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Research Article

DIVERSITY, TAXONOMY AND CONSERVATION STATUS OF HERPETOFAUNA OF RAMNAGAR FOREST DIVISION IN WESTERN TERAI ARC LANDSCAPE, INDIA

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ABSTRACT

Terai Arc Landscape (TAL) is a highly biodiverse region and is listed among the 200 important ecoregions of the world. Situated in the foot plains of Himalaya, TAL is distributed among two countries, India and Nepal. The present study was conducted in the western part of TAL known as Ramnagar Forest division (RFD). We used the Visual encounter survey method, along with other methods for sampling. Total 10 species of anurans, 13 species of lizards, 20 species of snakes, and 4 species of Testudinata were reported in RFD. Out of the total 47 species recorded in RFD, six species are listed in various threatened categories of IUCN, and 27 species were protected under the Wildlife (Protection) Act, (1972) of India. 11 species were listed in CITES. We found that RFD accommodates a good diversity of amphibians and reptiles and also is an abode of some important herpetofauna species such as King cobra (*Ophiophagus hannah*), Burmese python (*Python bivittatus*), Indian monitor (*Varanus bengalensis*) and Elongate tortoise (*Indotestudo elongata*).

Keywords: Amphibia, Reptiles, Wildlife, Visual Encounter Survey, Ecoregion.

INTRODUCTION

Terai Arc Landscape (TAL) is a well-known biologically significant region; it is enlisted in 'Global 200', a list of the world's most valuable ecoregions (Olson & Dinerstein, 1998). TAL is extended from river Yamuna in the west to river Bagmati in east, including 5 states of India and 14 districts of Nepal (Chanchani *et al*., 2014). The total area of TAL is 49500 km^2, starting from Rajaji National park in the west to Parsa National Park in the east. More than 60% area of TAL is situated in India and the rest part falls in Nepal (Semwal, 2005). Due to its high biodiversity, 14 Wildlife protected areas are situated in TAL, including Corbett national park, the first national park of India (Semwal, 2005). Although TAL is a well-known region for its biodiversity but still not many studies have been done on the amphibians and reptiles of this region (Bhattarai *et al*., 2017).

Amphibians and reptiles are collectively called herpetofauna; these are ecologically an important group of chordates. They have a unique trophic position as mid-level consumers; hence they prevent overpopulation of their prey species and also serve as food for their predator species (Pough, 1980). They are significant components of food webs and act as connecting links between aquatic and terrestrial ecosystems (Donnelly & Crump, 1998). They provide various ecological services like; nutrient cycling, bioturbulation, and pollination (Cortés-Gomez *et al*., 2015) and they are also the indicators of ecological health (Simon *et al*., 2011). Other than that herpetofauna also poses a great economic value (Witczak & Dorcas, 2009) as

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well as significant use in tribal medicines in various parts of India and the world (Pradhan *et al*., 2014). But still, most of the time herpetofauna are overlooked, while making strategies for the conservation of wildlife (Vasudevan & Sondhi, 2010). In spite of their importance, not much attention is paid to the study and conservation of herpetofauna, while the worldwide decline of herpetofauna is more than other animals (Worldwide, 2004). For the assessment of the diversity of amphibians and reptiles, the present study was conducted in the western part of TAL named Ramnagar Forest Division (RFD). The total area of RFD is around 593 km^2 (Ahmed *et al*., 2018) and shares its western boundary with Corbett National Park (CNP). The region including RFD, Corbett National Park (CNP), and other territorial forest divisions surrounding CNP is termed as Corbett Landscape. In spite of being a famous spot for wildlife enthusiasts and a significant ecological region, the herpetofauna is relatively less studied in this region and literature is limited in comparison to the studies on higher vertebrates like birds and mammals. This study was aimed to highlight the status of herpetofauna and to enhance the existing information about the biodiversity of this region.

MATERIALS AND METHODS

Study area

RFD is located in the Nainital district of Uttarakhand, India latitude Latitude 29 33’10’’- 20 13’40’’ N and Longitude 79 5’50’’-79 32’40’’E (Figure 1). The area is flanked by perennial rivers viz., Kosi and Khichadi. During monsoons also flooded by rain-fed rivers viz., Dabka and Baur. Kosi is the most significant river with substantial water and is considered as the lifeline of the Ramnagar area. Good diversity in vegetation and luxuriant water system in RFD supports a good population of herbivore species, due to which various types of carnivore species are also found in the region.

Sampling methods

Data was collected by Visual Encounter Survey (VES) (Crump & Scott, 1994; Sutherland, 2006), following transects of 1 Km. searched for the herpetofauna species under leaf litter, boulders, rocks, in ditches, etc., animal sighted were recorded. Total 118 no. of transects surveys were done starting from Sep 2016 to Feb 2018. Specimen photographs were taken for identification and no specimen is collected in this study. Data was also gathered additionally by using methods like roadkill surveys, night searches in and around human-dominated areas, and by recording opportunistic encounters of herpetofauna species in the study area and also by snake rescue program run by the first author, near the study area. Identification is done with the help of identification keys (Blumstein & Daniel, 2002; Vasudevan *et al*., 2010; Whitaker *et al*., 2004).

RESULTS AND DISCUSSION

In the present study total of 47 species of herpetofauna were recorded from the study area. A total of 10 species of amphibians from order Anura (Table 1), and 37 species of reptiles from two orders Squamata and Test dines were found (Table 1). The 10 species of order Anura were reported from four families and eight genera. While 13 species of order Squamata were reported from four families and eight genera of lizards and six families and 17 genera of snakes. Also 4 species of order Testudinata were reported from three families and three genera (Table 1). Out of total 47 species, 57.44% (n=27) were under the protection of various Schedules of Wildlife (Protection) Act, 1972 India, (WPA), 12.76% (n=6) species were under various threatened categories of IUCN and 23.40% (n=11) species were in various Appendices of CITES (Figure 1-5). Among anurans, maximum five species were recorded from the family Dicroglossidae, two species from Bufonidae, two species from Microhylidae, and one species was recorded from family Rhacophoridae (Figure 6). Two species viz. *Hoplobatrachus tigerinus* and *Hoplobatrachus crassus* were protected under Schedule-IV of WPA, India, and *Hoplobatrachus tigerinus* was also categorized under Appendix-II of The CITES (Table 1). Among lizards maximum six species of the lizards were recorded from the family Scincidae, followed by four species from the family Geckonidae and two species from the family Agamidae (Figure 7). While only one species was recorded from the family Varanidae. (Table 2). *Varanus bengalensis* was in the Appendix-I category of CITES and is also protected under Schedule-I of the Indian Wildlife (Protection) Act, 1972 (Table 1), which is the highest degree of legal protection in the country is also provided to the national animal of India, i.e. tiger (*Panthera tigris*).

