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Species diversity, composition, and distribution of the herpetofauna in the Northwestern Region of Bangladesh

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***Abstract.*—Species diversity is an important parameter for monitoring ecology that can accelerate conservation planning. A study on the diversity, composition, and distribution of the herpetofauna in four districts of northwestern Bangladesh was conducted through direct field observations and plot counting during day and night from April 2017 to March 2018. A total of 33 species of herpetofauna were recorded, representing 20 reptiles and 13 amphibians, and the estimated species richness was 37. The highest number of species (22) was found in both Kornai (Thakurgaon) and Mollapara (Nilphamari), while the lowest (10) was in Nolabari (Nilphamari) and Koyagolahat (Nilphamari). The highest number of amphibian species (11) was recorded in Singra forest and Kornai, while Mollapara harbored the most reptilian species (12). Based on the Shannon-Wiener index of diversity, the highest diversity was in Kornai (H' = 2.562) while the lowest was in Singra forest (H' = 1.304). The Jaccard similarity index varied from 0.33 to 0.71, indicating the variations of species compositions among different sites. Among the 2,421 herpetofauanal individuals recorded, Common Toad, *Duttaphrynus melanostictus* (n = 639) represented the highest number among the amphibians and Yellow-green House Gecko, *Hemidactylus flaviviridis* (n = 130) represented the highest number among reptiles. The baseline data on herpetofaunal diversity reported here will help the scientific community and policymakers to effectively accelerate the conservation plans for this region.**

Keywords. Abundance, Amphibia, conservation, diversity indices, Reptilia, species richness

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Introduction

Bangladesh is unique in having temperate climatic conditions that have created 25 bio-ecological zones throughout the country (Nishat et al. 2002). These ecological zones are mainly forested habitats, although Bangladesh has minimal natural forest and forest patches except the Sundarbans (Khan 2015). Wild animals use these diverse forest ecosystems, as well as human-dominated landscapes in both urban and rural areas and in city centers. The needs of the growing human population, such as land use for human habitations and cultivation, have been influencing many species in close proximity to human habitats over the past few decades (Khan 2015). In Bangladesh, wildlife research has mainly emphasized megafauna such as tigers (Azad et al. 2005; Inskip et al. 2013, 2016; Reza et al. 2002), elephants (Palash et al. 2018; Sarker and Roskaft 2010; Wahed et al. 2016), and langurs (Green 1980; Jaman 2015; Khatun et al. 2012, 2013). Research on the herpetofauna is still inadequate in Bangladesh and this has led to controversy among researchers regarding the exact number of species (Hasan et al. 2014; Hasan and Feeroz 2014). Herpetofaunal discovery (i.e., species newly described for science) has become common in Bangladesh in recent times (Reza and Perry 2015), and 27 species of amphibians and 57 species of reptiles have been added to the list since 2000 (IUCN Bangladesh 2015). A total of 49 species of amphibians and 167 species of reptiles have been assessed by IUCN Bangladesh in 2015. The number of assessed herpetofaunal species has increased for both groups and many undiscovered species were added to the list after their discovery and assessment of threats (IUCN Bangladesh 2015).

The herpetofauna of Bangladesh are facing many threats and under extreme pressure due to habitat loss, excessive use of agrochemicals, drying up of water sources, intentional forest fires, and extensive fuelwood

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collection (Hasan et al. 2014; IUCN Bangladesh 2015). In addition, anthropogenic threats are causing the degradation and loss of the very few natural reserve forests that still exist in this region (Hasan et al. 2014; IUCN Bangladesh 2015; Karmakar et al. 2011; Rahman et al. 2012). In the last few decades, the natural habitats of herpetofauna have been completely degraded and this process is continuing presently. The modes and styles of degradation or alteration of natural habitats in the northwestern districts are diverse, such as urbanization, uncontrolled irrigation, pressure from increasing human settlements and unmanaged fishery practices, among others. Rapid urbanization and the conversion of land into human habitation and agricultural production are posing serious threats in this study area. A total of 10 species of amphibians and 38 species of reptiles are nationally threatened according to IUCN Bangladesh (2015).

