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Diversity, Distribution and Threats to Freshwater Turtles in Mirpur, Azad Jammu and Kashmir, Pakistan

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ABSTRACT

Turtles are important component of freshwater ecosystem, but their population is decreasing worldwide. Eight freshwater turtle species have been reported from Pakistan. The present study aimed to investigate the diversity, distribution, threats and conservation of freshwater turtles in Mirpur, Azad Jammu and Kashmir, Pakistan where no research work was done previously. Study area was divided in three study zones (Mirpur, Dadhyal and Chakswari) along the Jhelum river and further sub-divided into 18 localities. Line transect, hand capture, visual survey, tracking, trapping methods were applied to collect data related to diversity, distribution, density and questionnaire method applied to assess threats. Analysis of data revealed that four freshwater turtle species including Indian flapshell turtle (*Lissemys punctate*), Indian narrow headed softshell turtle (*Chitra indica)* Indian softshell turtle (*Nilssonia gangetica*) and Crowned river turtle (*Hardella thurjii*) were identified and distributed in all study zones. *Lissemys punctata* was recorded as the most common (73.72%) species while *Hardella thurjii* was the rare (6.74%). Highly significant difference (df=3, p=0.00) was noted among turtle species. Maximum population density (16.67 turtle/km^2) recorded in Mirpur zone followed by Chakswari (12 turtle/km^2) and minimum population density was recorded at Dadhyal zone (7.17 turtle/km^2). Most favorite altitudinal level was 300 m and below with the highest population density of 16.8 turtle/km^2 whereas lowest population density of 6.12 turtle/km^2 was recorded in Class III (above 400 m). Maximum population density (20.7 turtle/km^2) was recorded in the month of June while minimum population density (6 turtle/km^2) was noted in the month of April. Freshwater turtles faced various threats including killing for commercial use (73%), medicinal use (13%). Habitat degradation (32%) due to pollution, poisonous chemicals and cruel fishing techniques are serious issues for their survival while anthropogenic activities (10%) are responsible due to destruction of habitat. Limited awareness was observed among local inhabitants regarding importance, ecological role and legal status of freshwater turtles. Awareness and strict law enforcement is recommended to reduce illegal turtle trade and conserve these important species.

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Authors' Contribution
AA, MF and UA designed the study. WA, ZH, MA and MMS helped in field work. AA and UA drafted the article. ZA, RAM and KBA improved the manuscript.

Key words
Diversity, Threats, Line transect, Hand capture, Mirpur AJ and K

INTRODUCTION

Turtles are the keystone component of freshwater ecosystem. Their vital roles include control of insect and snail population, vegetation management, seed dispersal and Scavenging activities (Safi and Khan, 2014). There are eight freshwaters turtles species are present in Pakistan including, black pond turtle (*Geoclemys hamiltonii)*, crowned river turtle (*Hardella thurjii*), brown roofed turtle (*Pangshura smithii*), Indian roofed turtle (*Pangshura tectum*), Indian narrow-headed softshell turtle (*Chitra indica*), Indian softshell turtle (*Nilssonia gangeticus*), Indian peacock softshell turtle (*Nilssonia hurum*) and Indian flapshell turtle (*Lissemys punctata andersonii*) (Khan *et al*., 2018).

Turtles are heavily exploited for medicine and food in Asia and China. Soft shell turtles are hunted for food due to palatability of its meat (Jatkins, 1995; Motluk, 1995). Turtle species are considered to be fish predators that engender a conflict with fishermen and consequently resulted in turtles killing. Turtle species can easily be captured by collectors through fences (kundy), nets and also by hand (Akbar *et al*., 2006; Noureen, 2007). Major threats are channeling of rivers, pollution, destruction of

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habitats, and involvement of local community in killing and trade of turtles. Mortality rate of fresh water turtles is increasing due to de-siltation and canal closure, use of poisonous chemicals (Wahab et al., 2012) and nest destruction by anthropogenic activities (Tikader and Sharma, 1985; Joyal *et al*., 2001).

Turtle populations are globally threatened; about 47 % species are classified as Vulnerable, Endangered and Critically Endangered (IUCN, 2010; Van Dijk *et al*., 2014). Turtles are facing many anthropogenic threats such as degraded habitat, excessive hunting, closure of canals, unavailability of proper nesting sites, illegal export and pollution (Wahab *et al*., 2012). Lack of knowledge about freshwater turtles has affected their conservation and several species are declining. Current study is an effort to bridge the information gap and provide a baseline data for further scientific exploration for biodiversity management perspective in order to keep our ecosystem intact.

