1   | 1.1 | 1.1  |       |     |                                                                                 |            |    |
|    |                                  |            |    | Heart disease | LR8  | 2   | 2.2 | 2.2  |       |     |                                                                                 |            |    |
| 23 | *Labeo calbasu* (Hamilton, 1822), Orangefin labeo, Kalbans | Brain, oil O, T |    | Joint pain   | LC1  | 55  | 8  | 55   | 100   | 100 | Increase energy, CNS, galactagogue, enhance memory, enhance energy, sexual power, reduce overweight, increase lactation in mother, energy, cold | [48, 62]  | 0.125 |
|    |                                  |            |    | Body pain    | LC2  | 55  | 100 | 100  |       |     |                                                                                 |            |    |
|    |                                  |            |    | Sexual potency | LC3  | 55  | 100 | 100  |       |     |                                                                                 |            |    |
|    |                                  |            |    | Eye sight     | LC4  | 5   | 9.1 | 9.1  |       |     |                                                                                 |            |    |
|    |                                  |            |    | Depression    | LC5  | 2   | 3.6 | 3.6  |       |     |                                                                                 |            |    |
|    |                                  |            |    | Diabetes      | LC6  | 2   | 3.6 | 3.6  |       |     |                                                                                 |            |    |
|    |                                  |            |    | Alzheimer     | LC7  | 1   | 1.8 | 1.8  |       |     |                                                                                 |            |    |
|    |                                  |            |    | Heart disease | LC8  | 2   | 3.6 | 3.6  |       |     |                                                                                 |            |    |
| 24 | *Labeo dero* (Hamilton, 1822), Dero, Dero machhalli | Brain, oil O, T |    | Eyesight     | LD1  | 5   | 5  | 57   | 8.8   | 8.8 |                                                                      | 0          |    |
|    |                                  |            |    | Night blindness | LD2  | 5   | 8.8 | 8.8  |       |     |                                                                                 |            |    |
|    |                                  |            |    | Fever         | LD3  | 57  | 100 | 100  |       |     |                                                                                 |            |    |
|    |                                  |            |    | Cold          | LD4  | 57  | 100 | 100  |       |     |                                                                                 |            |    |
|    |                                  |            |    | Joint pain    | LD5  | 3   | 5.3 | 5.3  |       |     |                                                                                 |            |    |
| 25 | *Gibelion catla* (Hamilton, 1822), Catla, Thaila | Brain O      |    | Improve CNS  | GC1  | 10  | 2  | 17.9 | 1.000 | 17.9 | Increases energy & memory, galactagogue, rheumatic pain, enhance sexual power | [48, 59, 62] | 1   |
|    |                                  |            |    | Cold          | GC2  | 3   | 5.4 | 5.4  |       |     |                                                                                 |            |    |