The southeastern and northeastern parts of Bangladesh have been blessed with strong conservation efforts and have more diverse and protected areas. Research on herpetofaunal species diversity and richness have mainly been conducted in the protected areas of these regions (Chowdhury et al. 2016; Hasan et al. 2014; Hasan and Feeroz 2014; Khan 2007; Mahony and Reza 2008; Reza and Mukul 2009; Reza and Perry 2015). Some additional works on herpetofauna have been done in northwestern Bangladesh (Alam et al. 2019; Al-Razi et al. 2015; Hossain and Jing 2019; Rahman et al. 2018). Thus far, no endemic reptile species have been reported in Bangladesh, but seven endemic amphibian species (*Fejervarya asmati*, *Hoplobatrachus litoralis*, *Microhyla mymensinghensis*, *M. mukhlesuri*, *M. nilphamariensis*, *Zakerana dhaka*, and *Euphlyctis kalasgramensis*) occur in diverse habitats of this country (Howlader et al. 2015a,b, 2016; IUCN Bangladesh 2015; Khan 2015). Despite this recent increase in research on the herpetofauna of Bangladesh, research on the diversity and richness of herpetofauna specifically in northwestern Bangladesh has yet to be reported. Therefore, the aims of this study were to characterize the species assemblage, including species diversity and distributions, and estimate the herpetofaunal species richness in four districts in northwestern Bangladesh.

Methods

Study Area

This study was conducted from April 2017 to March 2018 in Thakurgaon, Dinajpur, Nilphamari, and Rangpur districts of northwestern Bangladesh. Three of the four, Dinajpur, Nilphamari, and Thakurgaon, are situated adjacent to the international border with India. Some major river systems linked to the Barind tract flow through West Bengal of India and into northwestern Bangladesh, and the sites are reticulated with many small- to medium-sized rivers. Eight study sites in these four districts were selected based on the biological characteristics of their habitats, logistical concerns and flexible opportunities for study. Representatives of all major habitat types in the study area (ponds and wetlands, homestead gardens, agricultural or cropland areas, and forests) were surveyed during the whole study period.

Summary of the Study Sites

A map of all the districts and study sites is shown in Fig. 1.

Dinajpur has an area of about 3,437.98 km^2, and this district includes some ecologically important areas. Among them, Singra forest (25°53’33.0”N, 88°34’04.7”E) was selected mainly due to its rich vegetation.

Nilphamari, adjacent to Dinajpur district, has an area of 1,580.85 km^2. The study sites in this area were Mollapara (25°53’11.67”N, 88°52’31.21”E), Koyagolahat (25°48’10.01”N, 88°53’59.51”E), and Nolabari (25°49’15.96”N, 88°50’1.42”E), which were selected according to their habitat types.

Thakurgaon covers an area of 1,809.52 km^2, and the study sites were Kornai (25°45’47.1”N, 88°22’30.0”E) and Mollikpur (25°48’01.8”N, 88°22’18.3”E).

Rangpur has an area of 2,370.45 km^2, and the study sites were Khatkhatia (25°47’1.76”N, 89°15’34.34”E) and Burirhat (25°49’21.41”N, 89°14’5.95”E). Khatkhatia is mainly agricultural land with canals, while Burirhat is a fallow land with bushy areas and ponds.

Field Methods

Data were collected through direct field observations. Observations were mainly done in the evening to nighttime, starting from 1830 h to 2230 h, as the herpetofauna are mostly active at night. Generally, the nocturnal surveys were conducted with torchlight and were more successful on nights just following rain. Observations were also made for those reptilians who were active during the daytime for their feeding and basking. In particular, we searched thickets and bushes to find lizards and skinks in the study areas.

Searches for herpetofauna were carried out by turning over the land surface cover, such as debris, fallen logs, dead leaves, etc. that could be moved by hand. This was done by walking through an area of habitat and searching for exposed or active amphibians and reptiles. Each study site was divided into a similar number of plots. The size of each plot was 10 m × 10 m, and each plot was extensively searched for herpetofauna. A total of 152 plots were surveyed, with counting of the observed populations. Species were identified according to the most recent country herpetofaunal field guide (Hasan et al. 2014). Species which were difficult to identify in the field were photographed and their identification was later confirmed by experts.

