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HERPETOFAUNAL COMMUNITY COMPOSITION IN AN AGRO-ECOSYSTEM IN THE GANGETIC PLAIN OF EASTERN INDIA

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Abstract. The Gangetic plain of India is one of the most intensively farmed lands in the world. This study examined the species composition of the herpetofaunal community in Haripal, Hooghly, West Bengal, India, located within the Gangetic Delta's plain of eastern India. A total of 32 species (10 amphibians, 22 reptiles) belonging to 23 genera (7 amphibian, 16 reptile), 13 families (4 amphibian, 9 reptile), and two orders (1 amphibian, 1 reptile) were recorded. Among the amphibians, the highest number of species (5) was recorded in the family Dicroglossidae, while the Colubridae family was represented by a maximum of 7 species among the reptiles. All of the recorded species except *Varanus flavescens* (Hardwicke and Gray, 1827) are listed as Least Concern (LC) in the IUCN Red List. *Varanus flavescens* has been declared as Endangered (EN). Among the recorded species, one species is included in Schedule I, 6 species in Schedule II, and 13 species are listed in Schedule IV of the Indian Wildlife (Protection) Act, 1972. This report provides baseline data on herpetofaunal community composition in the Haripal block for the first time. The study area is rich in herpetofaunal diversity. This study also emphasises the necessity of holistic conservation strategies in the study area and the demand for additional studies to explore the country's biodiversity beyond the protected areas.

INTRODUCTION

Herpetofauna are one of the most vulnerable vertebrate taxa on earth (Gibbons et al. 2000; Collins and Storfer 2003). A total of 8425 amphibian species (Frost 2022) and 11690 reptile species are known all over the world (Uetz et al. 2021), of which 40.7% of all amphibians and 21.1% of all reptiles have become threatened with extinction (Cox et al. 2022). Amphibians and reptiles have been in the focus of intense research because of the variety of ecological, physiological, morphological, behavioural, and evolutionary patterns displayed (Vitt and Caldwell 2014). Since herpetofauna is represented by the only ectothermic terrestrial vertebrates, their biological and ecological requirements differ from those of other warm-blooded species (Goin and Goin 1971; Pough 1980; Bureau of Land Management 2022).

Healthy herpetofauna populations impact ecosystems in a variety of ways, such as through the interactions between predators and prey, energy flow, and nutrient cycling (Stebbins and Cohen 1995; Bureau of Land Management 2022). Since many herpetofaunal species rely on terrestrial and aquatic habitat types for various aspects of their life histories, changes to these areas could have an impact on their populations (Guzy et al. 2019; Youngquist and Boone 2021). They are good indicators of environmental health as well (Rabbe et al. 2022). Amphibians are well-known predators of a wide variety of insects, including agricultural pest species, on the one hand, and on the other hand, they are also considered food items for many reptiles, larger water birds, and mammals (Andrew 2021). Moreover, snakes help to reduce the population of rodents, insects, and small mammals as predators, which in turn helps in agriculture (Greene 2000; Beaupre and Douglas 2009). However, climate change, land transformation, forest fragmentation, habitat loss, wetland destruction, increased human population, urbanization, agricultural expansion, indiscriminate use of pesticides, and negative public perceptions all pose significant challenges to herpetofauna (Vitt and Caldwell 2014; Ghosh and Basu 2020; Eversole et al. 2021). Human-snake conflict and the ruthless killing of snakes are of growing concern all over the world. In the tropics and subtropics, snake biting is a neglected public health issue (WHO 2021). Each year, around 5.4 million snake bites occur around the world. In India, 1.2 million people died as a result of snakebites between 2000 and 2019 (Suraweera et al. 2020), with agricultural workers and children being at risk (WHO 2021).