| 26 | *Channa punctata* (Bloch, 1793), Spotted snakehead, Dola | Flesh O     |    | Regulate blood chemical | CP1  | 4  | 4  | 6.9  | 1.000 | 6.9 | Appetite, blood purification, malaria, body pain, enhance energy, sexual power, treat cold and joint pain | [48, 61, 63, 64] | 0   |
|    |                                  |            |    | Eye sight     | CP2  | 4   | 6.9 | 6.9  |       |     |                                                                                 |            |    |
| 27 | *Channa marulius* (Hamilton, 1822), Great snakehead, Soul | Flesh O     |    | Sexual potency | CMH1 | 12  | 20.7 | 1.000 | 20.7   | Increases sex power, hemoglobin, memory and energy, cure rheumatic pain, cold, joint pain | [30, 59, 61, 62] | 0.5 |
|    |                                  |            |    | Weakness      | CMH2 | 10  | 17.2 | 17.2  |       |     |                                                                                 |            |    |
| #  | Scientific, common and local name | Parts used | MA | Diseases | Code | IMA | ND | FC | FL | RPL | ROP | Reported use                                                                 | References | SI |
|----|----------------------------------|------------|----|----------|------|-----|----|----|----|-----|-----|-----|--------------------------------------------------------------------------------|------------|----|
| 28 | Oreochromis niloticus (Linnaeus, 1758), Nile tilapia, Tilapia | Flesh ash | T  | Scorpion, wasp, spider and insect bite | ON1 | 4   | 2  | 53 | 7.5 | 1.000 | 7.5 | Abscesses, carbuncle, vision, scorpion bite, enhance memory, energy and sexual power | [48, 60]    | 0.5|
| 29 | Rita rita (Hamilton, 1822), Catfish, Khaga | Flesh and oil | O, T | Joint pain, Sexual potency | ON2 | 12  | 2  | 22.6 | 22.6 | 1.000 | 6.4 | 6.4 | Joint pain, CNS, enhance energy, sexual power, treat cold and joint pain | [48, 59]    | 1  |
| 30 | Bagarius bagarius (Hamilton, 1822), Goonch, Foji Khaga | Flesh soup | O | Body pain, Sexual potency | ON2 | 12  | 22.6 | 22.6 | 22.6 | 1.000 | 6.4 | 6.4 | Body burns, body pain, stomach pain | [57, 61]    | 0.5|
| 31 | Mystus cavasius (Hamilton, 1822), Ganges mystus, Tangra Machhali | Flesh | O | Small pox, Chicken pox | MC1 | 1   | 2  | 10.0 | 2.222 | 2.222 | 2.222 | Small pox, joint pain | [59, 65]    | 0.5|
| 32 | Mastacembelus armatus (Skyes, 1839, Zig zag eel, Baam Machhali) | Flesh | O | Sexual potency | MA1 | 10  | 2  | 65.4 | 15.4 | 15.4 | 15.4 | 15.4 | 15.4 | 15.4 | 15.4 | 15.4 | 15.4 | [52, 48, 47, 49, 71, 72] | 0.5|
| 33 | Wallago attu (Bloch & Schneider, 1801), Wallago catfish, Mali | Flesh | O | Liver disease, Hepatitis | WA1 | 2   | 2  | 68.0 | 2.9  | 2.9  | 2.9  | 2.9  | 2.9  | 2.9  | 2.9  | 2.9  | 2.9  | 2.9  | [68, 69] | 0.5|
| 34 | Notopterus notopterus (Pallas, 1769), Bronze featherback, But Pari | Flesh | O | Small pox, Chicken pox | NN1 | 1   | 2  | 25.0 | 4.0  | 2.224 | 2.224 | 2.224 | 2.224 | 2.224 | 2.224 | 2.224 | 2.224 | [69, 70] | 0.5|
| 35 | Puntius sophore (Hamilton, 1822), Spotfin swamp barb, Sophore popra | Flesh | O | Regulate blood-chemical balance | PT1 | 3   | 4  | 5   | 60.0 | 0.111 | 6.66 | 6.66 | 6.66 | 6.66 | 6.66 | 6.66 | 6.66 | 6.66 | [63, 70] | 1  |
| 36 | Pethia ticto (Hamilton, 1822), Ticto barb, Ticto popra | Brain | O | Night blindness | PT2 | 5   | 100 | 11.1 | 11.1 | 11.1 | 11.1 | 11.1 | 11.1 | 11.1 | 11.1 | 11.1 | 11.1 | 11.1 | [67, 71] | 1  |
| 37 | Heteropneustes fossilis (Bloch, 1794), Stinging catfish, Sanghe Machhali | Flesh | O | Increase hemoglobin level | HF1 | 2   | 40.0 | 0.111 | 4.44 | 4.44 | 4.44 | 4.44 | 4.44 | 4.44 | 4.44 | 4.44 | 4.44 | 4.44 | [47, 48, 52] | 1  |
| 38 | Gagata cenia (Hamilton, 1822), Indian gagata, Gagata cenia | Bone | O | Urine problem | GCH1 | 2   | 1  | 8   | 25.0 | 0.178 | 4.45 | 4.45 | 4.45 | 4.45 | 4.45 | 4.45 | 4.45 | 4.45 | [47, 71, 72] | 1  |