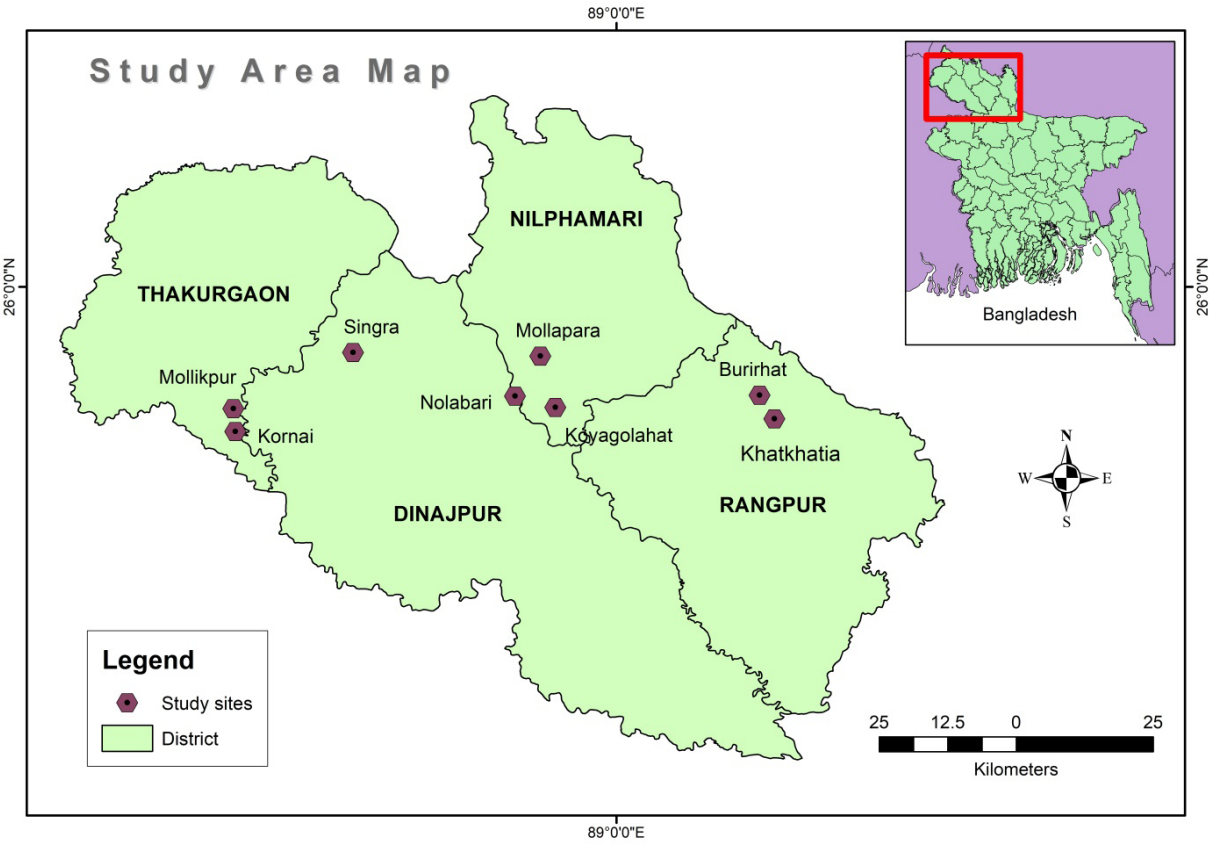

Fig. 1. Locations of the study sites in the Northwestern region of Bangladesh.

Data Analysis

The names of all available amphibians and reptiles in the study areas were recorded and classified for further analysis. Amphibian and reptilian species were grouped with their total numbers of individuals, and species richness and abundance were subsequently calculated. Species diversity levels of all study sites were calculated using the Shannon-Wiener index of diversity. Similarities of species composition in different sites were also calculated using Jaccard similarity index in EstimateS software. Estimated species richness was calculated using the freely available EstimateS 9 Windows software and the data of presence or absence for each species in each sample (Colwell 2009). The five most popular non-parametric estimators (ACE, ICE, Chao1, Jacknife 1, and Bootstrap) with 100 runs for each were used for estimating species richness.

Results and Discussion

Observed and estimated species richness. A total of 33 species of herpetofauna were recorded from the study sites. They represent 20 genera in 13 families, and the 13 amphibian species belong to five families (Bufonidae, Dicroglossidae, Microhylidae, Ranidae, and Rhacophoridae) while the 20 reptilian species belong to eight families (Agamidae, Colubridae, Elapidae, Gekkonidae, Homalopsidae, Natricidae, Scincidae, and Varanidae). The herpetofaunal diversity in the study area was quite remarkable, and the family-level species diversity was higher for the reptiles than the amphibians. The numbers of amphibian and reptilian species in Bangladesh have varied among different studies conducted at different times (Husain and Rahman 1978; Hasan et al. 2014; IUCN Bangladesh 2000, 2015; Khan MAR 1982, 2004, 2010, 2015; Khan MMH 2008; Sarker and Sarker 1988). Aziz et al. (2014) found nine species of amphibians and 18 reptiles from Pabna district, whereas Sarker (2015) recorded 11 amphibians and 19 reptiles from wetlands of Chalan Beel. Our findings suggest that further study could increase the species richness reported in those areas. The findings of this study also showed very similar results with an increase of species numbers for northwestern Bangladesh (Aziz et al. 2014; Sarker 2015).

