Online: ISSN 2771-5868
Print: ISSN 2771-585X

Original Research Article

Inventory of Herpetofauna Species Assemblages and Distribution in Different Habitat Types of Manas National Park, Assam, India.

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Received: March 8, 2021; revised: August 1, 2021 accepted: August 22, 2021

https://doi.org/10.17605/OSF.IO/G37WC

Abstract: Manas National Park, the part of Eastern Himalayan biodiversity hotspot areas of Assam is supports diverse assemblages of herpeto-faunal species. Habitat-wise inventory of herpeto-faunal diversity in Manas National Park (MNP) was carried out from September 2018 through March 2021. The study mainly emphasized the total inventory of herpeto-faunal species assemblages and distribution patterns in different habitat types in MNP. Data was collected using standard protocols of active searching methods (ASM) and Visual encounter survey (VES) methods to find out the expected goal. The study encountered altogether 46 species and 222 individuals of herpetofauna belongs to 16 families. Of which, 19 species and 145 individuals were encountered from amphibian groups, 27 species and 77 individuals from reptilian groups (including lizards, snakes and chelonian species). Analysis of Shannon Weiner Index of diversity indicated highest diversity among amphibians and reptiles in the woodland habitat, whereas, agricultural land and wetland habitats recorded lowest diversity of herpetofauna. Among the reptiles, *Melanochelys tricarinata, Cyclemys gemeli, Varanus bengalensis, Varanus flavescens* and *Varanus salvator* were Schedule I of IWPA, 1972, whereas, the tortoise species *Indotestudo elongata* was critically endangered, and *Melanochelys tricarinata* and *Python bivittatus* were vulnerable species as per IUCN Red List category of threatened species. The present study has contributed to the total inventory and updating of herpetofauna diversity in Manas National Park that suggested the future conservation and management perspectives of both the species and habitats.

Key words: Herpetofauna diversity, Species assemblages, habitat-wise distributions, conservation, Manas national park

Introduction

The UNESCO designated world heritage site of Manas National Park (MNP) and Tiger Reserve (MTR) have located in the foothills of Eastern Himalayan biodiversity hot-spot areas harbours diverse assemblages of amphibians and reptilian fauna along with other most threatened and rare wildlife species since the British period (BNHS, 1934-36). Preliminary studies on herpetofauna were conducted in transboundary landscapes of Manas National Park, Assam and Royal Manas National Park (RMNP), Bhutan by Das *et al.* (2014) and another study by Ahmed and Das (2010) have also reported Turtlesand Tortoises from Manas National Park. In 2006, Tiwari *et al.* (2006) have documented the diversity

of herpetofauna in MTR in a book entitled "Faunal Diversity of Tiger Reserves in India". However, the amphibians and reptiles are supported as a major constituent component of the food chain in ecosystems and also acts as a bio-control agent on agroecosystem (Channing and Howell, 2006). The documented evidence showed that India harbors altogether 571 species of reptiles that includes 231 species of lizards, 303 species of snakes, and 34 species of turtles (Aengals *et al.*, 2018), whereas, out of 432 species of total recorded amphibians, 395 species are anurans, 35 species are Gymnophiona and two species are Salamanders (Dinesh *et al.*, 2019). Even then, there is a strong possibility to get more new species of herpetofauna within Indian landscapes, if we could carry out an extensive field survey in all the existing ecological pockets. Apart from that, the herpetofauna plays a critical role in ecosystem processes such as species diversity, trophic dynamics and ecosystem functioning and thereby promoting herpetofauna diversity in different habitats could contribute to the long-term ecosystem stability, resilience and resistance (Gibbon *et al.*, 2000). Till to date, the majority of the global herpetofauna species exists as either data deficient or not being evaluated, however many of the known amphibians and reptilian species are rapidly declining on a global scale (Gibbon *et al.*, 2000). The major habitat and environmental degradation, habitat fragmentation and alterations, along with human interferences have led to declining the herpetofauna populations' worldwide (Krishnamurthy, 1996). Adding to the alarmed caused by the gruesome deformities were observed, beginning in the late 1980s, of another disturbing trend: global amphibian populations seem to be in decline (Vie, 2009; Bowman *et al.,* 2017). By 1993, over 500 populations of frogs and salamanders from around the world were reported to be decreasing in size or under threat of extinction. In some cases, entire species were in danger across the globe, hundreds of species were extinct, missing or critically endangered. Since 1980 at least 24 amphibian species have become extinct. An additional 113 species have not been seen since that time and as listed as " Possibly extinct" (Vie, 2009).