MA. Mode of application, IMA. Informant of major ailment, ND. Number of diseases, FC. Frequency of citation, FL. Fidelity level, RPL. Relative popularity level, ROP. Rank order priority, SI. Similarity index, T. topical, O. oral

*Italic: Medicinal uses which are reported for very first time in this study

*Bold: Medicinal uses which are different than reported uses
such as *L. melanura melanura*, *A. cantor*, *A. pannonicus*, *Naja naja naja*, and *E. macularia* which have black, blue, red, and black and brown color lines and hence were named kali kirli, neeli poosh kirli, surakh posh kirli, Kala naag, and bori kaa kirli, respectively.

The vernacular names of the reported species had also connections with the habitats like sahari kirli as the name of *C. montiumsalorum*, because it lives in desert (Sahari) landscapes, whereas *H. flaviviridis* and *B. stomaticus* were named asghariallo daddo and ghariallo kirli, respectively.

Eight species of fish had the same suffix “machhali” such as *Cirrhitus reba* (reba machhali), *Labeo dero* (dero machhali), *Oreochromis niloticus* (tilapia/chira machhli), *Mystus cavasius* (tangra machhali), *Mastacembelus armatus* (baam machhali), *Osteobrama cotio* (pali roo machhali), *Salmostoma bacala* (choti chal machhali), and *Heteropneustes fossilis* (sangehi machhali). The English and local names of *Hypophthalmichthys molitrix* were the same—“silver carp”. Vernacular names of two species were based on their color: *H. molitrix* has silver color and *C. idella* has grass color; therefore, they were named as silver carp and grass carp, respectively. Some fish were also classified on the basis of morphology, e.g., the shape of *Channa punctata* is similar to an arm muscle; therefore, it was called dola (bicep muscle); *O. niloticus* size resembles a house sparrow and thus, the species was named chira machhli (chira is house sparrow) and *S. bacaia* has small size, and was known as choti chal machhali (choti means small).