We recorded 15 non-venomous and five venomous species of snakes from RFD. Among the 15 species of non-venomous snakes, maximum 10 species belong to the Colubridae family, followed by two species from the family Natricidae, two species Typhlopidae family, and one species from the family Pythonidae (Figure 8). While among the five species of venomous snakes, two species belong to Viperidae, and three species belong to the Elapidae family. All 20 species of snakes reported in RFD were protected under different schedules of Wildlife (Protection) Act, 1972, India. One species was under Schedule-I of WPA, five species were protected under Schedule-II and 14 species were under Schedule-IV. Internationally, three species were under Appendix - II and two species were under Appendix-III categories of CITES. Four species were under the vulnerable category and other five species were under the Least Concern category in the Red List of IUCN (Table 1). A total of four species of Testudines were reported in RFD (Figure 9). All four species were protected under Schedule-I of WPA, India. *Indotestudo elongata* is also categorized in

endangered category of IUCN, while *Melanochelys tricarinata* and *Melanochelys trijuga* are in the Vulnerable and the Near-threatened categories respectively. Out of our species, *Melanochelys tricarinata* is in the Appendix - I category of CITES, and the other three species were in Appendix - II category of CITES (Table 1).

Table 1. Amphibian species recorded in Ramnagar forest division, TAL, India - WPA-Wildlife (Protection) Act-1972, India, Sch-Schedule, IUCN- International Union for Conservation of Nature and Natural Resources, CITES - Convention on International Trade in Endangered Species of wild fauna and flora.

S. No	Species name	Common name	Family	Sampling methods	WPA, India Status	IUCN Status	CITES Status
1.	*Duttaphrynus melanostictus* (Schneider,1799)	Common Indian Toad	Bufonidae (Gray, 1825)	Night search, Road Kill (Human habitation)	-	Least concern	-
2.	*Duttaphrynus stomaticus* (Lütken, 1864)	Marbled toad	Bufonidae (Gray, 1825)	Night search, Road Kill (Human habitation)	-	Least concern	-
3.	*Sphaerotheca breviceps* (Schneider, 1799)	Indian burrowing frog	Dicroglossidae (Anderson, 1871)	Night search, VES	-	Least concern	-
4.	*Fejervarya limnocharis* (Gravenhorst, 1829)	Paddy field frog	Dicroglossidae (Anderson, 1871)	Night search, VES	-	Least concern	-
5.	*Euphlyctis cyanophlyctis* (Schneider,1799)	Indian skipper frog	Dicroglossidae (Anderson, 1871)	Night search, VES, Sudden encounter	-	Least concern	-
6.	*Hoplobatrachus tigerinus* (Daudin, 1803)	Indian bull frog	Dicroglossidae (Anderson, 1871)	Night search, VES	Sch-IV	Least concern	Appendix II
7.	*Hoplobatrachus crassus* (Jerdon, 1854)	Jerdon's bull frog	Dicroglossidae (Anderson, 1871)	VES	Sch-IV Sch-IV	Least concern	-
8.	*Microhyla nilphamariensis (*Howlader, Nair, Gopalan&Merilä, 2015)	Nilphamari narrow mouthed frog	Microhylidae (Gunther, 1858)	Night search, Sudden encounter	-	Least concern	-
9.	*Uperodon systoma* (Schneider,1799)	Marbled balloon frog	Microhylidae (Gunther, 1858)	Road kill (Grassland)	-	Least concern	-
10.	*Polypedates maculatus* (J.E. Gray, 1830)	Common tree frog	Rhacophoridae (Hoffman, 1931)	Opportunistic encounter	-	Least concern	-

Table 2. Reptile species recorded in Ramnagar forest division, TAL, India - WPA-Wildlife (Protection) Act-1972, India, Sch-Schedule, IUCN- International Union for Conservation of Nature and Natural Resources, CITES- Convention on International Trade in Endangered Species of wild fauna and flora.

S. No.	Species name	Common name	Family	Sampling methods	WPA, India Status	IUCN Status	CITES Status
1.	*Varanus bengalensis* (Daudin, 1802)	Indian monitor lizard	Varanidae (Merrem,1820)	Opportunistic encounter, Rescue, VES	Sch-I	Least concern	Appendix –I
2.	*Laudakia tuberculata* (Gray, 1827)	Himalayan rock lizard	Agamidae (Gray, 1827)	Opportunistic encounter, Rescue	-	-	-
3.	*Calotes versicolor* (Daudin, 1802)	Oriental garden lizard	Agamidae (Gray, 1827)	VES, Sudden encounter	-	-	-
4.	*Cyrtodactylus fasciolatus* (Edward Blyth, 1861)	Banded bent toad gecko	Gekkonidae (Gray, 1825)	Opportunistic encounter	-	Vulnerable	-
5.	*Hemidactylus kushmorensis* (Gray, 1845)	Kushmore's house Gecko	Gekkonidae (Gray, 1825)	Opportunistic encounter	-	Least concern	-
6.	*Hemidactylus leschenaultii* (Rüppell, 1835)	Leschenault's house gecko	Gekkonidae (Gray	VES	-	Least concern	-
7.	*Hemidactylus flaviviridis* (Rüppell, 1835)	Northern house gecko	Gekkonidae (Gray	Opportunistic encounter	-	-	-
8.	*Eutropis carinata* (Schneider, 1801)	Keeled grass skink	Scincidae, (Gray, 1825)	VES, Opportunistic encounter	-	Least concern	-
9.	*Eutropis dissimilis* (Hallowell, 1857)	Striped grass skink	Scincidae, (Gray, 1825)	Opportunistic encounter	-	-	-
10.	*Eutropis macularia* (Blyth, 1853	Bronze grass skink	Scincidae	VES	-		
11.	*Lygosoma punctata* (Gmelin 1799)	Dotted garden skink	Scincidae, (Gray, 1825)	Opportunistic encounter	-	Least concern	-
12.	*Lygosoma albopunctata* (Gray, 1846)	White spotted supple skink	Scincidae, (Gray, 1825)	VES	-		
13.	*Asymblepharus himalayanus* (Günther, 1864)	Himalayan rock skink	Scincidae, (Gray, 1825)	VES	-	-	-
14.	*Daboia russelii* (Shaw & Nodder, 1797)	Russell's viper	Viperidae (Oppel, 1811)	Rescue	Sch-II	Least concern	Appendix III
15.	*Trimeresurus septentrionalis* (Kramer, 1977)	Himalayan white lipped pit viper	Viperidae (Oppel, 1811)	Opportunistic encounter	Sch-IV	Least concern	-
16.	*Bungarus caeruleus* (Schneider, 1801)	Common Indian krait	Elapidae (Boi, 1827)	Rescue, Road kill (Sal forest)	Sch-IV	Vulnerable	-
17.	*Naja naja* (Linnaeus, 1758)	Indian cobra	Elapidae (Boi, 1827)	Rescue	Sch-II	-	Appendix II