With 2.4% of the world's land area, India possesses nearly 8% of the world's total biodiversity, making it one of the world's 17 mega diversity countries (Government of India 2014). India is home to 454 different amphibian species (Dinesh et al. 2021). According to the IUCN Red List, 20 species of amphibians are Critically Endangered, 36 species are Endangered, and 22 species are Vulnerable among the listed amphibian species (Dinesh et al. 2021). In India, 572 species of reptiles are reported, of which 6 species are Critically Endangered, 20 species are Endangered, and 28 species are in the Vulnerable category as per IUCN Red List status (Aengals et al. 2018). The state of West Bengal supports 49 amphibian species (Deuti 2021) and 148 reptilian species (Sanyal et al. 2012). West Bengal is an agrarian state and one of the most snake bite prevalent states in the country (Majumder et al. 2014). Agricultural lands beyond protected area and networks support a rich biodiversity, including herpetofauna, but it is often overlooked (Ghosh and Basu 2022). Several herpetologists have documented herpetofaunal assemblages in West Bengal (Sarkar 1984; Pal et al. 2012;

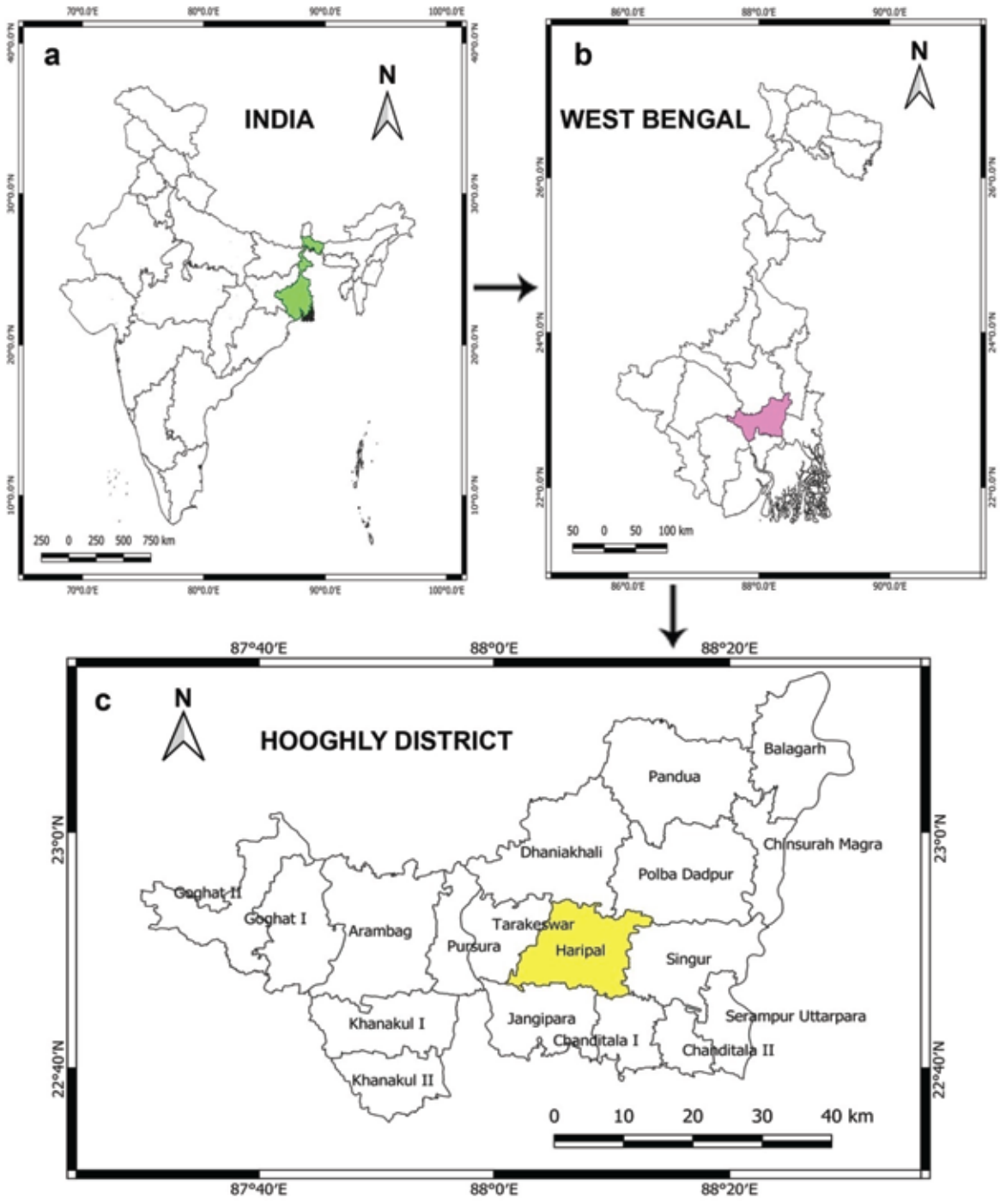

Figure 1. Location map of the study area: a: India, b: West Bengal, c: Haripal block within Hooghly district, W.B.

