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Research Article

Species diversity of reptiles in Palpa District, Nepal

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Abstract

Gastrointestinal (GI) This study was conducted in agricultural field, forests, riparian and wetland habitats, and human habitats of six sampling sites in Palpa, Nepal, from May 2016 and April 2020. The purpose of the study was to document and measure the richness, abundance, and diversity of the reptile in this district. Data was collected randomly in these habitats of this district using quadrat, visual encounter, and opportunistic survey methods. For 100 quadrates for each site seasonally, 20 quadrats were placed in each habitat along 5 transects. In total, 554 individual species belonging to 9 families, 26 genera, and 34 species were recorded. The richness of reptiles was high in the human habitat and forest (S = 25) but lower in wetland (S = 6). The abundance was more in human habitat than in other habitats. Shannon diversity index (H') of reptile was 2.51 and 0.99 in forest and wetland respectively. Similarly, the Simpson index in reptiles (λ) was high in forest (0.87) and low in wetland (0.57). Pielou evenness (J) of individuals among the species was 0.29 in forest and 0.54 in a wetland. The values indicate that the diversity of reptiles were more diverse in forest as compared to the wetland. This study aids the resources for additional research.

Keywords: Agricultural fields; Diversity indices; Forests; Human habitats; Riparian; Wetland

1 | Introduction

Since The diversity and distribution of reptile species are influenced by factors such as geography, humidity, disturbance, and habitat type. There are 11,690 reptile species reported in which lizards (7,144 species), snakes (3956 species), turtles (360 species), amphisbaenians (202 species), crocodiles (27 species), and tuataras (1 species) (Uetz 2021). In Nepal, there are 142 species of scaled reptiles, including crocodiles (2 species), turtles and tortoises (15 species), 40 lizard species, and 70 snake species (Schleich & Rai 2012).

South Asia has a rich diversity of herpetofauna including several unique and endemic species (Shah & Tiwari 2004). The identification and distribution of the herpetofauna in Nepal was aided by the research of Swan and Leviton (1962), Fleming and Fleming (1974), Kramer (1977), Nanhoe and Ouboter (1989), Schleich and Kastle (2002), Anders (2002), and others. Other Nepalese researchers have taken an interest in herpetology following T. K. Shrestha (1989), including Shah and Gire (1992), Shrestha (2001), and Shah and Tiwari (2004). Reptiles have diverse forms, are widely distributed, except polar ice and the Tundra regions. They are among the most successful vertebrates in terms of diversity, distribution, and abundance as they occupy and live in a great variety of aquatic and terrestrial habitats (Hickman et al. 2007; McDiarmid et al. 2012). Some species of reptiles have adapted to live in very harsh climates such as desert and arid areas. The occurrence of these species in the dry climate is attributed to their thickened skin.

Indexes of richness, evenness, diversity, and abundance, as well as distribution models, are the most used types of species diversity metrics (Magurran 1988; Ludwig & Reynolds 1988). Species richness is commonly used as a measure of biodiversity for many purposes, including monitoring of biodiversity and determining where to prioritize conservation efforts (Magurran 2004; Kerr 1997).

Although they are extensively distributed in Nepal and the around the world, research on reptiles has been less focused as that on other vertebrates. Less research has been carried out on the population, distribution, and status of reptiles in Nepal than other vertebrate species (CEPF 2005; Bhattarai et al. 2017). There is still a shortage of information on these species from western Nepal (Lumbini region). This study assesses the diversity, abundance, and richness of the reptiles in the Palpa district of Nepal and includes comprehensive data.

2 | Materials and methods

2.1 | Study area

This study was conducted from May 2016 and April 2020 in Palpa district. It extends from 83°15′ to 84°22′ east and 27°24′ to 27°57′ north. The six sampling stations were Tansen, Sardewa, Deugir- jhadewa, Dobhan, Rampur and Ringneraha. It is hilly district and covers an area of 1,373 km². It has several terrestrial macro-habitat type. It covers Siwalik hill or Churia range and Mahavarat range. It consists of tropical to temperate climates and consists of shrubs area, slight to moderately dense forests, fertile lands, slope landscape, caves, and varied microclimatic conditions.