Myths about herptiles and fish

Some common myths on snake and fish species were also noted during the field survey. These myths were comparable to previous reports [15].

- It is a common assumption that if *Eryx johnii* (common sand boa) bites somebody, it will bite on the arrival of the new moon in each month.
- If the male or female of snake pair is killed by someone, then the other will certainly take revenge from the assassin.
- *Naja naja* changes into a human after 100 year of age and can transfer poison to a person if it sniffs someone.
- Some people of the study area believe that *Python molurus* (rock python) has seven mouths.
- Most people believe that a special bone called Mankana is present in the snake head, and that this bone can absorb poison from snake-bitten people.
- Seeing a snake in a dream means that an enemy may attack a person.
- Every species of fish has a special kind head like a human and body like a fish, which locally known as Jal Pari.
- Turtles have a blade which can cut anything.

Ethnomedicinal uses herptiles and fish

Inhabitants of the study area possessed significant knowledge on the medicinal as well as cultural uses of animal species, particularly that of herptiles and fish (Fig. 3). As mentioned in Table 1, 38 species of herptiles and fish were used to treat various health disorders such as allergy, cardiovascular, nervous and respiratory disorders, sexual impotency, skin infections, and as antidote and anti-diabetic agents in human and livestock (Table 2).
leucine, tyrosine, phenylalanine, histidine, lysine, arginine, and hydroxylysine [80], have also been reported in the skin of fish. Collagen (I) is used in membranes for guided tissue regeneration [81]. While, essential amino acids profile of fish is required to humans for balanced diet [82].

Inhabitants of the study area use carapace of the turtle to treat internal injuries, allergy, cough, and as a sexual stimulant. These pharmacological properties of turtle carapace are mainly due to the presence of β-pleated sheet keratin [83], keratinocytes, melanocytes, lipids [84], and mineralized collagen fibrils [85]. Likewise, fish brain is used to treat joint pain, Alzheimer, heart diseases, for sexual potency, to improve eye-sight, as an anti-depressant and anti-diabetic. The health beneficial properties of fish brain mainly attributed to rich compounds of docosahexaenoic acid, omega-3 fatty acids, and proteins present in it [76, 86].

Diseases treated
As mentioned in Fig. 5, joint pain, eye diseases, sexual impotency, common cold, and fever were among the top ranked diseases treated with maximum number of animal-based recipes. Lack of hygiene, nutritional deficiency, and “community evils” were among the major factors involved in the high prevalence of diseases in the study area. Comparative analysis of the present findings with previous reports on medicinal uses of herptiles and fish species indicate that different methods of treatments and body parts were used in study area (Table 1). The inhabitants of the study area use skin of Indus valley toad (Duttaphrynus stomaticus) to treat skin infections, while the same species have been reported to treat allergy, thelitis, bolianerengia, bronchial pneumonia, dermatitis, abscess, and to heal wounds [46–48]. Body fat of the Indian bullfrog (Hoplobatrachus tigerinus) was used to treat backbone pain, sexual impotency, and joint pain; but in previous studies [49–52], different body parts of this species have been reported against acidity, burn, cold, cough, diarrhea, dysentery, and to heal wounds. In the study area, carapace ash, fat, and oil of the Indian flap-shelled turtle (Lissemys punctata ander-soni) were used to enhance sexual potency and in the treatment of internal injuries, allergy, and cough. However, this species has also been reported to treat acne, piles, arthritis, asthma, bronchitis, burns, cough, dermatitis, epilepsy, backbone pain, diabetes, urinary obstruction, diarrhea, indigestion, lung diseases, malaria fever, menorrhagia, rashes, wound healing, and tuberculosis [48, 53–55]. Fat, oil, and bile of Agror agama (Laudakia agrogrensis) were used for joint pain; sexual potency; snake, spider, wasp, and scorpion sting; as well as body pain. Same species are used to treat jaundice, joint pain, malaria, arthritis, burn, cough, fever, and skin disease [47, 48, 50, 52, 56–58]. The Indus spiny-tail lizard (Uromastyx hardwickii) is used in the treatment of body pain, joint pain, sciatica pain, and for sexual potency,
Table 2: Cultural uses of herptiles and fishes in the study area