MATERIALS AND METHODS

Study area

Mirpur is located 33°1480'N Latitude and 73°7437'E Longitude. Mangla Dam is located in Mirpur and area of Mirpur district is 1010 km^2 which is partly plain and hilly. During summer overall climate remains hot, dry and winter is moderate to cold (Ali *et al*., 2011).

Methodology

Twelve months surveys were conducted from April 2013-April 2014 in different study sites. The study area was divided into three study zones Mirpur, Chakswari and Dadyal. Each zone was further subdivided in six different study localities. The first zone, Mirpur zone comprised of Afzal Pur, Mangla, Raipur, Bang, Rathua and Jari Nala. Second zone Chakswari was divided in to New Kakra, Andra Kalan, Dangri Bala, Panyam, Dehri Rampur and Palak localities whereas the third zone Dadhyal was subdivided in to Darhari, Unah, Ramkot, Chhatroh, Ankar and Dhan Gali localities (Fig. 1).

Sampling methods

Surveys were carried out to determine diversity, distribution and population of turtle species using the following different methods.

1. Line transects method (Akbar *et al*., 2006) was used to assess population density and its distribution in different localities. Fixed length transects of 1 km^2 were laid on each side of the river, canals and nullahs in every locality. On each transect start, finish times, altitudinal range type of habitat and GPS location were recorded.
2. Hand capturing technique was used which is very helpful for identification of different turtle species (Mills, 2002). Turtles were identified with the help of keys (color pattern, scutes, carapace and plastron shape, head features) and photographs (Das, 1991). Netted turtles were identified, counted and instantly safely released back into their habitat.
3. Visual survey method was adopted to study basking turtles in different habitats. This method is helpful for species identification, population of particular specie and type of habitat (Lindemann, 1996). Species were identified following methods of Ernst *et al*. (2000) and Khan (2013).
4. Presence of turtles also detected by signs and tracks including trails, shells of dead animals, tunnels and excreta.
5. Trapping method was used to determine abundance of a particular species. It was done with drag net and dip nets (Gamble and Simons, 2004).
6. In muddy places blind capture technique was used by searching with hand or by immersing the feet into mud blindly (McDiarmid *et al*., 2012).
7. Questionnaire method was adopted to gather information from local community, fisherman, hunters and wildlife workers about population distribution, diversity and threats.

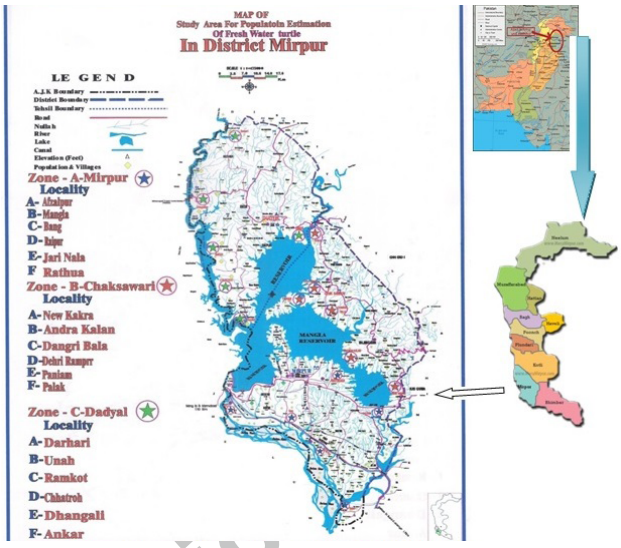

Fig. 1. Map of the area showing different study sites in District Mirpur.

Population density

Population density was determined using the formula:

$$D = n / A$$

where, n is mean number of turtles of a particular species observed and A is area of the transect.

Data analysis

Data gathered from field observations was analyzed statistically using F-test (One way ANOVA) in order to find variation among population density. MS Excel and SPSS (ver. 16.0) were used to compute tabular data.