Although the sporadic information of herpetofauna species lists is available for MNP, the pieces of informations have no scale data and habitat information, such data has less scientific value, especially at the global level. Thus, the habitat-wise inventory of herpetofauna diversity is essential in MNP for scientific documentation and future conservation action plan because of recent climate change. Again, it was also emphasized to observed the existence of any deformity of herpetofauna owing to widespread environmental degradation and anthropogenic disturbances. Thus, the present study has mainly focussed on the total inventory of species, their site-specific distribution, abundance and species-specific habitat used types in Manas National Park based on proper scientific design of data collection in the study area. The study also emphasized finding out the new occurence of previously undocumented species and monitoring the past documented species.

Materials and methods

Study area

The study area Manas National Park (MNP) and Manas Tiger Reserve (MTR) is located within the coordinates of 26°28'N to 26°49'N latitudes and 90°15'E to 90°49'E. longitude in the administrative boundaries of Chirang and Baska districts of Assam. The study area covers and ares of 950km^2 including new additions. The study area has divided into four different ranges such as Bhuyanpara (Eastern Range), Bansbari (Central Range), Panbari (Western Range) and the first new addition of Kuklung range (c350km^{2}area, added newly in the year 2016). The MNP shares its boundary with RMNP of Bhutan in north, and south by North Kamrup district. The southern boundary of the park is dominated by agricultural lands, whereas, the eastern and western boundary is surrounded by forest reserves. Several streams and tributaries of river Brahmaputra have criss-cros the MNP (See Fig. 1). The vegetation of the park mainly comprises of Sub-Himalayan high alluvial, Tropical semi-evergreen forests, Eastern Bhabhar type forests, East Himalaya moist mixed deciduous forests, Assam valley semi-evergreen forests and Eastern wet alluvial grassland (Champion and Seth, 1968). The climate of the study area

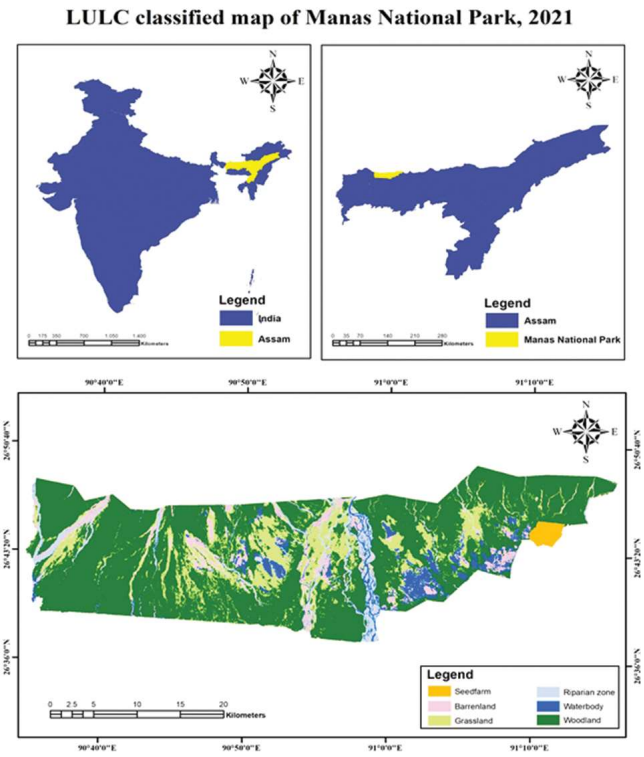

Fig. 1. LULC classified map of Manas National Park.

has experienced tropical climate with hot and humid and the relative humidity reaching up to 75% and mean temperature ranging from 5^0 to 37^0C **(FSI, 2011).** According to (Barthakur, 1986), the climate of Manas national park could be divided into four distinct seasons **viz**., pre-monsoon (March-May), monsoon (June to September), retreating monsoon (October to November) and winter (December to February). Rainfall starts from the month mid-March and lasts till end of October. During the study period the mean rainfall recorded was 3300cm and the months from November to February was found relatively dry and thus drying up most of the water exists in the study area.