| Sr. # | Scientific, common, and local name | FC | RFC | CU | STS | MD | NR | CC | TL | ET | FD | HF | MG | EX | OR | SPR |
|-------|-----------------------------------|----|-----|----|-----|----|----|----|----|----|----|----|----|----|----|----|
| 1     | Bufo bufo (Linnaeus, 1758), European Toad, Common Toad | 7  | 0.401 | 2 | LC | X | √ | X | X | X | √ | X | X | X | X | X |
| 2     | Duttaphrynus melanostictus (Boulenger, 1882), Indian Toad, Common Toad | 30 | 1.720 | 3 | LC | √ | √ | X | X | X | X | X | X | X | X | X |
| 3     | Microhyla ornata (Dumeril and Bibron, 1841), Agile Frog, Bona daddo | 7  | 0.401 | 2 | LC | X | √ | X | X | X | √ | X | X | X | X | X |
| 4     | Fejervarya limnocharis (Gravenhorst, 1829), Asian Grass Frog, Pidda daddo | 5  | 0.287 | 2 | LC | X | √ | X | X | X | √ | X | X | X | X | X |
| 5     | Hoplobatrachus tigerinus (Daudin, 1802), Indian Bullfrog, Wada daddo | 40 | 2.294 | 4 | LC | √ | √ | √ | X | X | X | X | X | X | X | X |
| 6     | Sphaerotheca breviceps (Schneider, 1799), Indian burrowing frog, Chota dahri daddo | 5  | 0.287 | 4 | LC | X | √ | X | X | X | √ | X | X | X | X | X |
| 7     | Aspideretes gangeticus Ernst and Barbour, 1989, Indian soft shell, Plaither | 8  | 0.459 | 5 | VU | √ | √ | √ | X | X | X | X | X | X | X | X |
| 8     | Aspideretes hurum Ernst and Barbour, 1989, Peacock soft shell, Kachhokuma | 8  | 0.459 | 5 | VU | √ | √ | √ | X | X | X | X | X | X | X | X |
| 9     | Lissamys punctata andersoni Webb, 1980, Indian Flap-shelled Turtle, Hara kachopra | 7  | 0.401 | 5 | LC | √ | √ | √ | X | X | X | X | X | X | X | X |
| 10    | Calotes minor (Hardwicke and gray, 1827), Hardwicke’s Short Tail Agama, Choti dum kirli | 5  | 0.287 | 2 | NE | X | X | X | X | X | √ | X | X | X | X | X |
| 11    | Calotes versicolor (Daudin, 1802), Oriental garden lizard, Girgit | 12 | 0.688 | 3 | NE | √ | √ | X | X | X | X | X | X | X | X | X |
| 12    | Laudakia agrorensis (Stoliczka, 1872), Agror agama, Goh | 20 | 1.147 | 4 | NE | √ | √ | √ | X | X | X | X | X | X | X | X |
| 13    | Laudakia melanura melanura (Blyth, 1854), Black agama, Kali kirli | 2  | 0.115 | 2 | NE | X | X | X | X | X | √ | X | X | X | X | X |
| 14    | Trapelus agilis pakistanensis Rastegar-Pouyani, 1999, Brilliant ground agama, Korth kirla | 5  | 0.287 | 2 | NE | X | X | X | X | X | √ | X | X | X | X | X |
| 15    | Eublepharis macularius (Blyth, 1854), Common leopard gecko, Korth kirli | 6  | 0.344 | 4 | NE | √ | √ | X | X | X | X | X | X | X | X | X |
| 16    | Cyrtopodion montiumsalsorum (Annandale, 1913), Salt range ground gecko, Sahari kirli | 4  | 0.229 | 2 | NE | X | X | X | X | X | √ | X | X | X | X | X |
| 17    | Cyrtopodion Scabrum (Heydenn 1827), Common tuberculated ground gecko, Toor kirli | 2  | 0.115 | 2 | LC | X | X | X | X | X | √ | X | X | X | X | X |
| 18    | Hemidactylus flaviviridis Rüppell, 1835, Yellow belly common house gecko, Gharailo kirli | 44 | 2.523 | 2 | NE | X | X | X | X | X | √ | X | X | X | X | X |
| 19    | Hemidactylus persicus Anderson, 1872, Persian house gecko, Irani kirli | 3  | 0.172 | 2 | NE | X | X | X | X | X | √ | X | X | X | X | X |
| 20    | Acantodactylus cantoris Gunther, 1864, Blue tailed sand lizard, Neeli poosh kirli | 0.000 | 2 | NE | X | X | X | X | X | √ | X | X | X | X | X | X |
| 21    | Ophisops jerdonii Blyth, 1853, Punjab snake-eyed lacerta, Safaid dahari kirli | 4  | 0.229 | 2 | NE | X | X | X | X | X | √ | X | X | X | X | X |
| 22    | Ablepharus grayanus (Stoliczka, 1872), Earless snake eyed skink, Bahut kirli | 1  | 0.057 | 2 | NE | X | X | X | X | X | √ | X | X | X | X | X |
| 23    | Ablepharus pannonicus (Fitzinger, 1824), Red tail snake eyed skink, Surakh posh kirli | 3  | 0.172 | 2 | NE | X | X | X | X | X | √ | X | X | X | X | X |
| 24    | Eutropis macularia (Blyth, 1853), Bronz grass skink, Bori kaa kirli | 2  | 0.115 | 2 | NE | X | X | X | X | X | √ | X | X | X | X | X |
| 25    | Eurypleps taeniobolus taeniobolus Blyth, 1854, Alpine Punjabi skink, Maidani kirli | 3  | 0.172 | 2 | NE | X | X | X | X | X | √ | X | X | X | X | X |
| 26    | Ophiomorus tridactylus(Blyth, 1853), Three toed snake skink, Tray ungl kirli | 2  | 0.115 | 2 | NE | X | X | X | X | X | √ | X | X | X | X | X |
| 27    | Scincella himalayana (Günther, 1864), Himalayan skink, Pahari kirli | 2  | 0.115 | 2 | NE | X | X | X | X | X | √ | X | X | X | X | X |
Table 2  Cultural uses of herptiles and fishes in the study area (Continued)