Deuti et al. 2017; Deuti 2021), but there is still a lack of studies on herpetofauna in the densely populated, agriculture-based fertile landscape of the Gangetic plain. Therefore, an attempt has been made to compile a list of species composition of herpetofauna found in the Haripal block, Hooghly, West Bengal, India, and to further study their relative abundance and diversity indices.

MATERIALS AND METHODS

Study Area

Haripal is a rural community development (CD) block with an area of 184.42 km^2 in the Chandannagore subdivision of the Hooghly district of West Bengal, India (Government of West Bengal 2022) (Figure 1**)**. The Haripal CD block is located in the Hooghly-Damodar Plain, one of the Gangetic Delta's flat alluvial plains (Census of India 2011). The entire area of the block is still covered with lush flora, agricultural fields, wetlands, and aquatic ecosystems apart from human settlements (Government of West Bengal 2022). Agriculture is the primary source of income in this area since paddy, potatoes and other vegetables are commonly cultivated here (Siddique and Mukherjee 2017). The climate of the district is characterised by an oppressive summer season, abundant rainfall, and high humidity throughout the year (Census of India 2011).

Sampling methods and data analyses

The study was conducted between November 2018 and November 2019. In addition to the visual encounter survey, direct searches were conducted in leaf litter, tree trunks, fallen and decaying logs, grass clumps, agricultural fields, roadside, damp soil, wetlands, ponds, and temporary rain puddles. Additionally, data obtained from opportunistic sightings, information from local peoples and road kill analyses were also used. Calls from amphibians were recorded. Skins from sloughed-off snakes were also collected for species identification. Photographs were taken in all the possible cases. Using standard literature (Smith 1935, 1943; Dutta 1997; Daniel 2002; Das 2002; Whitaker and Captain 2004; Frost 2022; Mathew and Sen 2010), the amphibians and reptiles found were recognised up to species level. More recent taxonomic literature (Ganesh et al. 2017; Garg et al. 2018; Gowande et al. 2021; Lajmi et al. 2016; Mallik et al. 2020; Paira and Ray 2022) was consulted and the species name followed accordingly. The conservation status was assessed using the IUCN Red List (IUCN 2022) and the Indian Wildlife (Protection) Act (1972). Based on the obtained data, rank abundance curves were created using Microsoft Office Excel 2010.

The Simpson's dominance index (Simpson 1949), Simpson's diversity index (Simpson 1949), Shannon index (Shannon and Weaver 1949), and evenness index (Pielou 1966) were calculated using PAST version 4.03 software (Hammer et al. 2001). QGIS 3.16 Hannover version was used to show the location map of the study area, whereas Microsoft Office Excel 2010 was used to construct a species accumulation curve.

RESULTS

Altogether, 32 species of herpetofauna belonging to 23 genera and 13 families were recorded during the study (Table 1). Figures 2, 3 and 4 show photographic records of the most common herpetofauna. Herpetofauna was dominated by reptiles (22 species), followed by amphibians (10 species). This comprises 10 species of amphibians belonging to 7 genera, 4 families and 1 order, while reptiles were represented by 22 species belonging to 16 genera, 9 families and 1 order (Table 1). Among the amphibians, the highest species diversity was recorded within the Dicroglossidae family (5 species), followed by Microhylidae (3 species), Bufonidae (1 species) and Rhacophoridae (1 species), as shown in Figure 5. *Hoplobatrachus*, *Euphlyctis*, and *Uperodon* were represented by two species, while the rest of the genera contained only one species (Table 1). Among the reptiles, the Colubridae family showed the highest diversity (7 species), followed by the Elapidae (4 species), Gekkonidae (3 species), Scincidae (2 species), Varanidae (2 species), while the remaining 5 families had one species each (Figure 6). Species diversity was the highest in the genus *Hemidactylus* (3 species), followed by *Varanus* (2 species), *Lycodon* (2 species), *Bungarus* (2 species), *Naja* (2 species), with one species for each of the remaining genera (Table 1).