Study methods

Study has been carried out from September, 2018 through March, 2021 in three different forest ranges of MNP **Viz.,** Bhuyanpara, Bansbari and Kuklung range. Data were collected using line transect methods (as per Jaeger, 1994) and Visual encounter survey (VES) and Active searching methods (ASM) were used as per Heyer *et al.* (1994). Prior to field survey, the entire study area has been stratified into five different habitat types using ArcGIS techniques (version 10.4) such as (a) Woodland habitat, (b) Grassland habitat, (c) Water bodies (or wetland habitat), and (d) Agricultural land as per the vegetation classification criteria based on Jain and Hajra (1975) and Champion & Seth (1968). In each stratified habitat, total of 20 randomly selected line transect with a length and width of 100m×1m respectively and altogether 100 line transects were established within the entire study area (for details of habitat and transect see Table -1).

Survey, data collection and data analysis

Field surveys for amphibian data collections were carried out during active periods of the day from early morning (from 06:00 to 08:00 hours) and evening (from 17:00 to 19:00 hours). Whereas, for data collection of snakes, lizards and chelonians both early morning mid-day evening and night time surveys were conducted as per the species concerns, because both diurnal, nocturnal and corpuscular species of reptiles are available in the habitats. For evening to night, the data were collected mostly from 17:00 to 20:00 hours, during daytime from 10:00 to 12:00 hours and 14:00 to 16:00 hours were used. Each line transect was surveyed for one hour and each transects surveyed twice from September, 2018 to March, 2021. A total of 250 field hours were devoted for data collection. Active searching turning rocks and logs, removal or stirring substratum, peeling bark, digging through leaf litter and excavating burrows and termite mounds were employed to find the herpeto-faunal species in the study area. On encounter with each individual of a species, photographs were taken and the locality, date, time, weather condition, their GPS locations were recorded in the field note book and the individuals were released back into the field after necessary observation and data collections. Also, road kill individuals and other threats found were recorded during surveys. GPS locations were taken using Garmin etrex 64 and photographs were taken using Canon Digital Camera 430x, Canon Digital camera 1200d. Identification of all the species were done using the taxonomic keys developed by Smith (1935 and 1943), Schleich & Kästle (2002), Das (1995), Dutta (1997), Das (2002) and Whitakar and Captain (2004).

Table 1. Major habitat types, habitat characteristics, sampling sites and transect designed of the study area.

Major Habitat (Land Use Land Cover Pattern)	Characteristics	Sampling sites	Area (%)	Transect No.
Woodland	Tropical semi evergreen forest: Semi-evergreen parches occur chiefly along the northern part of the sanctuary, on the India-Bhutan international boundary. The common trees in these forests are *Aphanumixis porlystnchyn, Anthroocephalus chinensis, Syzygium cumini, S. fornosum, S, oblaturn, S, fruticosa, Bauhinia sp.,* East Himalaya mixed moist deciduous forest: This is the common vegetation type in the sanctuary. The common trees here are *Bombex ceiba, Sterculia vitlosa, Dillenina indica, D. pentagyna, Careyo arborea, Terminalia bellirica, T. chebula, Gmelina arborea.*	c, v, k, l, r, w, so, t, v, j, p, n, q	66.26	20
Grassland	East wet alluvial grassland: Extensive patches of grasslands are found in the western part of the sanctuary. They also occur in open areas at other spats. The common grass species are *Apluda mutica, Brachiaria distuchya, Cynodon dactylon, Cyrtococcum accrescens, Digitaria ciliaris, D. longiflora, Impereta cylindrical, Saccharum procerum, S. Spontaneum.*	a, b, c, f, g, h, if, j, k, l, m, n	15.74	20
Water-bodies	It includes wetlands, swamps, marshes and river areas flooded by water seasonally or throughout the year. They are mainly dominated by emergent and submerging vegetation dominated by species such as such as *Ruppia spp., Eichornia crassipes, Potamogeton sp., Nymphaea spp.* and *Pistia sp.*		6.61	20
Riparian Zones	It is the transitional area between land and river or stream characterized by presence of stones, pebbles, rocks, sand dominated by herbs and grasses species like *Imperata cylindrica* and *Ageratum conyzoides.*	c, o, l, p, n, q, r	3.99	20
Agricultural areas	It includes rice fields, agricultural lands, home gardens and tea gardens with scattered shade trees dominated by species such as *Albizia spp* and *Acacia sp.* in the encroached areas, villages around the park boundary and also in the range offices	a, b, c, d,e	1.06	20