Among the 13 amphibian species, 11 (84.6%) were observed in Singra forest and Kornai which were the highest, and seven (53.8%) were observed in Nolabari and Khatkhatia which were the lowest (Table 1). The highest reptilian diversity was recorded in Mollapara with 12 (60%) species, and the lowest diversity was in Koyagolahat with two (10%) species (Table 1). The numbers of amphibian and reptilian species were the same in Khatkhatia, Burirhat, and Kornai, but they were different in Koyagolahat (Fig. 2). The highest amphibian

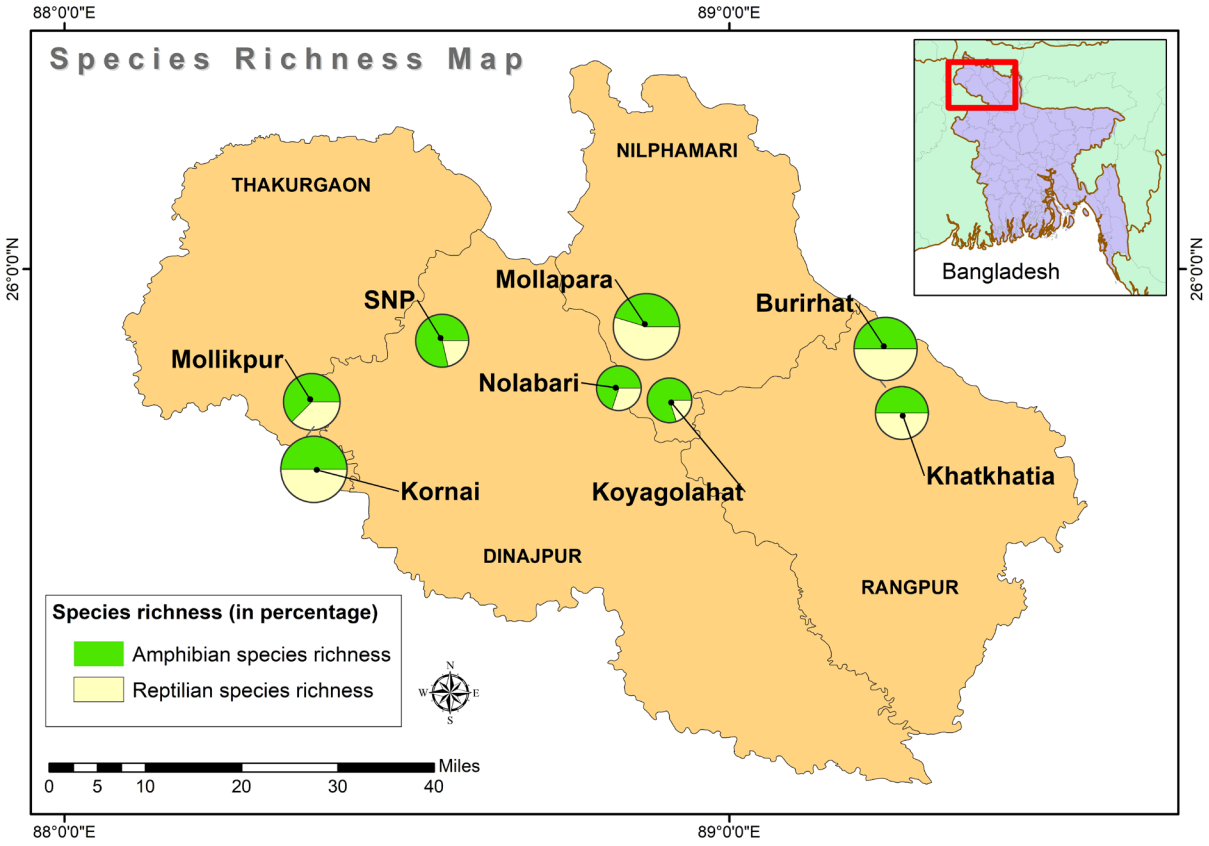

Fig. 2. Species richness of amphibians and reptiles at different study sites.

species diversity was found in Singra forest and Kornai, and the highest reptilian diversity was recorded in Mollapara (Fig. 2).