18.	*Ophiphagus hannah* (Cantor, 1836)	King cobra	Elapidae (Boi, 1827)	Rescue, Opportunistic encounter	Sch-II	Vulnerable	Appendix II
19.	*Ptyas mucosa* (Linnaeus, 1758)	Rat snake	Colubridae (Boi, 1827)	Rescue, Opportunistic encounter	Sch-II	Least concern	Appendix II
20.	*Oligodon arnensis* (Shaw, 1802)	Common kukri	Colubridae (Boi, 1827)	Road kill(Sal forest)	Sch-IV	-	-
21.	*Dendrelaphis tristis* (Daudin, 1803)	Common bronze back	Colubridae (Boi, 1827)	Road kill(Sal forest)	Sch-IV	-	-
22.	*Coelognathus helena* (Schulz, 1992)	Common trinket	Colubridae (Boi, 1827)	Opportunistic encounter	Sch-IV	-	-
23.	*Boiga trigonata* (Schneider, 1802)	Common cat snake	Colubridae (Boi, 1827)	Opportunistic encounter	Sch-IV	Least concern	-
24.	*Boiga forsteni* (A.M.C. Duméril, Bibron & A.H.A. Duméril, 1854)	Forstain's cat snake	Colubridae (Boi, 1827)	Road kill (Sal forest)	Sch-IV	Least concern	-
25.	*Coelognathus radiata* (F. Boie, 1827)	Copper headed trinket	Colubridae (Boi, 1827)	Opportunistic encounter	Sch-IV	-	-
26.	*Lycodon aulicus* (Linnaeus, 1758)	Common wolf snake	Colubridae (Boi, 1827)	Opportunistic encounter	Sch-IV	-	-
27.	*Lycodon jara* (Shaw, 1802)	Spotted wolf snake	Colubridae (Boi, 1827)	Opportunistic encounter	Sch-IV	-	-
28.	*Sibynophis sagittarius* (Cantor, 1839)	Cantor's black headed snake	Colubridae (Boi, 1827)	Road kill (Mixed forest)	Sch-IV		-
29.	*Amphiasma stolata* (Linnaeus, 1758)	Striped keel back	Natricidae (Bonaparte, 1838)	VES, Opportunistic encounter	Sch-IV	-	-
30.	*Xenochrophis piscator* (Schneider, 1799)	Checkered keel back	Natricidae (Bonaparte, 1838)	Opportunistic encounter, VES	Sch-II	-	Appendix III
31.	*Indotyphlops braminus* (Daudin, 1803)	Common blind snake	Typhlopidae (Merrem, 1820)	Opportunistic encounter	Sch-IV	-	-
32.	*Argyrophis diardii* (Schlegel, 1839)	Diard's blind snake	Typhlopidae (Merrem, 1820)	Road kill (Human settlement)	Sch-IV	Least concern	-
33.	*Python bivittatus* (Kuhl, 1820)	Burmese python	Pythonoidae (Fitzinger, 1826)	Rescue, Opportunistic encounter	Sch-I	Vulnerable	Appendix II
34.	*Melanochelys tricarinata* (Blyth, 1856)	Tricarinate hill turtle	Testudinata (Batsch, 1788)	Opportunistic encounter	Sch-I	Vulnerable	Appendix –I
35.	*Melanochelys trijuga* (Schweigger, 1812	Indian black turtle	Testudinata (Batsch, 1788)	Opportunistic encounter	Sch-I	Near threatened	Appendix –II
36.	*Lissemys punctata* (Lacépède, 1788)	Indian flap shell turtle	Testudinata (Batsch, 1788)	Opportunistic encounter	Sch-I	Least concern	Appendix –II
37.	*Indotestudo elongata* (Blyth, 1853)	Elongate tortoise	Testudinata (Batsch, 1788)	Opportunistic encounter	Sch-I	Endangered	Appendix –II