RESULTS AND DISCUSSION

Diversity

Four species of freshwater turtle were recorded including Indian flap shell turtle, Crowned river turtle, Indian softshell turtle and Indian narrow headed softshell turtle. in the study area. Turtles are important part of faunal diversity of an ecosystem and perform various ecological services for smooth functioning of the ecosystem (Akbar *et al*., 2006; Noureen, 2007; Khan *et al*., 2015). Mirpur district is adjacent to Jhelum and Gujrat districts of Punjab and shares similar climatic, faunal and floral diversity of these cities. These turtle species have been reported by various researchers in adjoining areas of Punjab province (Akbar *et al*., 2006; Noureen *et al*., 2009; Saeed *et al*., 2011; Khan, 2013; Bibi *et al*., 2013) and Khyber Pakhtunkhwa (Safi and Khan, 2014).

Distribution

Direct and indirect evidence revealed that Indian narrow headed softshell turtle was distributed in all localities of the study area with a maximum population (n=6) in Unah locality of Dadhyal zone, followed by Mangla (n=5) and Afzal Pur (n=4) of Mirpur study zone. Indian flapshell turtle was another species distributed in all localities of the study area. Highest population (n=43) was recorded at Afzal Pur locality of Mangla study zone followed by (n=35) at Mangla and (n=27) at Bang localities. Minimum (n=3) individuals were noted at Ramkot and Panyam localities. Indian softshell turtle, was recorded in 15 localities, with highest population (n=6) at New Kakra and lowest (n=1) at Rathua, Unah and Chhatroh localities. This species was absent in Ankar, Dan Gali and Raipur localities. Crowned river turtle was reported in 16 study localities. Highest population (n=5) was recorded at Andra Kalan, followed by Panyam (n=3), whereas lowest population (n=1) was recorded at 7 localities of 3 study zones. This species was absent in Rathua and Mangla localities of the study area. Most common species were Indian flapshell turtle (73.72%) followed by Indian narrow headed softshell turtle (10.23%) and Indian softshell turtle (9.30%) whereas crowned river turtle (6.74%) was recorded as rare turtle species.

Population density

The highest population density of different turtle species was recorded in Mirpur zone (16.67 turtle/km^2) followed by Chakswari (12 turtle/km^2) while minimum population density was recorded at Dadhyal zone (7.17 turtle/km^2) (Fig. 2). A total of 200 individuals were recorded in Mirpur zone that comprised of 47% of the total turtle population in the study area. Highest population density was recorded at Afzal Pur (25.5 turtle/km^2), followed by Mangla (21 turtle/km^2) and Bang (17 turtle/km^2) while minimum population was recorded at Raipur (10 turtle/km^2). Indian narrow headed softshell turtle and Indian flapshell turtle were distributed in all 6 localities of this zone, however Indian softshell turtle was not recorded in locality Raipur while crowned river turtle was absent in two localities including Raipur and Rathua (Table I).

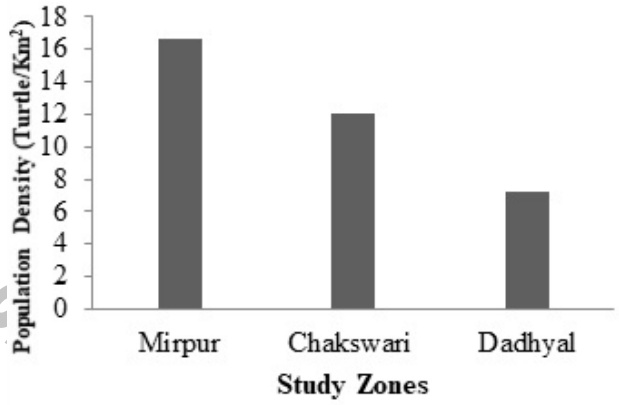

Fig. 2. Comparison of population density of turtles among different study Zones.

Second important zone was Chakswari that harbored 33% (n= 144) of the total population of turtles. Maximum population density (16 turtle/km^2) was recorded at two localities viz., New Kakra and Dehri Rampur, followed by Palak (12.5 turtle/km^2) and Dangri Bala (11.5 turtle/km^2) while locality Panyam has minimum population density (6.5 turtle/km^2) of turtle species (Table I). All four turtle species were distributed in all 6 localities in this zone having maximum population density (11.5 turtle/km^2) of Indian flapshell turtle and minimum (0.5 turtle/km^2) of Indian narrow headed softshell turtle (Table I).