Abbreviations: a= Lwkhibazar; b= Sewali Camp; c = Teklai Camp; d= Seed Farm; e=Rubber Farm; f= Rupohi Camp; g= Makhibaha Camp; h= Plot.No.07 Gwnpuri; i= Matigaltab Grassland; j= Kodom Pukhuri Anti-Poaching Camp; k=Corphuli Camp; l= 5th Mile Road; m=Pohufield; n= Bura Buri Jharnala; o= Koklabari; p= 3rd Mile Road; q= Kuribeel; r= Panbari Jhar; s= Kalamati River; t= Agragnala; u= Rai Gajli; v= Bansbari-Mothanguri Road; w= Roisingla Tiniali; x= Roisingla Camp

All statistical analyses were done using Species Diversity and Richness Software (SDR-IV) version 4.1.2 and SPSS statistical software version 16.0 and bootstrap method was used to calculate 95% CL. Shannon-Weiner Diversity Index (H^1) was used to determine species diversity in each habitat (Ludwig and Reynolds, 1988). Pielou's Evenness Index (J/) was calculated to test the homogeneity or the pattern of distribution of species in relation to other species of the particular habitat sampled (Pielou, 1966). The t-test (Brower *et al.*, 1990) was used to test the differences in species diversity indices between different habitats. Preparation of map for the study area and the distribution map of the species was done using the software of ArcGIS (version 10.4). For status evaluation of Herpeto-faunal species, IUCN Red List (2019), Indian Wildlife (Protection) Act 1972 and Appendices of CITES (CITES, 2005) were referred.

Results

Study encountered altogether 46 species and 222 individuals of herpetofauna belonging to 16 families in MNP. Of which 19 species and 145 individuals were amphibians and 27 species and 77 individuals were reptiles. Of the total 27 species of reptiles, 13 species were lizards (three among were skink), 11 species were snakes, three species were chelonians. The amphibian fauna of MNP was represented by five families **viz.**, Bufonidae (4.82%), Dicroglossidae (63.44%), Ranidae

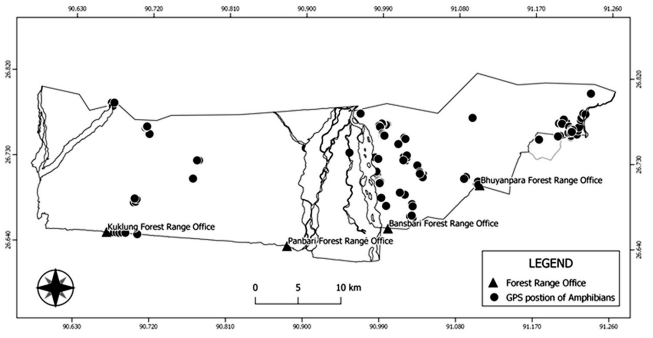

Fig. 2. Distribution of Amphibians in Manas National Park.

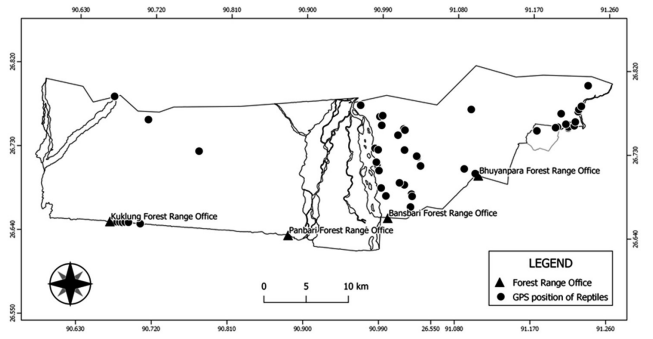

Fig. 3. Distribution of Reptiles in Manas National Park.