While it is not possible to thoroughly cover a whole study area for all the different groups of herpetofauna, the estimated species richness is often calculated to overcome all kinds of sampling errors and obstacles. Here, we used the EstimateS software developed by Colwell in 2009 to estimate the species richness of our study areas. Using five nonparametric estimators in EstimateS, the highest estimated species richness was 37 in Kornai and Mollapara and the lowest estimated species richness was 16 in Nolabari (Table 1). The range of total observed species varied from 10 to 22, with the highest in Kornai (22) and the lowest in Nolabari (10), whereas the total estimated species richness varied from 16 to 37 in each of the study sites (Table 1). There were only small differences between the observed and estimated species richness for amphibians but the differences were greater for reptiles. This is probably because of the cryptic behavior of reptiles which limits the success of searching and finding the species during the field study.

Diversity and similarity indices. The Shannon-Wiener index of diversity was used to calculate the diversity in different study sites, and the value was the highest (H' = 2.562) in Kornai (Thakurgaon) and the lowest (H' = 1.304) in Singra forest (Dinajpur). Based on the evenness

Table 1. Observed species richness (S_{obs}) and estimated species richness (S_{est}) in the study sites in Bangladesh.

	Observed species richness (S_{obs})			Estimated species richness (S_{est})		
Study site	Amphibians	Reptiles	Total	Amphibians	Reptiles	Total
Nolabari	7	3	10	9	7	16
Koyagolahat	8	2	10	12	17	29
Khatkhatia	7	7	14	12	19	31
Singra	11	3	14	13	20	33
Mollikpur	10	6	16	13	22	35
Burirhat	10	10	20	13	23	36
Mollapara	10	12	22	13	24	37
Kornai	11	11	22	13	24	37

Table 2. Species diversity indices based on different study sites in Bangladesh.

Parameter	Dinajpur	Nilphamari		Thakurgaon			Rangpur	
	Singra	Mollapara	Koyagolahat	Nolabari	Kornai	Mollikpur	Khatkhatia	Burirhat
Shannon-Wiener Index (H')	1.304	2.403	1.841	1.748	2.562	2.221	2.133	2.379
Evenness (E)	0.373	0.687	0.527	0.5	0.733	0.635	0.61	0.68

calculations, the herpetofaunal species were more evenly distributed in Kornai (Thakurgaon) (E = 0.733) and less so in Singra forest (Dinajpur) (E = 0.373) (Table 2). Singra forest is dominated with Sal trees (*Shorea robusta*) and this type of unique vegetation might be one of the causes of the low herpetofaunal diversity. In contrast, the presence of diverse habitats such as ponds, croplands, bushy areas, thickets, and fallow grassland may be the reason that Kornai (Thakurgaon) harbors the highest number of species among the sites.

The Jaccard similarity index for herpetofaunal overlap varied between study site pairs from 0.71 to 0.33 (average: 0.50), which means that half of the species were shared by different sites on average (Table 3). This index uses species richness only to compare the common species shared in two sites. Among the 33 species found in the surveys, 17 species were common between Kornai-Mollapara and Kornai-Burirhat which was the highest, and seven species were common between Khatkhatia-Nolabari and Khatkhatia-Koyagolahat which was the lowest, but the Jaccard similarity index was the highest for Burirhat-Mollikpur and the lowest for Khatkhatia-Singra forest (Table 3). The results of these two differed because the Jaccard similarity index uses unique species number and common species number to calculate the similarity. The results also showed that the three sites (Kornai, Mollapara, and Burirhat) with high species richness also shared the most species, sharing about 52% of total species, and the sites with the lowest species richness (Nolabari, Koyagolahat, and Khatkhatia) shared the fewest species, only about 23% of the total species.