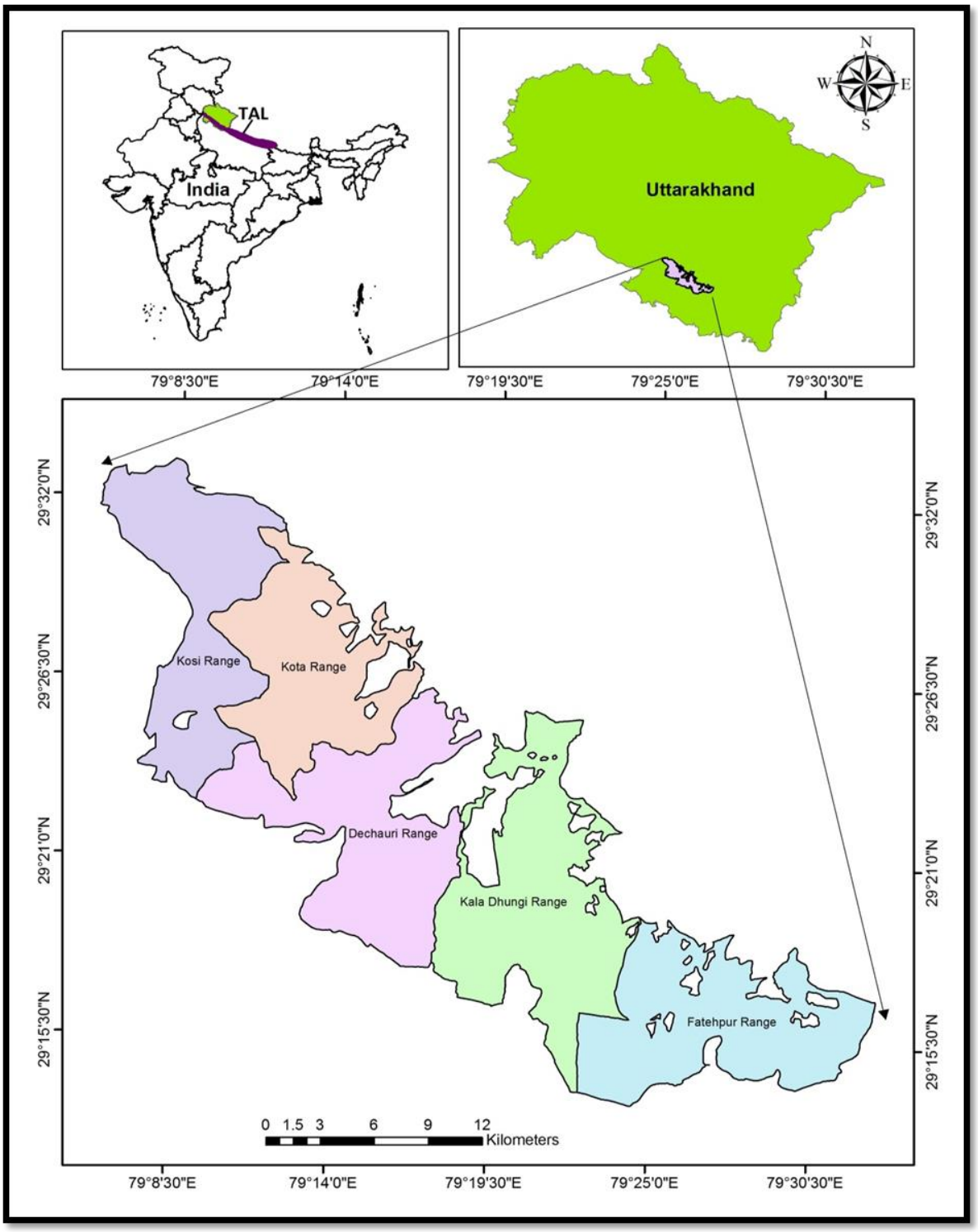

Figure 1. Map showing location of TAL and Ramnagar Forest Division.

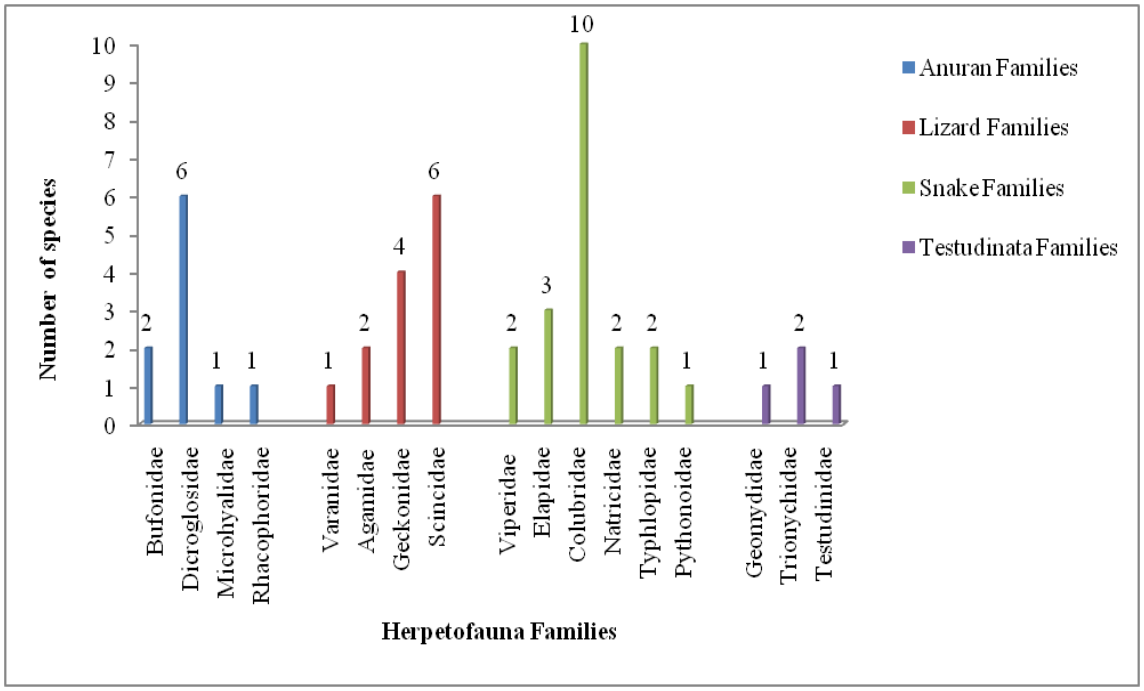

Figure 2. Number of species in various families of herpetofauna.