(9.65%), Rhacophoridae (12.41%) and Microhylidae (9.65%), whereas, reptilian fauna was represented by 11 families **viz**., Agamidae (19.48%), Gekkonidae (38.96%), Scincidae (9.09%), Varanidae (7.71%), Pythonidae (7.71%), Colubridae (7.71%), Elapidae (2.59%), Homalopsidae (1.29%), Testudinidae (1.29%), Geoemydidae (2.59%) and Typhlopidae (1.29%). Again, among amphibians, the family Dicroglossidae was the most dominant family with eight species, whereas, among reptiles, the family Gekkonidae was the most dominant family represented by six species. Study also revealed that, all the total 46 species of herpetofauna recorded so far in MNP, 11 species were newly sighted and not been documented prior to present study in the area. Those species were such as *Minervarya syhadrensis, Duttaphrynus stomaticus, Hemidactylus garnotii, Coelognathus helenus, Ptyas korros, Dendrelaphis sp., Oligodon sp., Bungarus lividus, Enhydris enhydris, Cyclemys gemeli* and *Varanus flavescens*.

IUCN Threatened and Endangered species

Among all the 46 species of herpeto-faunal species recorded in MNP, the species *Melanochelys tricarinata, Cyclemys gemeli, Varanus bengalensis, Varanus flavescens* and *Varanus salvator* were recorded as a Schedule -I species of Indian Wildlife Protection (Act) 1972, and the species *Xenochrophis piscator was* Schedule -II, whereas, 10 species were Schedule IV of IWPA 1972. Those species were such as *Haplobatrachus crassus, Haplobatrachus tigerinus, Ptyas korros, Rhabdophis subminiatus, Coelognathus helenus, Bungarus lividus, Bungurus fasciatus, Enhydris enhydris, Indotestudo elongata* and *Typhlops diardii.* Again, the species *Indotestudo elongata* was an IUCN Critically Endangered tortoise species found in the study area, whereas, the species *Melanochelys tricarinata* and *Python bivittatus* were categorized as Vulnerable species, 26 species were categorized as Least Concern of IUCN Red List category of Threatened Species.

Comparing the -different habitat, it was observed that the amphibians were highest, in grasslands with a mean average of 2.21±0.615SE individuals and in woodlands with 2.15±0.503SE, followed by riparian zones with 1.26±0.295SE individuals and water bodies with 1.10±0.433SE individuals. Amphibian individuals were observed lowest in the agricultural areas with 0.894±0.365SE individuals. Among reptiles, highest numbers of individuals were observed in woodlands with an average of 1.07±0.266SE individuals, followed by grasslands with 0.70±0.260SE individuals and riparian zones with 0.66±0.192SE individuals. Least number of reptilian individuals was observed in the agricultural areas and water bodies with a mean average of 0.25±0.101SE individuals and 0.14±0.069SE individuals respectively. Analysis of Shannon Weiner index of diversity in different habitats of the sampling sites showed that, diversity of amphibians was highest in woodlands (H'=2.418) and riparian zones (H'=2.369); and lowest in agricultural areas (H'=1.602) during the study period. Pielou's evenness index among amphibians showed highest values for riparian zones (J'=0.8909) and lowest for water bodies (J'= 0.5552). Again, the Shannon Weiner index of reptilian diversity in different habitats of the sampling sites was found to be highest in woodlands (H'=2.481) and found least in the water bodies (H'=1.386). Again, Evenness index of reptiles was found highest in water bodies (J'=1.000) as all the species recorded

Table 2. Comprehensive checklist of Herpetofauna species recorded and their individual encountered in five different habitat types of Manas National Park and their Threatened status.