| Sr. # | Scientific, common, and local name | FC | RFC | CU | STS | MD | NR | CC | TL | ET | FD | HG | MG | EX | OR | SPR |
|-------|-----------------------------------|----|-----|----|-----|----|----|----|----|----|----|----|----|----|----|-----|
| 28    | Uromastyx hardwickei (Smith, 1935), Indus spiny-tail lizard, Sanda | 24 | 3 | 1.376 | 3 | NE | √ | X | X | X | X | X | √ | X | X | √ |
| 29    | Varanus bengalensis (Daudin, 1802), Bengal Monitor, Bengali goh, Goh | 20 | 4 | 1.147 | 4 | LC | √ | X | X | X | X | √ | X | X | X | √ |
| 30    | Leptophis macrorynchus Hahn, 1978, long-nosed worm snake, Dhaga sap | 5 | 2 | 0.287 | 2 | LC | X | √ | X | X | X | X | X | X | X | X |
| 31    | Rhamphothecus brasinius Daudin, 1803, Barhminy blind snake, Dhaga sap | 3 | 2 | 0.172 | 2 | NE | X | √ | X | X | X | X | X | X | X | X |
| 32    | Python molurus (Linnaeus, 1758), Rock python, Azdha sap | 5 | 4 | 0.287 | 3 | VL | √ | X | X | X | X | X | X | X | X | X |
| 33    | Amphiesma stolatum (Linnaeus, 1758), Buff Striped Keelback, Lakeer dhari sap | 5 | 3 | 0.287 | 3 | NE | √ | X | X | √ | X | X | X | X | X | X |
| 34    | Boiga trigonata (Schneider, 1802), Common cat snake, Billi sap | 5 | 2 | 0.287 | 2 | LC | X | √ | X | X | X | X | X | X | X | X |
| 35    | Lytrophrynchus paradoxus (Gunther, 1875), Sind longnose sand snake, Ollu sap | 6 | 2 | 0.344 | 2 | NE | X | √ | X | X | X | √ | X | X | X | X |
| 36    | Oligodon amensis amensis (Shaw, 1802), Banded kukri snake, Kukri Sap | 6 | 2 | 0.344 | 2 | NE | X | √ | X | X | X | √ | X | X | X | X |
| 37    | Oligodon taeniolatus taeniolatus (Jerdon, 1853), Streaked kukri snake, Kukri sap | 4 | 2 | 0.229 | 2 | LC | X | √ | X | X | X | √ | X | X | X | X |
| 38    | Platyceps rhodochris rhodochris (Jan, 1865), Cliff racer, Pheesi sap | 5 | 2 | 0.287 | 2 | NE | X | √ | X | X | X | √ | X | X | X | X |
| 39    | Eryx johnii (Russell, 1801), Common Sand boa, Do moi | 22 | 3 | 1.261 | 3 | NE | √ | X | X | X | X | √ | X | X | X | X |
| 40    | Psammophis leithii leithii Günther, 1869, Steppe ribbon snake, Teer maar sap | 8 | 2 | 0.459 | 2 | NE | X | √ | X | X | X | √ | X | X | X | X |
| 41    | Psammophis schokari schokari (Forskal, 1775), Schokari sand racer snake, Saharai sap | 5 | 2 | 0.287 | 2 | NE | X | √ | X | X | X | √ | X | X | X | X |
| 42    | Ptyas mucosus mucosus (Linnaeus, 1758), Indian rat snake, Chohay-maar sap | 25 | 4 | 1.433 | 4 | NE | √ | X | X | X | √ | X | X | X | X | X |
| 43    | Xenochrophis piscator piscator (Schneider, 1799), Chekered keelback, Chitra sap | 8 | 2 | 0.459 | 2 | NE | X | √ | X | X | X | √ | X | X | X | X |
| 44    | Bungarus caeruleus caeruleus (Schneider, 1801), Common krait, Sangchhor sap | 12 | 2 | 0.688 | 2 | NE | X | √ | X | X | X | √ | X | X | X | X |
| 45    | Naja naja naja (Linnaeus, 1768), Indian cobra, Kala naag | 17 | 5 | 0.975 | 5 | LC | √ | X | X | X | √ | X | X | X | X | X |
| 46    | Daboia russielluss russielluss (Shaw and Nodder, 1797), Russell’s chain viper, Dabian wala sap | 8 | 3 | 0.459 | 3 | NE | √ | X | X | X | X | √ | X | X | X | X |
| 47    | Echis carinatus sochureki Stemmler, 1964, Sind Valley saw snake viper, Pathar Sap | 7 | 3 | 0.401 | 3 | NE | √ | X | X | X | X | √ | X | X | X | X |
| 48    | Ctenopharyngodon idella (Valenciennes, 1844), Grass carp, Grass carp | 51 | 6 | 2.924 | 6 | NE | √ | X | X | X | X | √ | X | X | X | X |
| 49    | Cyprinus carpio (Linnaeus, 1758), Common carp, Gulform | 62 | 6 | 3.555 | 6 | VL | √ | X | X | X | X | √ | X | X | X | X |
| 50    | Hypophthalmichthys molitrix (Valenciennes, 1844), Silver carp, Silver carp | 60 | 6 | 3.440 | 6 | NT | √ | X | X | X | √ | X | X | X | X | X |
| 51    | Cirrhinus mirgala (Hamilton, 1822), Mirgal carp, Mori | 50 | 6 | 2.867 | 6 | LC | √ | X | X | X | X | √ | X | X | X | X |
| 52    | Cirrhinus reba (Hamilton, 1822), Reba carp, Reba Machhali | 67 | 6 | 3.842 | 6 | LC | √ | X | X | X | X | √ | X | X | X | X |
| 53    | Labeo rohita (Hamilton, 1822), Rohu, Raho | 90 | 6 | 5.161 | 6 | LC | √ | X | X | X | X | √ | X | X | X | X |
| 54    | Labeo calbasu (Hamilton, 1822), Orangefin labeo, Kaltibs | 55 | 6 | 3.154 | 6 | LC | √ | X | X | X | X | √ | X | X | X | X |
| 55    | Labeo dero (Hamilton, 1822), Dero, Dero machhali | 57 | 6 | 3.268 | 6 | LC | √ | X | X | X | X | √ | X | X | X | X |
| 56    | Channa catla (Hamilton, 1822), Catla, Thaila | 56 | 6 | 3.211 | 6 | LC | √ | X | X | X | X | √ | X | X | X | X |
| 57    | Channa punctata(Blanchard, 1793), Spotted snakehead, Dola | 58 | 6 | 3.326 | 6 | LC | √ | X | X | X | X | √ | X | X | X | X |
| 58    | Channa marulius (Hamilton, 1822), Great snakehead, Soul | 58 | 6 | 3.326 | 6 | LC | √ | X | X | X | X | √ | X | X | X | X |
| 59    | Oreochromis niloticus (Linnaeus, 1758), Nile tilapia, Tilapia/Chira machhili | 53 | 6 | 3.039 | 6 | NE | √ | X | X | X | X | √ | X | X | X | X |
whereas [48, 59] it was reported that the same species is useful against ear pain, backache, joint pain, and headache. Local people used body fat, skin, and oil of the Indian cobra (Naja naja naja) to treat sciatica, snakebite, to improve eye sight, and as sex stimulant. This species has been reported to cure arthritis, cancer, leprosy, muscular pain, as aphrodisiac, and as antidote [48, 51, 52, 59]. Fat and oil of Russell’s chain viper (Daboia russelii russelii) were used as a remedy for urine problem and hemorrhoids. However, in previous studies [50, 59, 87], different parts of this species have been reported as used against weak eye sight, urination, stool, flatus, and as anti-venom. Likewise, body fat and oil of the Sind valley saw snake vipers (Echis carinatus sochureki) were used to treat joint pain, snakebite, weak eye sight, and to enhance sexual desire [48, 59].