Dadhyal zone contained minimum population (n=86) that comprised 20% of total turtle population. Maximum population density (9.5 turtle/km^2) was recorded at Unah, followed by Ankar (9 turtle/km^2) and Chhatroh (7 turtle/km^2) while minimum population density (5 turtle/km^2) was observed at Dhan Gali locality (Table I). Highest density (7 turtle/km^2) was observed at Ankar of species Indian flapshell turtle, while Indian softshell turtle was not recorded in localities Ankar and Dhan Gali (Table I).

Table I. Comparison of population density of different turtle species in different localities of Mirpur, AJ and K, Pakistan.

Locality	Area surveyed ($km^{2)}$	GPS location		Elevation (m)	C.i	N. g	H. t	L. p	Estimated population	Density /km^2	Habitat
		N	E								
Zone A											
Afzal Pur	2	33.05'02.78°	73.79'39.42°	265	4	2	2	43	51	25.5	Trailing vegetation, steep water flow and substrate was sandy
Mangla	2	33.1153.51°	73.65'14.37°	260	5	2	0	35	42	21	Degraded vegetation, Deep dam water constrained by steep bank
Bang	2	33.06'19.61°	73.75'84.34°	240	3	3	1	27	34	17	Soft bottom stream and pools, sandy and gravel
Raipur	2	33.03'18.69°	73.84'99.47°	245	1	0	2	18	21	10.5	Natural riparian vegetation and steep slope with meandering channels and water flow was fast.
Jari Nala	2	33.10'75.92°	73.83.98.09°	320	4	5	1	10	20	10	Pool size was large and deep, natural vegetation with bed rocks and fine slits.
Rathua	2	33.15'27.95°	73.78'99.27°	380	1	1	0	30	32	16	The riparian vegetation was degraded, lotic dam water and fast flowing.
Zone B											
New Kakra	2	33.11'53.26°	73.87'08.45°	320	1	6	2	23	32	16	Rocky soft bottom stream and straight channel, pool large and deep
Andra Kalan	2	33.17'54.45°	73.86'10.84°	420	1	3	5	10	19	9.5	Lentic standing water with abundant algal growth, submerged logs, pool composition was gravel and fine rocks.
Dangri Bala	2	33.25'14.65°	73.76'27.97°	400	1	2	1	19	23	11.5	Steep bank with degraded riparian vegetation, deep and slow flowing water
Dehri Rampur	2	33.25'68.83°	73.76'29.63°	390	3	3	2	24	32	16	Rocky bottom stream, natural vegetation, shallow pool and fast flowing water flow
Panyam	2	33.24'91.15°	73.75'78.25°	400	1	3	3	6	13	6.5	Degraded vegetation, deep pool with large rocks, gravel, silt and water was deep and fast flowing.
Palak	2	33.34'10.22°	73.75'47.38°	440	2	2	2	19	25	12.5	Steep bank with natural vegetation and pool channel were meandering.
Zone C											
Darhari	2	33.33'33.22°	73.73'17.22°	360	3	3	2	4	12	6	Rocky soft bottom stream, pool large and deep, degraded vegetation with sandy substrate composition
Unah	2	33.22'54.02°	73.66'42.04°	370	6	1	1	11	19	9.5	Lentic standing water with abundant algal growth, pool gravel and fine rocks
Ramkot	2	33.22'43.06°	73.64'35.36°	370	3	3	1	6	13	6.5	Steep bank with degraded riparian vegetation, water was deep and slow flowing.
Chha-troh	2	33.26'85.12°	73.61'42.31°	380	1	1	2	10	14	7	Rocky bottom stream, natural vegetation, shallow pool and fast flowing water flow
Ankar	2	33.29'49.41°	73.61'09.59°	360	3	0	1	14	18	9	Degraded vegetation, pool consisting of large rocks, gravel, silt and water was deep, fast flowing.
Dhan Gali	2	33.35'62.73°	73.58'54.09°	420	1	0	1	8	10	5	Steep bank with natural vegetation, pool channels were meandering.

C.i (*Chitra indica*, Indian Narrow headed softshell turtle); N.g (*Nilssonia gangeticus*, Indian softshell turtle); H.t (*Hardella thurjii*, Crowned river turtle); L.p (*Lissemys punctata,* Indian flapshell turtle).