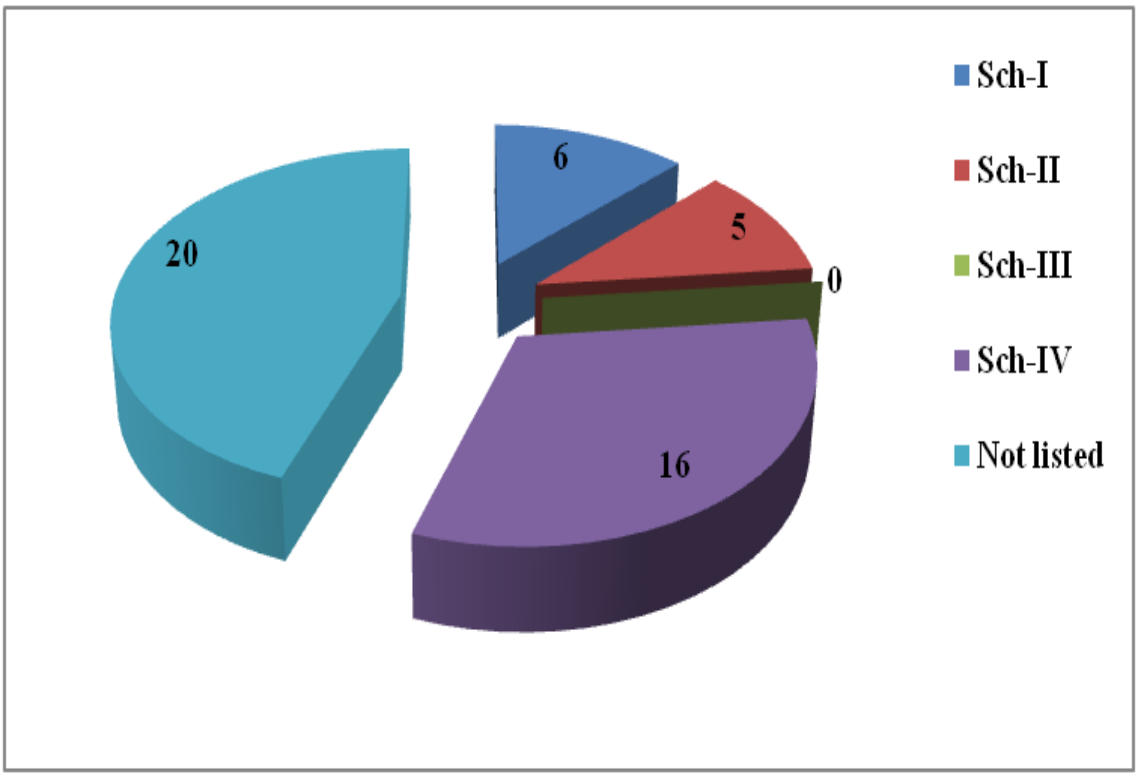

Figure 3. Species of herpetofauna protected under Wildlife Protection Act, 1972 (India).

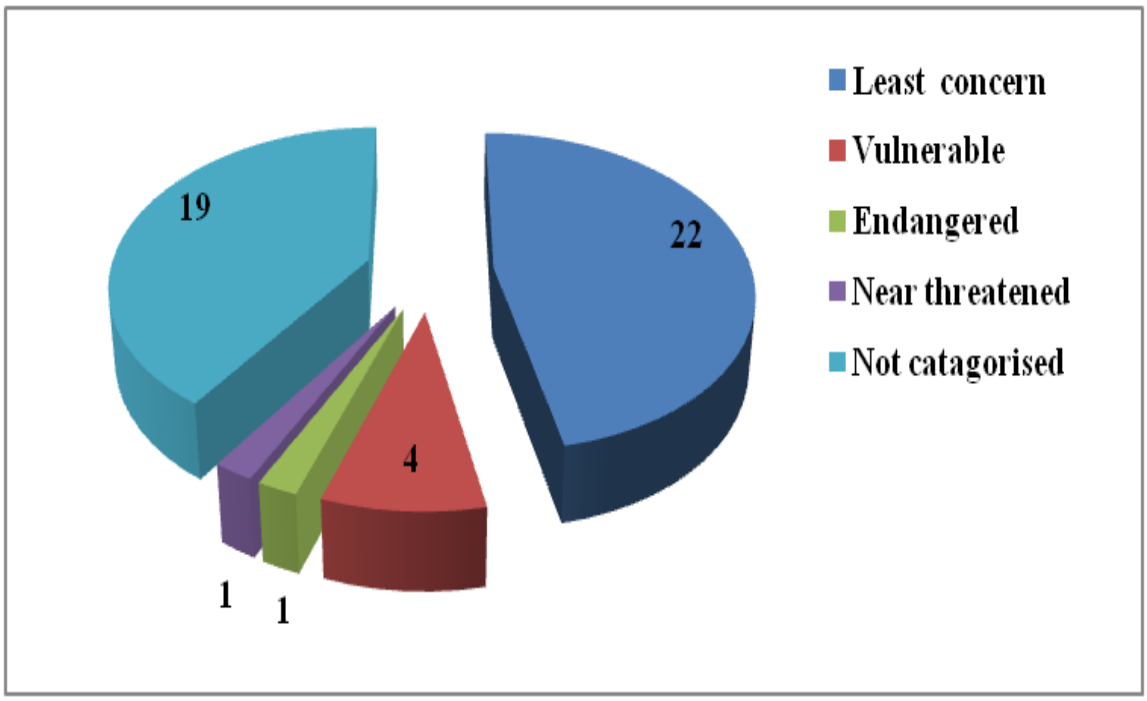

Figure 4. Species of herpetofauna listed in various categories of IUCN.

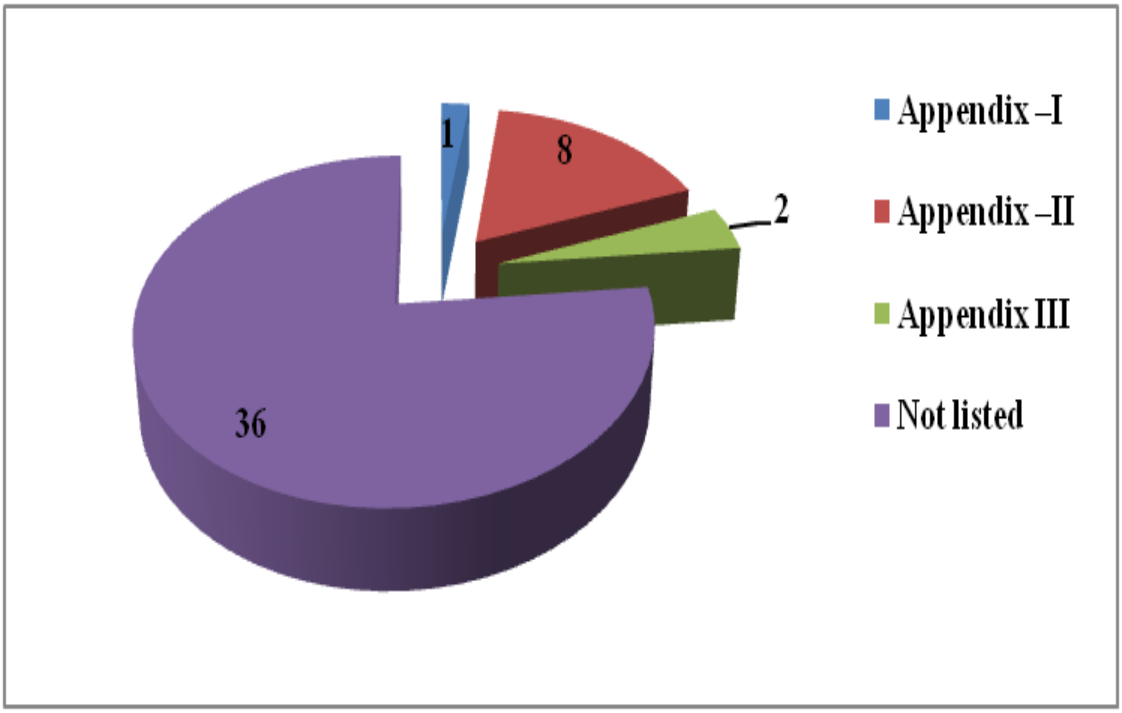

Figure 5. Species of herpetofauna listed in various appendices of CITES.