Figure 1. Map of Palpa District showing study area

Table 1. Station, coordinate and elevation of study area

SN	Station	Coordinate	Elevation (m)
1	Tansen	27.8666 °N, 83.5499 °E	1059
2	Somadi – Sardewa	27.9148 °N; 83.3974 °E	731
3	Jhadewa	27.7770 °N, 83.6797 °E	1062
4	Dovan	27.7453 °N, 83.4644 °E	271
5	Rampur	27.8469 °N, 83.9011 °E	402
6	Ringneraha	27.8265 °N, 83.7511 °E	827

2.2 | Data collection

Samplings were conducted from May 2016 to April 2020 six sampling stations of this district. Each sampling site was split into five sub-habitat sites (Agricultural fields, forest, human habitat, riparian and wetlands) in which 5 transects at which 20 cell quadrates were sampled in each sub-habitat and altogether 100 quadrates in each site. The other sampling methods were opportunistic surveys conducted in other parts based on (Gardner 2007) and visual encounter method on each habitat. Each sampling effort was carried out by field helpers for about three hours in morning from 6.00 am to 9.00 am, afternoon from 12.00 to 3.00 pm and evening from 7.00 pm to 9:00 pm. Trapping, digging, and raking was used to detect species. While looking for basking or active reptiles, visually recorded the habitat to be surveyed in the afternoon.

The possible individuals were caught then euthanized for morphological study, measured for future reference, taken of representatives of each species and habitats in a natural condition, and released back. Geographic coordinates for each survey site were determined in the field with a Garmin GPS (etrex 10) receiver. The sample specimens were fixed in 10% formalin and preserved in 70% alcohol. The specimens were identified using the identification keys developed by field guide of Gunther 1863), Smith (1981), Dixon (2000), Schleich & Kaestle (2002), and Rai (2003) and Shah & Tiwari 2004).

2.3 | Data analysis

Table and figure were prepared from Microsoft Excel 2013 and species diversity were calculated by software R package 3.6.1 in R Studio v.3.1.0 (R Development Core Team 2013). Species richness (the number of species) and abundance (number of individuals) of each taxon was estimated. Diversity indices used in this study were the Shannon Wiener index (1949), Simpson index (1949), and Evenness to find out the interrelationship between them. Richness and Evenness are the components of diversity (Pielou 1969; Liu et al. 2008). Biodiversity indices were calculated to investigate the differences in reptile diversity and abundance among different habitats (Table 2). Data was tested by using Menhinick's index (D=nN−−√N), Margalef's index (D=n−1lnN). The Shannon-Wiener Index [H′ = -Σ (pi ln pi)] was used to determine the diversity of species heterogeneity (where, H′ = species diversity, and pi = proportional frequency of the ith species). Simpson's Index (λ) λ DS=Σni (ni−1N(N−1)=1−Σni(ni−1N(N−1) and Pilou evenness (J) were tested.

$$J = \frac{H'}{H_{max}} = \frac{H'}{ln.S} =$$

3 | Results

Throughout this study, 34 species of reptiles exposed in the studied locations (Table 2). Ten species of lizards from four distinct families were present (Gekkonidae, Agamidae, Scincidae, and Varanidae). Five distinct snake families and 24 species of snake have identified. Among them family Colubridae has 15 species followed by Elapidae (5 species), Viperidae (2 species), Boidae (1 species), and Typhlopidae (1 species). There were 39 species of lizards, 81 species of snakes, 2 species of crocodiles, and 16 species of tortoise and turtles (Shrestha, 2001), Shah and Tiwari (2004), on the other hand, reported 123 reptiles in Nepal. In addition to