Based on relative abundance (%), rank abundance curves were created both for amphibian (Figure 7) and reptilian species (Figure 8). *Duttaphrynus melanostictus*, *Hoplobatrachus tigerinus*, *Polypedates maculatus*, and *Minervarya agricola* among the amphibians (Figure 7), while *H. flaviviridis*, *H. frenatus*, *H. kushmorensis*, *Calotes vultuosus*, *Amphiesma stolatum*, *Lycodon aulicus*, *Fowlea piscator*, and *Ptyas mucosa* among the reptiles (Figure 8) were common in the study areas. The majority of the sightings occurred from June to September. A species accumulation curve is presented in Figure 9. Reptiles accounted for the majority of herpetofaunal diversity (68%) in the study area, followed by amphibians (32%). Again, snakes (45%) within reptiles and frogs (29%) within amphibians constituted the major herpetofaunal composition (Figure 10). Different diversity indices for herpetofauna in Haripal, Hooghly, W.B., India are presented in Table 2.

Table 1. Systematic list of herpetofauna observed in Haripal block, Hooghly District, W.B., India along with their conservation and legal status.

Sl no.	Taxa	Habitat	Spotting frequency	IUCN Red List	IWPA, 1972 Schedule
Amphibia					
	Order Anura				
	Family Bufonidae				
1.	*Duttaphrynus melanostictus* (Schneider, 1799)	T	+++++	LC	–
	Family Dicroglossidae				
2.	*Hoplobatrachus crassus* (Jerdon, 1853)	AQ, T	+++	LC	IV
3.	*Hoplobatrachus tigerinus* (Daudin, 1802)	AQ, T	++++	LC	IV
4.	*Euphlyctis cyanophlyctis* (Schneider, 1799)	AQ	+++	LC	IV
5.	*Euphlyctis hexadactylus* (Lesson, 1834)	AQ	+++	LC	IV
6.	*Minervarya agricola* (Jerdon, 1853)	T	++++	LC	IV
	Family Microhylidae				
7.	*Microhyla ornata* (Dumeril and Bibron, 1841)	T	++	LC	–
8.	*Uperodon taprobanicus* (Parker, 1934)	AR,T, F	++	LC	–
9.	*Uperodon globulosus* (Günther, 1864)	T, F	+++	LC	–
	Family Rhacophoridae				
10.	*Polypedates maculatus* (Gray, 1830)	AR	++++	LC	–
Reptilia					
Order Squamata					
	Family Agamidae				
11.	*Calotes vultuosus*(Harlan, 1825)	AR	++++	LC	–
	Family Gekkonidae				
12.	*Hemidactylus flaviviridis* (Rüppell, 1835)	AR	+++++	LC	–
13.	*Hemidactylus frenatus* (Duméril and Bibron, 1836)	AR	+++++	LC	–
14.	*Hemidactylus kushmorensis* (Murray, 1884)	AR	++++	LC	–
	Family Scincidae				
15.	*Eutropis carinata* (Schneider, 1801)	T	+++	LC	–
16.	*Riopa punctata* (Linnaeus, 1758)	T	+++	LC	–
	Family Varanidae				
17.	*Varanus flavescens* (Hardwicke & Gray, 1827)	AQ, T	++	EN	I (Part II)
18.	*Varanus salvator* (Laurenti, 1768)	AQ, T	++	LC	II (Part II)
	Family Homalopsidae				
19.	*Enhydris enhydris* (Schneider, 1799)	AQ	+++	LC	IV
	Family Colubridae				
20.	*Ahaetulla oxyrhynca* (Bell, 1825)	AR	++	LC	IV
21.	*Amphiesma stolatum* (Linnaeus, 1758)	T	++++	LC	IV
22.	*Dendrelaphis tristis* (Daudin, 1803)	AR	+	LC	IV
23.	*Lycodon aulicus* (Linnaeus, 1758)	T	++++	LC	IV
24.	*Lycodon striatus* (Shaw, 1802)	T	+++	LC	IV
25.	*Ptyas mucosa* (Linnaeus, 1758)	AR, T, F	++++	LC	II (Part II)
26.	*Fowlea piscator* (Schneider, 1799)	AQ	++++	LC	II (Part II)
	Family Elapidae				
27.	*Bungarus caeruleus* (Schneider, 1801)	T	++	LC	IV
28.	*Bungarus fasciatus* (Schneider, 1801)	T	++	LC	IV
29.	*Naja naja* (Linnaeus, 1758)	T	++	LC	II (Part II)
30.	*Naja kaouthia* (Lesson, 1831)	T	++	LC	II (Part II)
	Family Typhlopidae				
31.	*Indotyphlops braminus* (Daudin, 1803)	F	+++	LC	IV
	Family Viperidae				
32.	*Daboia russelii* (Shaw and Nodder, 1797)	T	+++	LC	II (Part II)