Abundance, composition, and distribution. We counted a total of 2,003 individual amphibians, with Common Toad, *Duttaphrynus melanostictus* (n = 639) being most abundant and Red Microhylid Frog, *Microhyla rubra* (n = 5) being least abundant (Table 4). Among 418 observed individual reptiles, the highest number (n = 130) was for Yellow-green House Gecko, *Hemidactylus flaviviridis*, and the lowest number (n = 1) was tied for Common Smooth Water Snake, *Enhydris endydris*; Monocled Cobra, *Naja kaouthia*; and White-spotted Supple Skink, *Lygosoma albopunctata* (Table 5). Considering the eight study sites, the highest number of individuals was recorded in Burirhat (531, 21.9%), followed by Mollikpur (372, 15.4%), Kornai (354, 14.6%), Khatkhatia (337, 13.9%), Singra forest (230, 9.5%), Mollapara (217, 9%), Nolabari (208, 8.6%), and Koyagolahat (172, 7.1%).

Although Thakurgaon and Nilphamari districts were diverse in herpetofaunal species richness, the highest abundance was found in Rangpur district with 868 (35.85%) individuals. Thakurgaon was the second most abundant district with 725 (29.94%) individuals, and Dinajpur had the least abundance with 230 (9.5%) individuals. The amphibian population was most abundant in Rangpur (677, 33.8%) followed by Thakurgaon (598, 29.9%), Nilphamari (503, 25.11%), and Dinajpur (225, 11.2%). Rangpur also had the highest reptilian population (191, 45.7%). A total of 127 (30.4%) individual reptiles were recorded from Thakurgaon, 94 (22.5%) from Nilphamari, and 5 (1.2%) from Dinajpur. The pesticide usage in Rangpur (particularly in the study sites) has been decreasing through a community awareness program organized by the Upazila agricultural office. This might be one of the reasons for the highest abundance in Rangpur district, and the existence of different types of habitats might be another reason for the higher population in this area. On the contrary, unique habitat types, hunting of herpetofauna by ethnic communities, and the high rate of pesticide usage in Dinajpur district might be the reasons for its low abundance of amphibians and reptiles.

Common Toad, *Duttaphrynus melanostictus* (639, 31.9%) and Yellow-green House Gecko, *Hemidactylus flaviviridis* (130, 31.1%) were the most abundant species

Table 3. Jaccard similarity index values for comparing species assemblages in the study sites, with the shared species numbers in parentheses.

Study site	Koyagolahat	Khatkhatia	Singra	Mollikpur	Burirhat	Mollapara	Kornai
Nolabari	0.67 (8)	0.41(7)	0.50 (8)	0.53 (9)	0.50 (10)	0.39 (9)	0.46 (10)
Koyagolahat		0.41(7)	0.50 (8)	0.63 (10)	0.43 (9)	0.39 (9)	0.46 (10)
Khatkhatia			0.33 (7)	0.50 (10)	0.48 (11)	0.44 (11)	0.44 (11)
Singra				0.50 (10)	0.48 (11)	0.50 (12)	0.39 (10)
Mollikpur					0.71 (15)	0.58 (14)	0.58 (14)
Burirhat						0.62 (16)	0.68 (17)
Mollapara							0.63 (17)

Table 4. Numbers of each amphibian species observed in the study sites. Site numbers: 1, Singra; 2, Mollapara; 3, Koyagolahat; 4, Nolabari; 5, Kornai; 6, Mollikpur; 7, Khatkhatia; and 8, Burirhat.

		Dinajpur	Nilphamari			Thakurgaon		Rangpur	
English name	Scientific name	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8
Asmat's Cricket Frog	*Fejervarya asmati*	7	4	–	–	20	41	22	37
Common Toad	*Duttaphrynus melanostictus*	149	46	74	72	27	33	108	130
Common Tree Frog	*Polypedates leucomystax*	–	4	–	–	21	7	19	71
Bull Frog	*Hoplobatrachus tigerinus*	2	22	21	10	27	31	36	61
Jerdon's Bull Frog	*Hoplobatrachus crassus*	1	6	–	–	–	–	–	–
Nepal Cricket Frog	*Fejervarya nepalensis*	–	–	4	–	8	11	–	–
Microhylid Frog	*Microhyla* spp.	4	28	7	–	14	7	4	3
Pierre's Cricket Frog	*Fejervarya pierrei*	3	3	7	11	7	18	–	9
Red Microhylid Frog	*Microhyla rubra*	5	–	–	–	–	–	–	–
Skipper Frog	*Euphlyctis cyanophlyctis*	22	44	22	44	100	124	49	65
Syhadra Cricket Frog	*Fejervarya syhadrensis*	30	2	6	44	27	36	20	26
Terai Cricket Frog	*Fejervarya teraiensis*	1	1	13	7	21	11	–	14
Yellow-striped Frog	*Hylarana tytleri*	1	–	–	1	7	–	–	3

of herpetofauna found in all eight study sites. The observed amphibians mainly used agricultural land and pond areas, whereas reptiles preferred bush and human habitations. Most of the species of herpetofauna were found to use pond areas as their common grounds for feeding as well as breeding.