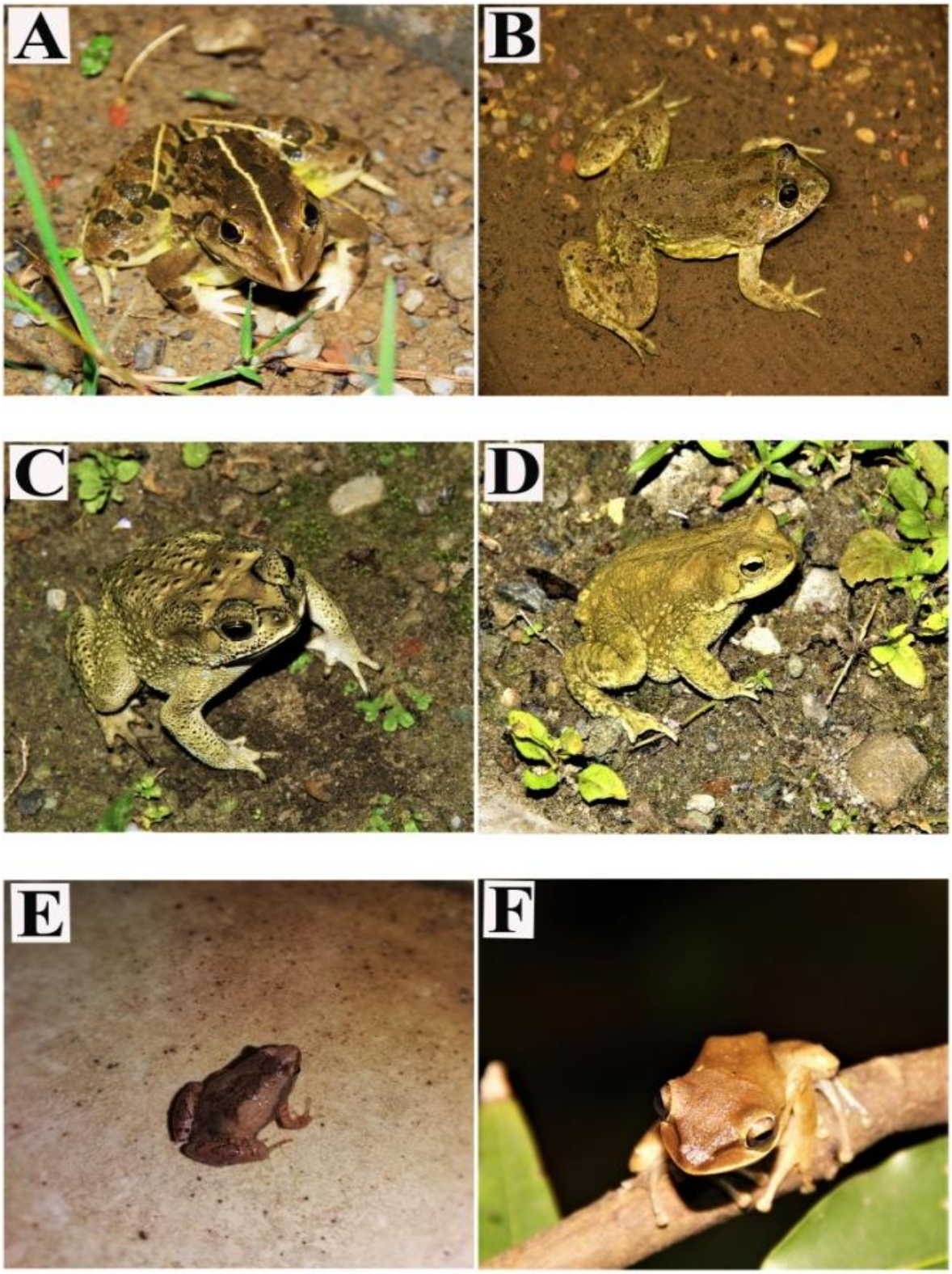

Figure 6. Some anuran species reported in RFD, TAL (India). A. *Hoplobatrachus tigerinus*. B. *Euphlyctis cyanophlyctis*. C. *Duttaphrynus melanostictus*, D. *Duttaphrynus stomaticus* E. *Microhyla nilphamariensis*, F. *Polypedates maculatus.*