Habitat: T – terrestrial, AQ – aquatic, AR – arboreal, F – fossorial; spotting frequency: abundant (+++++), common (++++), occasional (+++), rare (++), very rare (+); IUCN Red List: EN – Endangered, LC – Least Concern; IWPA, 1972: Indian Wildlife (Protection) Act, 1972.

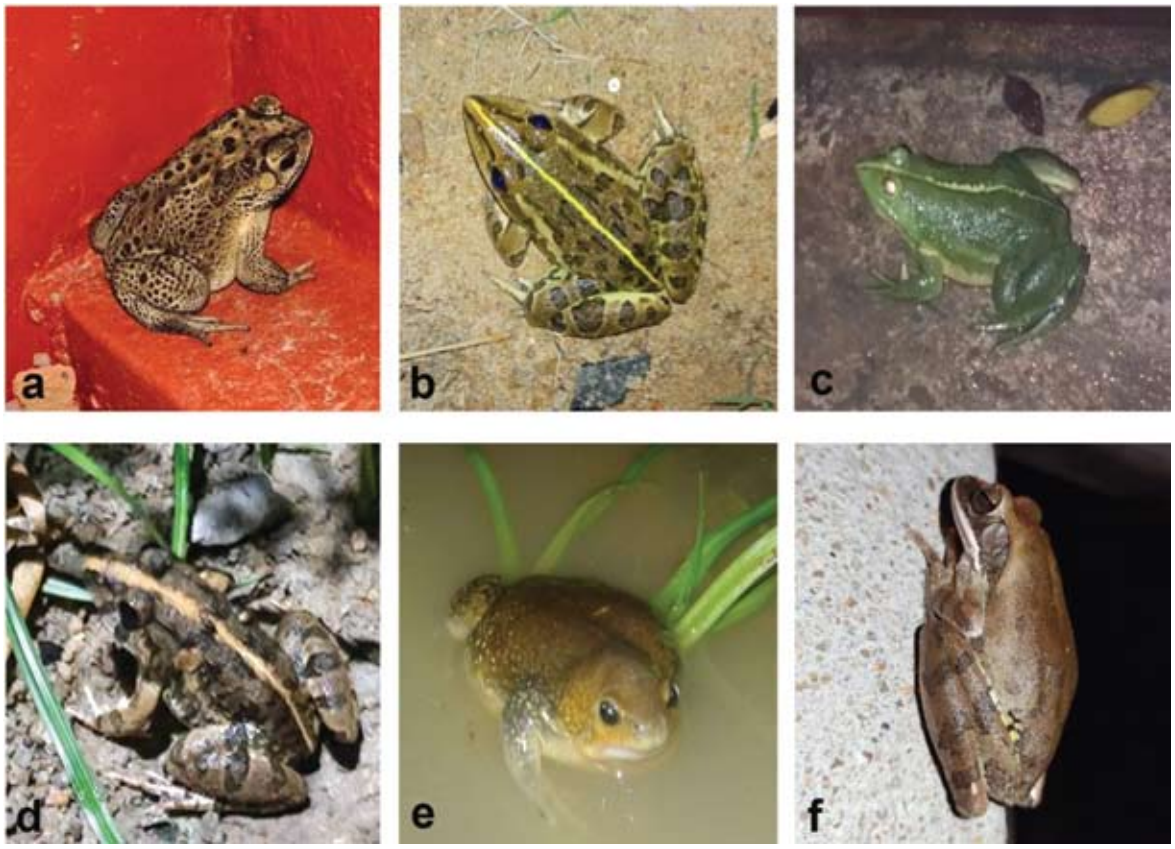

Figure 2. Photographs of some selected anurans of Haripal block, Hooghly, W.B.: a: *Duttaphrynus melanostictus,* b: *Hoplobatrachus tigerinus,* c: *Euphlyctis hexadactylus,* d: *Minervarya agricola,* e: *Uperodon globulosus,* f: *Polypedates maculatus*.