Inhabitants of the study area preferred Ctenopharyngodon idella for the treatment of eyesight, night
blindness, fever, cold, and joint pain, while the same species was reported to treat erectile disinfection, cold, to enhance memory, and sexual power and showed 0.20 similarity index with previous reports [31, 48]. Our findings revealed that *Cyprinus carpio* and *Cirrhinus mrigala* were effective against weak eyesight, night blindness, fever, cold, and joint pain. In previous studies [48, 60], *C. carpio* has been reported as used for CNS, erysipelas, lumbago, to enhance memory, enhance energy, sexual power, to reduce overweight, and against cold and has depicted similarity index = 0.20. Likewise, *C. mrigala* was reported to reduce weight, to treat joint pain, to enhance memory and sexual power, to provide energy, and to treat against cold [48, 59]. *Labeo rohita* and *L. calbasu* were used for the treatment of joint pain, body pain, sexual potency, eyesight, depression, diabetes, Alzheimer, and heart diseases. Similarly, the fish species *Gibelion catla*, *Rita rita*, *Puntius sophore*, and *Heteropneustes fossilis* were used to enhance hemoglobin, regulate blood chemistry, joint pain, sexual potency, improve CNS, cold, and have highest similarity index 1 with previous reports [47, 48, 59, 61].

The ethnomedicinal uses of eight herptiles, i.e., *A. gangeticus*, *A. hurum*, *E. macularius*, *V. bengalensis*, *P. molurus*, *E. johnii*, *P. mucosus mucosus*, *D. russelli russelli* and five fish species including *H. molitrix*, *C. reba*, *L. dero*, *M. armatu*, and *P. ticto* were reported for the first time from this region, and showed zero similarity with other studies. Among herptiles, *H. tigerinus*, *D. stomaticus*, and *P. mucosus mucosus* and in fishes *L. rohita*, *W. attu*, and *C. reba* were top ranked with maximum informant reports, frequency of citations, and rank order priority.
Cultural values of herptiles and fish

Cultural values of the reported species of herptiles and fish are given in Table 2. Local people of the study area used the skin of the black cobra in magic. Likewise, different species of snakes like the Indian cobra (Naja naja naja), Indian rat snake (Ptyas mucosus mucosus), and buff striped keelback snake (Amphiesma stolatum) were used for pleasure of the public such as the mongoose competition with a snake. According to local informants, the presence of the yellow belly common house gecko (Hemidactylus flaviviridis) in a home is considered as bad omen for residents. The Bengal monitor (Varanus bengalensis) is tied with rope and with the help of that rope a person can climb walls. Fish species were not only used in the treatment of various diseases but also as nutritious food. Local inhabitants used fish flesh as bait for various species of fish from rivers, as reported earlier by [88].

Inhabitants of the study area used different species of fish for commercial purposes. Likewise, Indian soft shell, Peacock soft shell, Indian Flap-shelled Turtle, and Indian Bullfrog were captured and sold for lab practice. Only four species of herptiles such as Indian soft shell (Aspideretes gangeticus), Peacock soft shell (Aspideretes hurum), Indian Flap-shelled Turtle (Lissamphys punctata andersoni), and common leopard gecko (Eublepharis macularius) were exported from the area, and are used as food and for medicines. Two species of fish, i.e., Bronze featherback (Notopeterus Notopterus) and Indian glassy fish (Parambassis ranga), are ornamental fish for aquaria.

The animal species reported by the maximum number of respondents were frequently used to treat various diseases, and exhibited high FC (Frequency of Citation) ranging from 5 to 90 (Fig. 6), i.e., Labeo rohita (rohu) had a maximum FC (90), followed by Wallago attu (wallago catfish) and Cirrhinus reba (Reba carp) (68 and 67, respectively).

The fidelity level is utilized to recognize species that are commonly favored by people to treat different diseases [89, 90]. The FL of herptile and fish species in this study varied from 2.9 to 100% (Table 2). Nine species, including U. hardwickii (Indus spiny-tail lizard), C. idella (grass carp), H. molitrix (silver carp), L. dero (dero), C. mrigala (mrigal carp), C. reba (reba carp), L. rohita (rohu), L. calbasu (orange fin laboe), and P. ticto (ticto barb) which were used for sexual potency, fever, cold, and to treat eyesight, body pain, and joint disorders, depicted 100% FL (Fig. 5). These findings indicate the prevalence of particular diseases in the area that were cured with species having high FL. The animal species with maximum FL were highly used in the area, as compared to species having low FL. The FL of herptile and fish species was documented for the first time, and species with highest FL might be subjected to in-depth compositional analysis and bioactivities in pharmaceutical industries, as possible sources to manufacture novel drugs.

The relative popularity level (RPL) of the reported species is given in Table 2. Both herptile and fish species were classified as popular and unpopular categories based on RPL (Fig. 7), which were comparable to [43, 44]. During the study, we noted that C. idella, C. carpio, H. molitrix, C. reba, C. mrigala, L. rohita, L. calbasu, L. dero, G. catla, C. punctata, C. marulius, O. niloticus, R. rita, B. bagarius, M. armatus, and W.
In this study, for the first time, reported the use of flesh ash, fat, and oil of *Aspideretes gangeticus* (for skin diseases and sexual potency), *Aspideretes hurum* (backbone/joint pain), flesh ash of *Calotes versicolor* (for foot and toe injuries), fat oil of *Daboia russelii russelii* (to treat urinary problems and hemorrhoids), brain oil of *Hypophthalmichthys molitrix* (to improve eyesight, night blindness, fever, cold, and joint pain); the flesh of *Mastacembelus armatus* was used to improve sexual potency and body weakness; the brain of *Pethia ticto* was used to treat night blindness, eyesight, and to develop central nervous system; and the brain of *Gagata cenia* was used to treat urinary problems (Table 1).