	Individuals Encountered					Threatened Status	
Family/Species	**H1**	**H2**	**H3**	**H4**	**H5**	IWPA	IUCN
Dicroglossidae							
Euphlyctis cyanophlyctis	6	10	4	8	7	NL	LC
Haplobatrachus crassus	1	0	2	2	3	Sch IV	LC
Haplobatrachus tigerinus	0	4	2	1	3	Sch IV	LC
Minervarya teraiensis	3	7	2	3	3	NL	LC
Minervarya nepalensis	0	3	2	1	1	NL	LC
Minervarya pierrie	0	3	2	2	2	NL	LC
Minervarya sp.	0	0	0	1	0	N/A	N/A
*Minervary syhadrensis***	0	2	1	0	1	NL	LC
Ranidae							
Hydrophylax leptoglossa	0	3	4	1	5	NL	LC
Hylarana taipehensis	0	0	1	0	0	NL	LC
Microhylidae							
Microhyla mymensinghensis	1	1	2	1	6	NL	LC
Uperodon globulosus	2	1	0	0	0	NL	LC
Rhacophoridae							
Chiromantis vittatus	0	0	1	0	0	NL	LC
Polypedates cf. himalayensis	0	0	0	0	1	NL	NE
Polypedates sp.	0	0	0	0	1	N/A	N/A
Polypedates teraiensis	3	4	0	1	5	NL	LC
Rhacophorus maximus	0	2	0	0	0	NL	LC
Bufonidae							
Duttaphrynus melanostictus	1	2	1	0	2	NL	LC
*Duttaphrynus stomaticus***	0	0	0	0	1	NL	LC
Agamidae							
Calotes versicolor	2	5	4	1	3	NL	NE
Gekkonidae							
Gekko gekko	0	0	0	0	2	NL	LC
Hemidactylus brookii	0	1	2	0	3	NL	LC
Hemidactylus frenatus	1	5	2	1	5	NL	LC
*Hemidactylus garnotii***	0	0	2	1	0	NL	NE
Hemidactylus platyurus	0	0	2	0	2	NL	NE
Hemidactylus sp.	1	0	0	0	0	N/A	N/A
Scincidae							
Eutrophis macularia	1	0	1	0	1	NL	NE
Eutrophis multifasciata	0	2	0	0	0	NL	LC
Lygosoma albopunctata	0	1	1	0	0	NL	NE
Varanidae							
Varanus bengalensis	0	0	0	0	2	Sch I	LC
*Varanus flavescens***	0	1	0	0	2	Sch I	LC
Varanus salvator	0	0	1	0	0	Sch I	LC
Colubridae							
*Dendrelaphis sp.***	0	0	0	0	1	N/A	N/A
*Oligodon sp.***	0	1	0	0	0	N/A	N/A
*Ptyas korros***	0	0	0	0	1	Sch IV	NE

Xenochrophis piscator	0	0	0	0	1	Sch II	NE
Rhabdophis subminiatus	0	0	0	1	0	Sch IV	NE
*Coelognathus helenus***	0	0	1	0	0	Sch IV	NE
Elapidae							
*Bungarus lividus***	0	0	0	0	1	Sch IV	NE
Bungurus fasciatus	1	0	0	0	0	Sch IV	LC
Homalopsidae							
*Enhydris enhydris***	1	0	0	0	0	Sch IV	LC
Typhlopidae							
Typhlops diardii	0	0	0	0	1	Sch IV	LC
Pythonidae							
Python bivittatus	0	1	1	0	4	Sch I	VU
Testudinidae							
Indotestudo elongata	0	1	0	0	0	Sch IV	CE
Geoemydidae							
Melanochelys tricarinata	0	1	0	0	0	Sch I	VU
*Cyclemys gemeli***	0	0	1	0	0	Sch I	NE

Abbreviations: H1: Agricultural areas, H2: Grasslands, H3: Riparian zones, H4: Water-bodies, H5: Woodlands, NL: Not Listed; Sch I: Schedule I; Sch II: Schedule II; Sch IV: Schedule IV; CE: Critically Endangered; LC: Least Concern; NE: Not evaluated; VU: Vulnerable; IWPA: Indian Wildlife Protection Act 1972; N/A: Not Applicable to individuals identified up to genus level, **: Species newly added to MNP

Table 3. Analyses results of the Species diversity indices of Herpetofauna (Amphibians and Reptiles) using Shannon Wiener diversity Indices, and Evenness Indices in five different habitats studied in the study area of MNP from 2018 to 2021.