This study covered all major types of habitats available in the study areas to understand the distribution of the herpetofauna in their preferred habitats. Among the species found at all study sites were four amphibians: Common Toad, *Duttaphrynus melanostictus*; Skipper Frog, *Euphlyctis cyanophlyctis*; Bull Frog, *Hoplobatrachus tigerinus*; and Syhadra Cricket Frog, *Fejervarya syhadrensis*, and the reptile Common House Gecko, *Hemidactylus frenatus* (Tables 4–5). The species found only in a single study site (12.5%; one of eight study sites) included the amphibian Red Microhylid Frog, *Microhyla rubra*, and nine reptiles: Rat Snake, *Ptyas mucosa*; Banded Krait, *Bangarus fasciatus*; Monocled Cobra, *Naja kaouthia*; Bowring's Gecko, *Hemidactylus bowringii*; Common Smooth Water Snake, *Enhydris enhydris*; Striped Keelback, *Amphiesma stolatum*; Striped Skink, *Mabuya carinata*; White-spotted Supple Skink, *Lygosoma albopunctata*; and Bowring's Supple Skink, *Lygosoma bowringii* (Tables 4–5). This distribution suggested that amphibians were more widely distributed in all the study sites compared to reptiles.

Conclusions

The herpetofaunal abundance and species richness in the study areas were found to be relatively high, but threats to the herpetofauna are leading to their population declines which might eventually cause endangerment or even extinction of some species. Creating conservation awareness among the local people in these areas may accelerate the conservation of these small but important species. Conservation efforts and priorities should be of concern since these areas still harbor many endemic and ecologically important species. Moreover, studies on the breeding biology, habitat preferences, population dynamics, and life patterns of herpetofauna should receive greater emphasis considering their ecological roles.

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Table 5. Numbers of each reptile species observed in the study sites. Site numbers: 1, Singra; 2, Mollapara; 3, Koyagolahat; 4, Nolabari; 5, Kornai; 6, Mollikpur; 7, Khatkhatia; and 8, Burirhat.

		Dinajpur		Nilphamari		Thakurgaon		Rangpur	
English name	Scientific name	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8
Banded Krait	*Bungarus fasciatus*	–	2	–	–	–	–	–	–
Bengal Monitor	*Varanus bengalensis*	–	1	–	–	7	–	–	–
Bowring's Gecko	*Hemidactylus bowringii*	–	–	–	–	–	1	–	4
Bowring's Supple Skink	*Lygosoma bowringii*	–	–	–	–	–	–	2	–
Brook's House Gecko	*Hemidactylus brookii*	–	11	–	–	2	1	–	10
Checkered Keelback	*Xenochrophis piscator*	–	5	–	4	7	11	16	8
Common Garden Lizard	*Calotes versicolor*	–	3	–	–	18	–	2	8
Common House Gecko	*Hemidactylus frenatus*	1	7	13	1	15	17	28	40
Common Smooth Water Snake	*Enhydris enhydris*	–	–	–	–	–	–	1	–
Common Wolf Snake	*Lycodon aulicus*	–	–	–	–	1	–	–	1
Rat Snake	*Ptyas mucosa*	–	–	–	–	–	–	6	
Keeled Grass Skink	*Eutropis carinata*	1	1	–	–	–	1	–	2
Monocled Cobra	*Naja kaouthia*	–	1	–	–	–	–	–	–
Spectacled Cobra	*Naja naja*	–	6	–	–	3	–	–	6
Striped Keelback	*Amphiesma stolatum*	–	–	–	–	–	–	–	2
Striped Skink	*Eutropis dissimilis*	–	–	–	–	4	–	–	–
Tokay Gecko	*Gekko gecko*	3	1	–	–	–	–	–	–
White–spotted Supple Skink	*Lygosoma albopunctata*	–	–	–	–	1	–	–	–
Yellow Monitor	*Varanus flavescens*	–	1	–	–	1	–	–	–
Yellow–green House Gecko	*Hemidactylus flaviviridis*	–	18	5	14	16	22	24	31

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