Results could be compared with the findings of Akbar *et al*. (2006) who stated that crowned river turtle (0.88%) and indian narrow headed softshell turtle (0.54 %) as rare species in five rivers of Punjab, Pakistan. Safi and Khan (2014) reported Indian flapshell turtle as most abundant (30.95%) while crowned river turtle (1.36%) as rare species in Charsadda, KPK.

Altitudinal variation

Altitude of the study area was grouped in three classes, class I 300 m above sea level (asl) and below, Class II ranged from 300-400 m asl while Class III has altitudinal range of 400 and above m asl. Highest population density of 16.8 turtle/km^2 was recorded at class I (below 300 m) followed by (11.8 turtle/km^2) in class II (300-400 m) whereas lowest population density of 6.12 turtle/km^2 was recorded in Class III (above 400 m) (Table II). Among turtle species, Indian flapshell turtle had maximum population density of 13.30 turtle/km^2 recorded in class I while crowned river turtle recorded as rarest species with a population density of 0.75 turtle/km^2 in class III. The study area lies in plain landscape, but slight altitudinal variation exits. Analysis revealed that the turtle's preferred altitude was below 300 m.

Table II. Comparison of population density of turtle species at different altitudes during April 2013-April 2014.

Altitudinal Class	Indian narrow headed softshell turtle	Indian softshell turtle	Crowned river turtle	Indian flapshell turtle	Population density/km^2
Class I (Below 300 m)	1.7	1.2	0.6	13.3	16.8
Class II (300-400 m)	1.06	1.17	0.94	8.67	11.83
Class III (Above 400 m)	1	0.88	0.75	3.5	6.13

Table III. Comparison of month wise population density of different turtle species.

Months	Indian narrow headed softshell turtle	Indian softshell turtle	Crowned river turtle	Indian flapshell turtle	Population density/km^2
April-13	0.67	0.33	0	5	6
May-13	0.75	1	0	9.75	11.5
June-13	2.67	4	1	13	20.7
July-13	1.25	1.25	0.75	9.5	12.8
August-13	1.2	1.8	1.2	11.2	15.4
September-13	1.23	0.77	0.77	8.92	11.7
October-13	1	0	1	8	10
November-13	1.6	1.2	1.2	5.6	9.6
January-14	1	0	2	13	16
February-14	0	0	0.5	8	8.5
March-14	2	0	0	5	7
April-14	1	0.5	2.5	5.5	9.5

Monthly variation

Data revealed that maximum population density was recorded as 20.7 turtle/km^2 in the month of June followed by January (16 turtle/km^2) and August (15.4 turtle/km^2) while minimum population density of 6 turtle/km^2 was recorded in the month of April. Our results in terms of lowest density, recorded in the winter season, could be due to the reason that field survey was not performed during December, and winter season shortened to two months only. Among species, highest population density of 13 turtle/km^2 of Indian flapshell turtle in two months, i.e. June and January, while minimum population density of 0.5 turtle/km^2 of Indian softshell turtle was recorded in the month of April (Table III). Indian flapshell turtle was most common species observed in all 12 months of study period, followed by Indian narrow headed softshell turtle observed in 11 months. Indian narrow headed softshell turtle was not recorded in the month of February, Indian

softshell turtle was absent in four months including October, January, February and March. Crowned river turtle could not be recorded in the months of March, April and May (Table III).

The turtle population has a general trend of increasing and declining in different months of the study period. Population gradually increases towards summer and decreases when winters are approaching. August and September were the months when population was recorded the maximum i.e. 77 and 76 animals, respectively. It might be the effect of monsoon rainy season, when the water level is raised in Mangla dam and its allied areas, where turtles move along bank sides in search of food and protection from floating down. Similar population trend was noted by various other researchers including Safi and Khan (2014) in Charsadda and Akbar *et al*. (2006) in Punjab province.

Habitat

Using questionnaire survey data, analysis revealed that maximum number of respondents (46%) stated that turtles were most commonly observed during autumn season, followed by summer (37%) and winter (13%), while minimum number of respondents (4%) observed turtles in spring period (Fig. 3). In response to the question that at which site turtles are commonly observed, 55% respondents stated that they are found near river or canal water. A considerable percentage (27%) of interviewers were of the opinion that turtles were often seen in grass or vegetation nearby the water. A total of 13% respondents claimed to have seen turtle species in sandy bank of river or canal, however small fraction of respondents (5%) observed turtles at an emerged rock inside the water (Fig. 4).