	Shannon (H')	Evenness (J')	Shannon (H')	Evenness (J')
Habitats	Amphibians		Reptiles	
Woodland	2.418	0.8015	2.413	0.8593
Grassland	2.267	0.8039	2.024	0.7572
Water-bodies	1.311	0.5552	1.099	1
Riaparian zone	2.369	0.8909	2.079	0.8889
Agricultural areas	1.602	0.8272	1.561	0.9524

in the habitat were encountered only once whereas, it was found lowest in the grasslands (Table 3).

A One-Way analysis of variance was conducted to compare the mean differences of herpeto-faunal species abundance scores in five different habitats of MNP. There was a statistically significant difference at the <0.05 level [$F_{4, 225}$ = 3.872, p = 0. 005]. Post hoc comparisons using LS.D test indicated that there was a significant difference between the mean abundance score in AG habitat (M= 0.52, SD=1.130) and grassland habitat (Mean= 1.33, SD= 2.119), P= .014 ; AG habitat (M= 0.52, SD=1.130) and woodland habitat (M= 1.52, SD= 1.823), P=.002; Grassland habitat (Mean= 1.33, SD= 2.119) and water bodies(M=0.54, SD= 1.312), P= .017; water bodies (M=0.54, SD= 1.312 and woodland habitat (M= 1.52, SD= 1.823), P=.003).

Discussion

The present study was undertaken to explore new potential additions of amphibians and reptiles to Manas National Park and their relative abundances in different habitats of the park. Compiling all the earlier studies and the present survey, Manas National Park has a total of 88 species of amphibians and reptiles recorded so far. The species *Minervarya syhadrensis, Duttaphrynus stomaticus, Hemidactylus garnotii, Coelognathus helenus, Ptyas korros, Dendrelaphis sp., Oligodon sp., Bungarus lividus, Enhydris enhydris, Cyclemys*

Fig. a. *Chiromantis vittatus.*

Fig. b. *Varanus flavescens.*

Fig. c. *Hylarana taipehensis.*

Fig. d. *Gecko gecko.*

Fig. e. *Rhacophorus smaragdinus.*

Fig. f. *Calotes versicolor.*

gemeli and *Varanus flavescens* recorded in this study were not described earlier in previous studies conducted by Das *et al.* (2014) and Tiwari *et al.* (2006). Although direct assessment cannot be made between the present and previous study because of differences in sampling effort and personnel, but record of amphibian and reptile species for the first time in this study could probably be because of significantly higher number of samplings in more study sites for a longer period of time compared to the previous surveys.

High diversity and abundance of amphibians were recorded from semi-evergreen, mixed moist deciduous forests and alluvial grasslands of Pohufield, Matigaltab, Rupohi camp, Koklabari, Bansbari-Mothanguri road and Makhibaha camp areas whereas, in the agricultural lands the herpeto-faunal abundance might be very less. In the present study, most majority of amphibians were encountered from moist microhabitats viz., tree holes, under rotten logs, leaf litter deposited areas and temporary water puddles inside dense

forests where the temperature is lower compared to open fields where temperature is comparatively higher. This could be the reason of low amphibian abundance in the crop fields and tea gardens outside the forest areas. Again, in tea- garden areas and some of the croplands, peoples are using pesticides and insecticides to reduce the pest species and thereby reduce the prey species of herpeto-fauna. Previous studies also suggest that amphibians have shown a preference for forest and grassland habitats over openly distributed agricultural habitat (Gibbs, 1998). The riparian zones of Teklai camp, Burha buri Jhar nala, Kuri-beel, Panbari Jhar were mostly dominated by common species like *Euphlyctis cyanophylictis* which were frequently seen floating on the surface of the water. Again, the amphibian abundance was reasonably less in the Manas Beki and Kalamati rivers of the study area which are fast flowing rivers unlike the other stagnant waters of the study areas because the amphibian species are not prefers these types of habitat as their regular feeding and breeding habitat. Gibbs (1993) also suggested that small wetlands are usually free of aquatic predators and thus provides a suitable breeding habitat particularly for the frogs and toads compared to fast flowing rivers. In case of lizards and snakes, more individuals were encountered from dense forested areas of Koklabari, 5th Mile Road, Roisingla tiniali, Bansbari-Mothanguri Road. During survey, it was observed that, most of the lizard species were adequately found inside tree barks or fallen tree logs associated microhabitats. Presence of leaf litter, tree twigs, and fallen logs highly influences the diversity of lizards in Manas National Park. This view of the microhabitat preferences of lizard species in MNP was also supported by Vitt and Zani (1996), who stated that lizard species were always associated with particular microhabitats which they prefers. Rais *et al*. (2015) in Pakistan also showed strong positive correlation of reptiles with hard substrate.