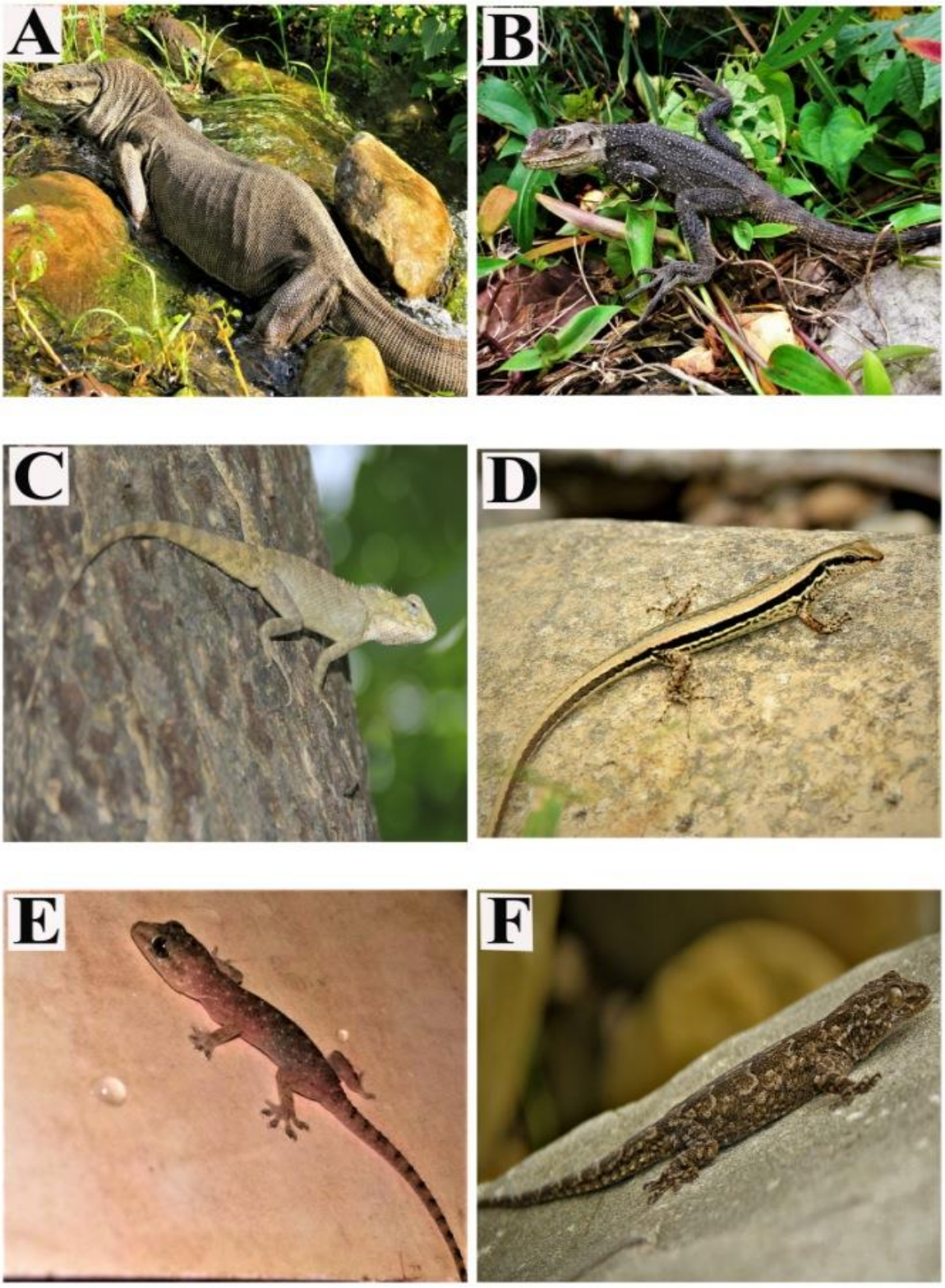

Figure 7. Some lizards species reported in RFD, TAL (India). A. *Varanus bengalensis.* B. *Laudakia tuberculata*. C. *Calotes versicolor.* D. *Asymblepharus himalayanus*. E. *Hemidactylus kushmorensis.* F. *Hemidactylus leschenaultii.*

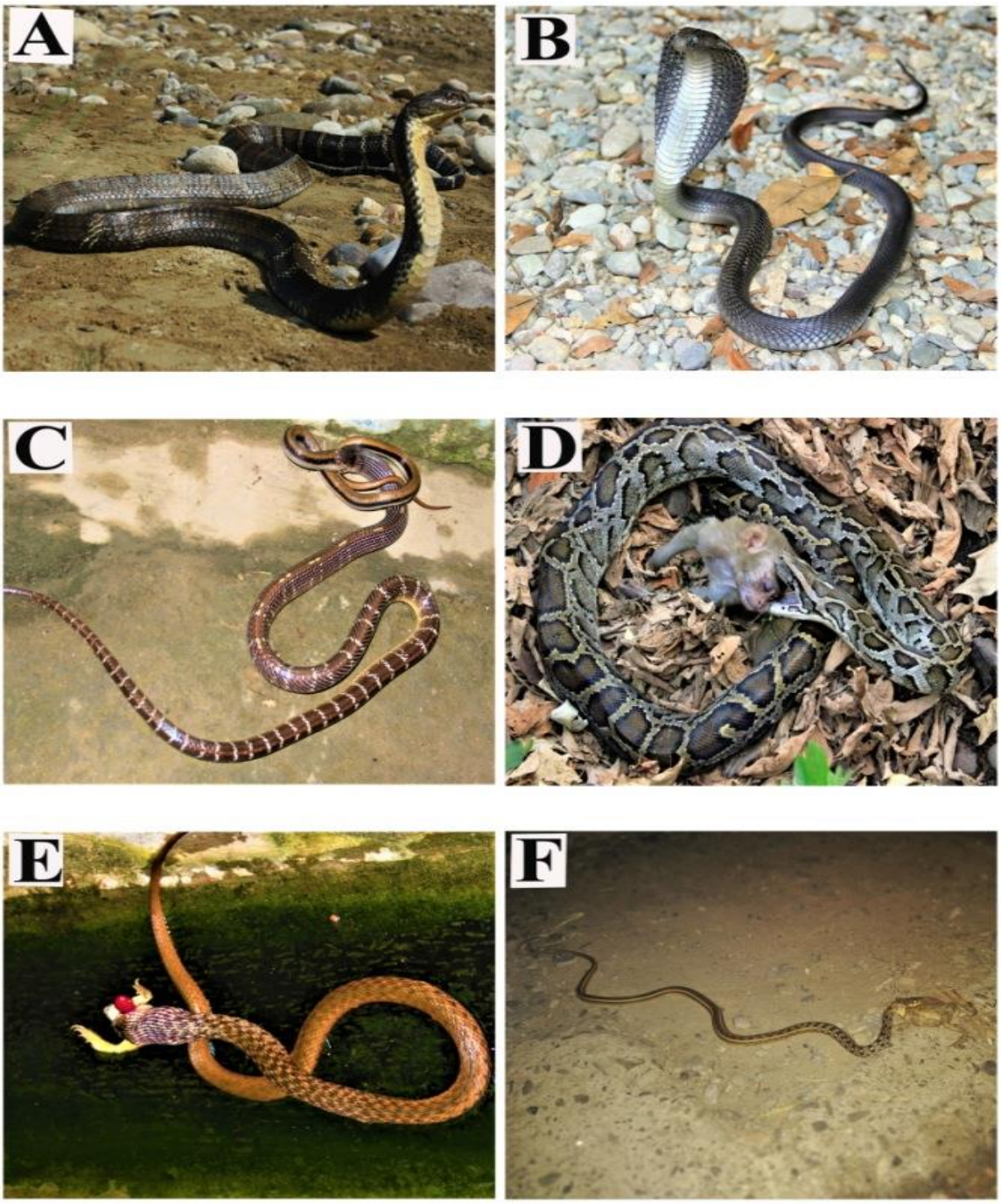

Figure 8. Some snake species reported in RFD, TAL (India). A. *Ophiophagus hannah*. B. *Naja naja*. C. *Bangarus caeruleus* (feeding on *Coelognathus helena*). D. *Python bivittatus* (feeding on *Macaca mulatta*). E. *Xenochrophis piscator* (feeding on a frog). F. *Amphiesma stolata* (feeding on a toad).