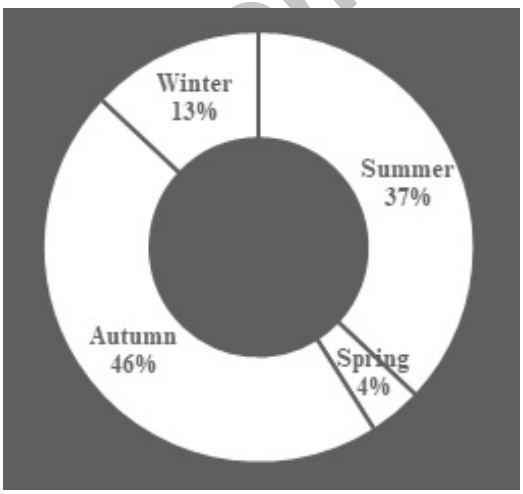

Fig. 3. Turtles observed by respondents in different seasons of the study period.

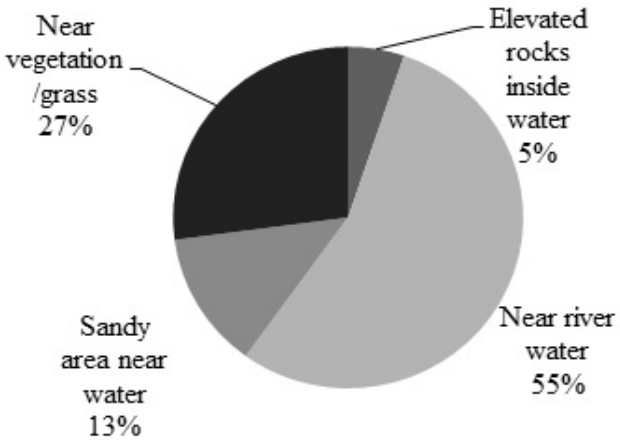

Fig. 4. Comparison of the sites where turtles are found frequently in opinion of respondents.

Indian flapshell turtle used the water bed as feeding habitat and found in close association with water *Eichhornia crassipes* (Kachoripana), *Enhydra* sp. (Helencha), *Ipomoea aquatica* (swamp morning glory), *Hydrilla verticillata* (Jhajipata) and semi-submerged vegetations (Hossain *et al*., 2008). A variety of habitats including ponds, lakes, pools, ditches, canals, rivers and stagnant seasonal water bodies are found in the study area, which are used by freshwater turtles, mainly by Indian flapshell turtle. Moll and Moll (2004) and Hossain *et al*. (2008) reported that such areas could be preferred habitats of Indian flapshell turtle. Indian softshell turtle though, mainly aquatic in nature but may live according to the availability of shallow, stagnant, clear water with plenty of vegetation. This species was found in deep and slow-moving water, large sized canal with sandy bottom. Saeed *et al*. (2011) reported similar habitat for this species.

Threats

Turtle species of the study area faced various threats to their survival. Data revealed from questionnaires that maximum (45%) threat was turtle killing for commercial use. A total of 32% respondents thought that pollution was the major cause of habitat destruction (10 %), destruction of nests (8 %) and killing of hatchlings (7 %) (Fig. 5). In response to the question that what was the main reason of the killing of turtle species in the study area? majority of respondents (73%) claimed the commercial use or sale while (13%) favoured use in local tibb (Hakeem). It is a common concept that turtles feed upon fishes, according to survey, 8% respondents claimed this conflict, while 6% respondents thought that these animals were killed without any reason. None of the respondents claimed that turtles were killed for eating purposes (Fig. 6).