During the study period, many anthropogenic threats to amphibian and reptile fauna have been observed in the study area such as road-kills due to vehicular impact, alteration of habitats for road construction and human settlements, agricultural practices soil and water pollution and also consumption of many herpetofauna species as food by the local communities adjoining areas of the study sites. All these types of threat factors of herpetofauna were also reported by several authors in many regions (Vyas, 2007). Tokay gecko (*Gecko gecko*) is the most affected species of lizard when it comes to extensive illegal trading activity. This species is claimed to be used in the treatment of diabetics, asthma, skin diseases and even cancer and HIV/AIDS (Bauer, 2009). A carapace of critically endangered tortoise *Indotestudo elongata* was sighted in a village house. The snakes *Dendrelaphis sp*. and *Oligodon sp*. were found dead along roadside inside forest, *Enhydris enhydris* was found trapped in a fishing net. An individual of non-venomous snake checkered keelback (*Xenochrophis piscator*) was killed to death by villagers near the park. In most cases, non-venomous snakes were found to be the victims in the human-snake conflict, as most people couldn't distinguish between venomous and non-venomous snakes so people regularly killed those non-venomous snakes also along with venomous snakes. Apart from that, some of the Adivasi people resides in and around the protected areas are regularly consuming all the snakes as their protein sources and those cannot be avoided. A lack of proper knowledge and misguided and misperception regarding snakes, the snake populations are threatened worldwide in recent times (Pandey *et al*., 2016).

Road-kill is one of the major causes of wildlife species mortality and is of global conservation concern (Lala *et al*., 2021). The high incidences of road-kill sighted in the park reflects the present scenerio that people are less aware of the consequences of species reduction and the needs of conservation of species specially the herpetofauna and so awareness programme and training on the conservation issues should be imparted to vehicle drivers by governmental and non governmental organisations in and around the fringe villages of the park. Semi-aquatic ecosystem such as riparian areas, marshlands is one of the important breeding grounds of most amphibians and such zones are actively altered by anthropogenic activities such as irrigation, livestock watering. The high composition of amphibians and reptiles found along

the water-bodies and dense forests recommends that riparian zones and woodlands should be made a priority for herpeto-faunal conservation. This could be done by conserving the existing forests and promoting growth of new bushes and trees along the water-bodies of the national park. Given the complexity of Manas National Park, more broad and intensive research focusing on the impact and responses of herpetofauna to habitat fragmentation, alteration and deforestation as well as climate change is prerequisite to generate sustainable management and conservation plans for the future.

The record of 11 newly recorded Herpeto-faunal species from MNP in present study specifies possible more new records or even new species from many explored and unexplored areas within the park in near future. The presence or absence of particular herpeto-faunal species could form the basis of conservation and management recommendations. The results of this survey could be useful in baseline monitoring and evaluation of many species of herpetofauna to provide higher conservation and protection than their current status. This study was carried out in some particular areas of Manas National Park in the foothills of Eastern Himalayas thus it is sure that, present study represents fraction of actual herpeto-faunal assemblage and additional and in-depth study will reveal more unrecorded species from the park.

Acknowledgement

The authors are highly thankful to National Missions on Himalayan Studies & the MoEF & CC government of India for funding our research works in Manas National Park of Assam. The authors are highly acknowledged the Head, Department of Zoology, Gauhati University for providing necessary infrastructure facilities, space and equipment. The authors are also grateful to the Assam forest department & Assam state biodiversity board (ASBB) for timely provide us the approval and permission to carry out field surveys. The authors are highly appreciated all the forest officials and the NGO people for their necessary logistic supports during the fieldwork. Lastly, the authors are thankful to the other team members for their immense supports during the entire study period.

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