Table 2. Families, species and habitat of Reptiles in Palpa district

Families	Scientific name	Agricultural field	Forest	Human habitat	Riparian	Wet land	Total	%	IUCN status
Agamidae	*Calotes versicolor*	41	34	39	5	1	120	21.66	LC
	Laudakia tuberculata	3	11	0	0	0	14	2.53	LC
	Oriotiaris tricarinata	1	7	1	0	0	9	1.62	LC
Gekkonidae	*Hemidactylus brooki*	0	0	30	0	0	30	5.42	NA
	Hemidactylus flaviviridis	0	0	28	0	0	28	5.05	LC
	Hemidactylus frentatus	0	0	13	0	0	13	2.35	LC
Scincidae	*Eutropis carinata*	2	7	4	0	0	13	2.35	LC
	Mabuya macularia	2	7	1	0	0	10	1.81	NA
	Sphenomorphos maculates	5	9	5	0	0	19	3.43	NA
Varanidae	*Varanus bengalensis*	0	7	0	0	0	7	1.26	LC
Typhlopidae	*Indotyphlops braminus*	5	12	6	0	0	23	4.15	LC
Boidae	*Python molurus*	0	2	0	0	0	2	0.36	NT
Colubridae	*Amphiesma solatum*	0	0	0	7	3	10	1.81	LC
	Boiga forsteni	1	3	1	0	0	5	0.90	LC
	Boiga ochracea	5	5	2	0	0	12	2.17	LC
	Boiga trigonata	5	10	7	0	0	22	3.97	LC
	Coelognathus helena	3	8	3	0	0	14	2.53	LC
	Coelognathus radiatus	3	5	4	1	0	13	2.35	LC
	Dendrelaphis trisis	2	6	2	0	0	10	1.81	NA
	Lycodon aulicus	2	0	4	2	1	9	1.62	LC
	Oligodon arnensis	1	0	2	0	0	3	0.54	LC
	Oligodon erythrogaster	6	0	6	0	0	12	2.17	NT
	Orthriophis hodgsonni	3	5	4	0	0	12	2.17	NA
	Ptyas mucosa	7	13	11	5	7	43	7.76	LC
	Trachischium guentheri	0	1	0	0	0	1	0.18	VU
	Xenochrophis piscator	2	0	0	9	7	18	3.25	LC
	Xenochrophis sanctjohannis	0	0	0	6	3	9	1.62	LC
Elapidae	*Bungarus caeruleus*	1	2	4	0	0	7	1.26	LC
	Sinomicrurus macclellandi	0	3	3	0	0	6	1.08	LC
	Naja kaouthia	1	2	1	0	0	4	0.72	LC
	Naja naja	2	6	2	0	0	10	1.81	LC
	Ophiophagus hannah	0	4	0	0	0	4	0.72	VU
Viperidae	*Trimeresus albolabris*	9	13	9	0	0	31	5.60	NA
	Ovophis monticola	5	5	1	0	0	11	1.99	LC
		117	187	193	35	22	554	100.00	

Table 3. Diversity index of reptile in different habitat in Palpa District

S. N	Diversity index	Agriculture field	Forest	Human habitat	Riparian	Wetland
1	Species richness (S)	23	25	26	7	6
2	Menhinick's index	1.86	2.05	1.51	1.00	0.80
3	Margalef's index	4.00	4.30	3.30	1.24	0.76
4	Shannon-Wiener Index (H')	2.47	2.51	2.25	1.41	0.96
5	Simpson's Index (λ)	0.86	0.87	0.84	0.73	0.57
6	Pilou evenness (J)	0.29	0.29	0.30	0.45	0.52

these, regional reptiles have been described taxonomically, geographically, genetically, and moreover by a variety of researchers. For example, Pokhrel and Thakuri (2010) observed 9 reptiles in the Manaslu conservation area, 34 species of reptiles (Bhattrai et al. 2018; 2010) in Chitwan National Park, and 56 species of reptiles (including 37 genera in 17 families) in Shuklaphanta National Park (Rawat et al. 2020). Das et al. (2009) found 45reptile species in the Barail Wildlife Sanctuary.

3.1 | Species richness and abundance

Species richness of reptile was 34 in Palpa district. During field visits, 554 individual reptiles were recorded. The most abundant reptile species was *Calotes versicolar* (21.66%) followed by *Ptyas mucosa* (7.76%) and *Python molurus* (0.36%) was rarely recorded in this district but least species recorded in *Trachischium guentheri* (0.18%). In this study, reptile preferred Human habitat (S=26), followed by forest (25), agricultural field (23), riparian (7), and 6 in Wetland (Table 3; Fig.2). There were four families of lizards, which were found in forest. Among them gecko was observed on ceiling and wall of building so preferred the human habitat.