Zoonoses with a wildlife reservoir are a major public health issue, affecting the whole world. Various pathogens and different modes of transmission are present, and many variables impact the epidemiology of different zoonoses. The recognition and importance of wildlife as a reservoir of zoonoses are increasing [91, 92]. The prevalence of transmission of disease-producing driving forces from fish to humans is however very low. In general, humans contract fish-borne diseases through ingestion of tissues, or by contamination of the skin [93]. Human sensitivity to amphibian proteins in a laboratory setting is rare. It remains possible, however, to become sensitized to amphibian proteins through inhalation or skin contact [94].

**Conservation status of the reported species**

Knowing the background of interaction and exploitation between humans and natural resources is vital for the implementation and development of animal and landscape conservation strategies [95]. Ethnozoological studies provide necessary information and contribute significantly to animal conservation because in addition to incorporating biological factors, and providing traditional knowledge on medicinal and cultural values of animal species in any area, such studies also cover...
cultural, social, economic and traditional roles of fauna in human civilization [96].

Based on the cultural uses of herptiles and fish species (Table 2), it was observed that 47% of the reported species are listed as least concern (LC), 44% are not evaluated (NE), 0.04% species (i.e., Indian soft shell, Peacock soft shell, Rock pathon, and Common carp) are vulnerable (V), and 0.03% species (i.e., Silver carp, Foji Khaga, and wallago catfish) are listed as near threatened (NT) globally by the International Union of Conservation of Nature (IUCN). Interestingly, most of the herptiles and fish species (74/91%) showed threats, and only 9% of the species were listed as threatened by IUCN as mentioned above. Use of animal species in traditional therapies and for cultural purpose by humans is not the only threat to animal biodiversity in any region. Factors also include changes in climate and various types of interactions in an ecosystem, i.e., food chain, food webs also contribute significantly in threatening animal population and diversity [96, 97]. Given the great need to find solutions to deal with the current crisis of biodiversity loss [98], more specifically that of animal species, it is obligatory to adopt strategies that address the problem in all its complexity. And for this, ethnozoology presents itself as an interdisciplinary tool, approaching the issue in an additional comprehensive method [99].

Principal component analysis

The ethnomedicinal data were analyzed through principal component analysis (PCA), which allowed for the ordination of plots in terms of three variables viz. Informant of major ailment (IMA), fidelity level (FL), and rank order priority (ROP). The result of the PCA showed the sum of all the eigenvalues with total inertia of 3105.67. The first eigenvalue was high (2881.04) which showed high gradient strength in distribution of indigenous knowledge along the first axis (PC1). The total variation explained along this axis is (92.77%). The first two axes of the principal component analysis showed 99.99% variation in samples (component 1: 92.77%; component 2: 7.23%); therefore, only two axes were considered in Fig. 8. The variables IMA ($r = 0.33506$), FL ($r = 0.57662$), and ROP ($r = 0.74514$) positively correlated with first axis (PC 1) while IMA ($r = -0.23734$) and ROP ($r = -0.52551$) was negatively correlated with component 2 and FL ($r = 0.81701$) was positively correlated with component 2 (PC 2), which were comparable with previous studies [100].

Conclusion

Traditional uses of various herptiles and fish species were recorded, and to the best of our knowledge, the ethno-pharmacological applications of 11 herptiles and seven fish species were reported for the first time from this region. Our findings revealed that the indigenous communities of the study possess significant traditional knowledge because of their strong relation with the nearby fauna. These results could be valuable for sustainable utilization and conservation of animal species. Additionally, detailed investigations on pharmacologically active substances and in vitro and/or in vivo of biological activities of compounds from herptiles and fish species with highest FL and FC could be interesting for
the development of novel animal-based drugs to treat various health disorders.

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Authors’ contributions
MA and AMA designed the project, were involved in data collection and analysis, and prepared final draft of the manuscript. MJL, MSA, and KI helped in the statistical analysis and manuscript revision while AMK assisted in species identification. The author(s) read and approved the final manuscript.

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Availability of data and materials
All data have already been included in the manuscript.

Ethics approval and consent to participate
Present study is purely based on filed survey instead of human or animal trails. Therefore, ethical approval and consent to participate is not applicable. However, formal consent was taken from informants regarding data collection and publication. In addition, ethical guidelines of the International Society of Ethnobiology (http://www.ethnobiology.net/) were strictly followed.

Consent for publication
Present paper does not contain any individual’s person data; therefore, this section is not applicable to our study.

Competing interests
The authors declare that they have no conflict of interest

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