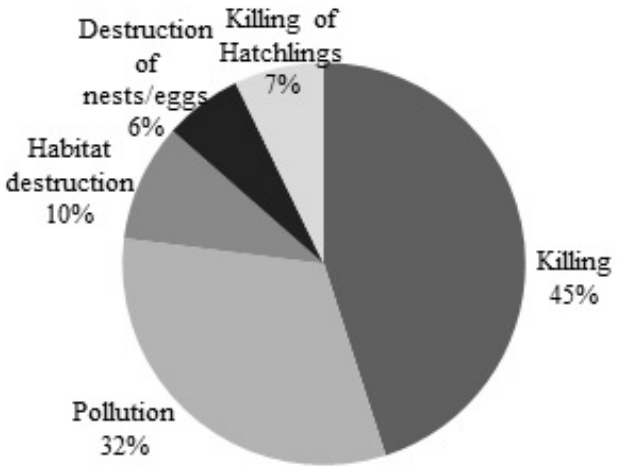

Fig. 5. Threats faced by turtle species according to local inhabitants.

Cumulatively these species are considered as carnivore animals as 71% of the respondents had this opinion. A total of 48% respondents were of the view that turtles fed upon fish, while 31% thought that their preferred diet included frogs and other insects. Maximum (45%) threat was turtle killing for commercial uses (including sale, export and ethno uses) and conflict killing (that majority of the respondents had the opinion that turtle fed upon fish, so reduction in turtle population would provide plenty of fishes). These threats have already been reported by studies conducted in Pakistan and worldwide (Akbar *et al*., 2006; Noureen *et al*., 2009; Safi and Khan, 2014; Khan, 2013; Hossain *et al*., 2008).

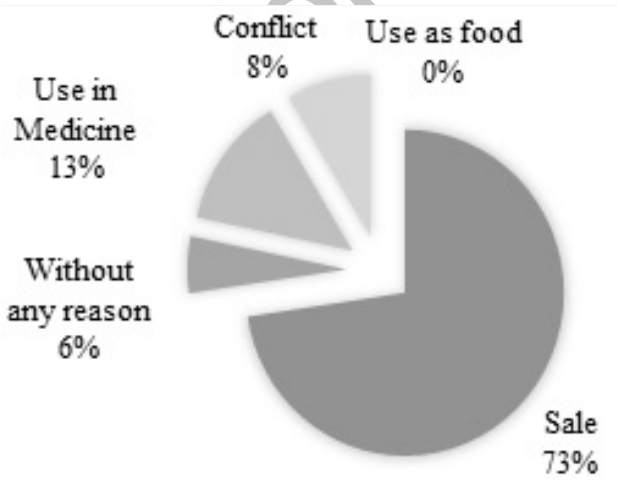

Fig. 6. Comparison of different causes of killing of turtle species in the study area.

Illegal trade is a serious issue and accelerating turtle extinction. In response to the question about the reason for maximum threat (killing, 45%) commercial use or sale was considered to be the most important (73%) motive of the killing of these animals. Noureen *et al*. (2012) reported that local people involved in this trade could earn PKRs 20,000 to 40,000 monthly. Some nomads worked on daily wage basis (PKRs 150 to 300). It is a common concept that turtles feed upon fishes, according to survey, 8% respondents claimed this conflict as a cause of killing, however, 6% respondents thought that these animals were killed without any reason. It includes killing during fishing, angling, nest destruction by children and killing of hatchlings. During the present study, none of the respondents claimed that turtles were killed for eating purposes, however, Noureen *et al*. (2009) recorded that turtle species had been used as a food item in Punjab. Pollution also posed immense threat (32%) for habitat destruction. It included use of pesticides, herbicides, use of dynamite for fishing. Habitat destruction (mainly by anthropogenic activities) is also an important factor (10%) that caused threat to the survival of turtle species in the study area. Khan *et al*. (2015) reported mass mortalities of turtles during drought conditions in Thatta and Badin of Sindh province. Loss of nesting sites and eating of eggs by other animals was also reported (Ali *et al*., 2018).

RECOMMENDATIONS

Limited awareness has been observed among local inhabitants regarding importance, and ecological role and legal status of freshwater turtles. Based on the investigation, it is recommended that; Human impact should be minimized in order to protect turtle biodiversity. Cruel fishing methods (use of current, explosives, poisonous chemicals) should strictly be prohibited and an improvement is needed in watch and ward conditions; Awareness campaigns through media, community based discussion should be started in the study area to protect these species, because these species are protected according to CITES and could not be traded. Illegal trade is a serious issue, it needs an immense action. It could be prevented through strict law enforcement. Further scientific explorations are required in order to investigate the comprehensive role of freshwater turtles in maintaining our ecosystem.

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Statement of conflict of interest

The authors have declared no conflict of interest.

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