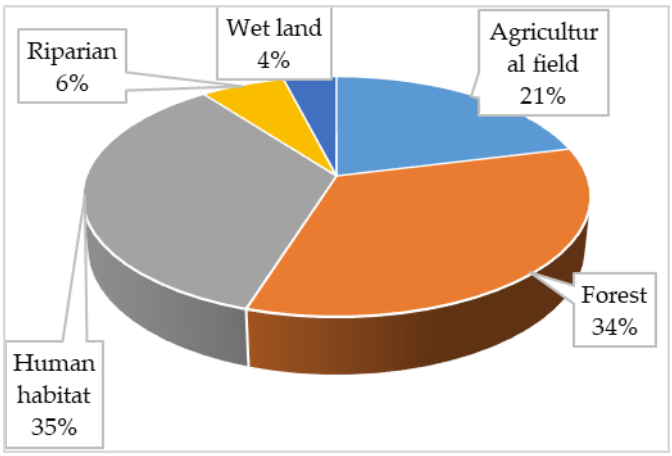

Figure 2. Habitat wise abundance of reptiles in Palpa

3.2 | Species diversity of reptiles

Menhinick's index and Margalef's index both have more value in forest and agricultural field. The Simpson diversity index was 0.86, 0.87, 0.84, 0.73, and 0.57 in different habitats of agricultural field, forest, human habitat, riparian, and wetland; respectively. A higher Simpson's index as well as a higher Shannon-Wiener's index also indicated great species evenness in the riparian and agricultural areas. The index value (H) was 2.51 in forest, 2.47 agricultural field and 2.25 in human habitat, which were more than 1.50. This indicates the higher diversity, but values of diversity index of riparian and wetlands were 1.41 and 0.96 respectively less than 1.50. Therefore, these habitats showed less diversity (Table 3).

4 | Discussion

There were 10 species of lizard and 24 species of snakes observed. Lizards were most diversified and well-adapted species for walking, running, climbing, and burrowing (Hickman et al. 2007). *Calotes versicobor* is most abundant and widespread agamid of Nepal (Shah and Tiwari 2004). *Calotes versicolor*, *Hemidactylus* spp .and *Mabuya macularia* remarkable appeared species. Snakes such as *Amphiesma stolatum*, *Coelognathus radiates*, *Lycodon aulicus*, *Ptyas mucosa*, *Xenochrophis piscator*, *Naja kaouthia*, *Naja naja*, *Indotyphlops braminus* and *Trimeresus albolabris* were notable records during the study period. Altogether 24 species of snakes were recorded in which eight species were venomous snakes. Local people often kill both venomous and non-venomous snakes in this area for preventive measures against snakebites. Reptile abundance and movement rise with early rains, according to Msuya (2003), because of increased food availability.

Simpson index ranges from 0 to 1. Mature and stable communities have high diversity value (0.6 to 0.9),

while the communities under stress conditions, exhibiting low diversity, usually show close to zero value (Dash 2003). Shannon-Weiner and Simpson diversities increase as richness increase for a given pattern of evenness, and increase as evenness increases for a given richness (Shah & Pandit 2013). Habitats have higher Margalef index values (> 1.50), indicating more reptile species diversity. Margalef index value was 4.0 in agricultural field, 4.3 in forest, and 3.3 in human habitat which was more than 1.50, showed the higher species diversity, but in other habitats, values were less than 1.50, thus, the lesser diversity. Pielou evenness (J) constrained between 0 and 1.0 and the more variation in abundances between different taxa within the community, the lower the J. It depended on sample size and was also highly sensitive to rare taxa. Pielou evenness was 0.29, 0.29, 0.30, 0.45, and 0.52in the habitats of agricultural field, forest, human habitat, riparian, and wetland; respectively. The exponential of the Shannon's diversity index was computed to get the effective diversity of species. The diversity indices as Simpson index (1-D > 0.80), and Shannon-Weiner (H >2.20) found the areas with high diversity. Shannon-Wiener index is expected to determine the evenness and richness (Melo 2008). In the present study, Shannon index (H′) were more in forest than other habitats. The relative abundance, equitability index (J > 0.80) and evenness (e^H/S) > 0.70) of individuals among the species show that species diversity was more abundant (Gixhari et al. 2016).

5 | Conclusions

Current study found that there was a total of 9 families, 34 species, and 554 reptiles in the study region. There were 24 different kinds of snakes, and 8 of them were venomous. The richness of reptile was higher in habitat and forest. Only one species of *Trachischium guentheri* was recorded during the survey. Many diversity indices had high diversity values for stable communities, while unstable ones had low values due to environmental degradation. Species diversity was higher in forest and agricultural fields. They preferred the human habitat, forest and agricultural field but not riparian and wetland. The majority of diversity indices' information was used to determine habitat characteristics and conduct quantitative analysis (species richness, evenness). This demonstrates the importance of maintaining both habitats (forests and agricultural areas) in order to preserve the diversity of reptiles in this area.

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Conflicts of interest

Authors declare no conflict of interest.

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