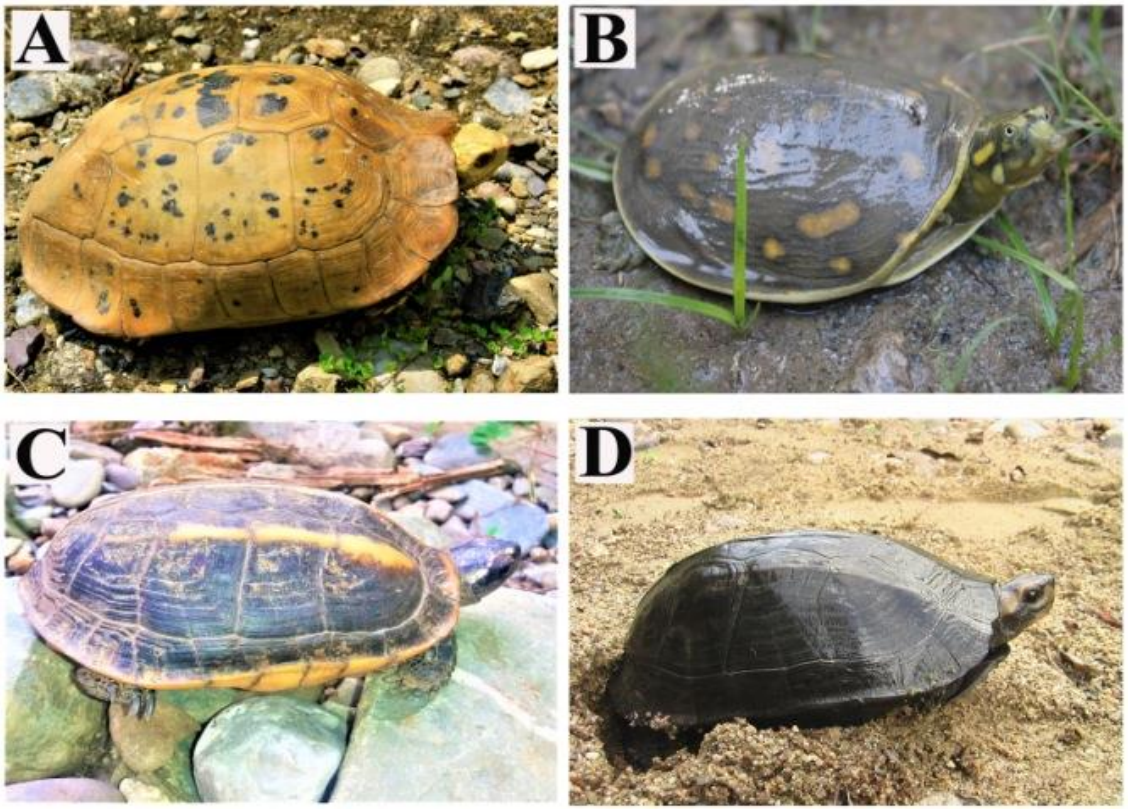

Figure 9. Tortoise and Turtle species reported in RFD, TAL (India). A. *Indotestudo elongata.* B. *Lissemys punctata*. C. *Melanochelys tricarinata.* D. *Melanochelys trijuga.*

TAL is a huge region and spread among two countries and it is difficult to survey the whole region. In the past, various studies have been conducted covering different parts of TAL. Some efforts were done for the assessment of herpetofauna in western TAL by Boruah *et al*., (2020); Chopra, (1977; Khanna, (2005); Khati (2004). We recorded ten species of anurans in RFD. In earlier studies in the western TAL region, in Corbett national park (CNP) a protected area nearby RFD, Chopra (1977) reported seven species, Husain & Tilak (1995) recorded nine species, Editor-Director, Zoological Survey of India (2008) reported 10 species of anurans. In the eastern part of TAL, in the Chitwan national park, Bhattarai *et al*. (2018) reported 13 species of anurans and in the Parsa national park, the easternmost part of TAL Bhattarai *et al*. (2018) reported 12 species of anurans. In this region of western TAL, we found a total of 13 species of lizards. In Rajaji National Park (RNP) the westernmost part of the TAL, Joshi *et al*. (2009) reported nine species of lizards. While in the eastern part of TAL, 11 species of lizards reported by Bhattarai et al. (2017), and in the easternmost part of TAL in Parsa national park, Bhattarai et al. (2018) recorded five species of lizards. In western TAL, Osmaston & Sale (1989), reported three species of snakes from the Rajaji National Park (RNP), Husain (1995) found 28 species in RNP. Husain (1995) reported 38 species of snakes from the Dehradun and Pauri Garhwal regions of western TAL. While in the eastern region of TAL, Chitwan national park, Bhattarai *et al*. (2017) reported 18 species of snakes, and 13 species of snakes were reported in Parsa national park, TAL Bhattarai e*t al*. (2018). We reported a total of four species of tortoise and turtles from the RFD region of western TAL. Other parts of TAL, Rao, (1998) reported 12 species in the river Ganga from Rishikesh to Kanpur. Editor Director (2010) reported 11 species of Chelonians from this region. In the eastern region of TAL, Bhattarai *et al*. (2017) reported four species of turtles. Bhattarai *et al*. (2018) encountered only *Indotestudo elongata* in Parsa national park.

CONCLUSION

Present study in RFD revealed that this part of TAL is also a significant habitat for the herpetofauna. Some species of herpetofauna, which are protected under various categories of conservation by national and international agencies, were found in RFD. This area needs attention for protection and conservation strategies for the successful thriving of these animals. More studies in the future in this region may yield more herpetological findings.

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