Figure 3. Photographs of some selected lizards and skink of Haripal block, Hooghly, W.B.: a: *Hemidactylus flaviviridis,* b: *Hemidactylus kushmorensis,* c: *Calotes vultuosus,* d: *Varanus flavescens,* e: *Varanus salvator,* f: *Eutropis carinata*.

Figure 4. Photographs of some selected snakes of Haripal block, Hooghly, W.B.: a: *Daboia russelii,* b: *Ptyas mucosa,* c: *Amphiesma stolatum,* d: *Fowlea piscator,* e: *Enhydris enhydris,* f: *Lycodon aulicus,* g: *Bungarus caeruleus,* h: *Ahaetulla oxyrhynca,* i: *Bungarus fasciatus*.

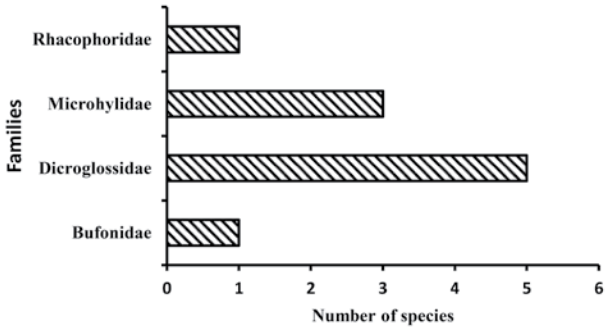

Figure 5. Family-wise distribution of amphibian species richness of Haripal block, Hooghly, W.B., India.

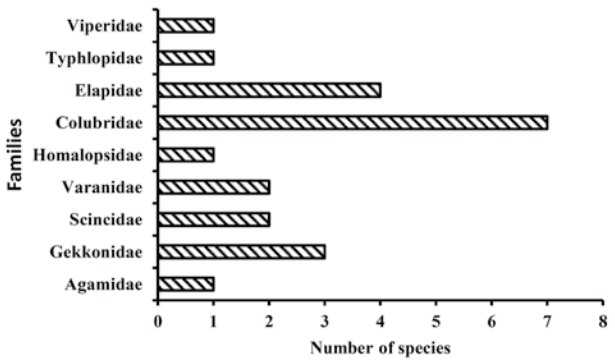

Figure 6. Family-wise distribution of reptilian species richness of Haripal block, Hooghly, W.B., India.

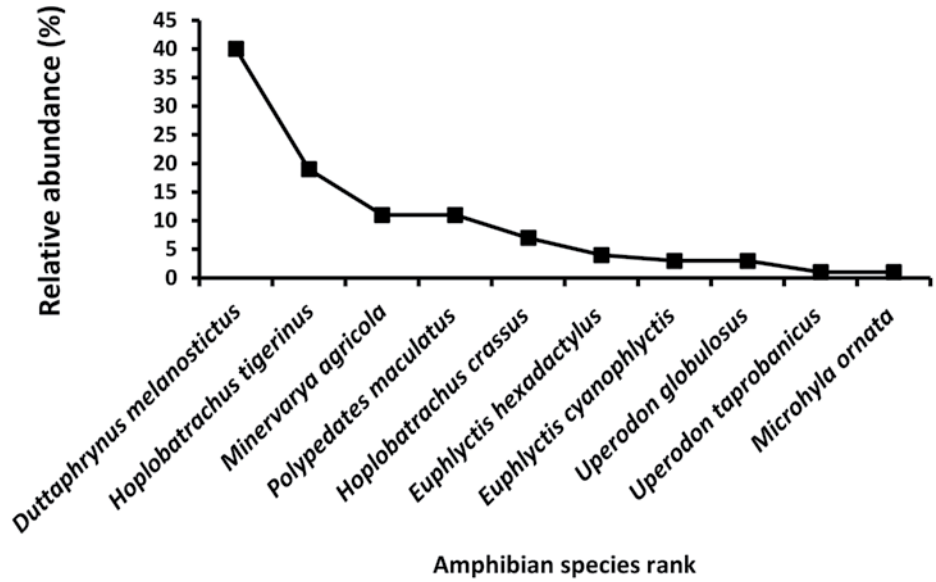

Figure 7. Rank abundance curve (Whittaker plot) of amphibian species of Haripal block, Hooghly, W.B., India.

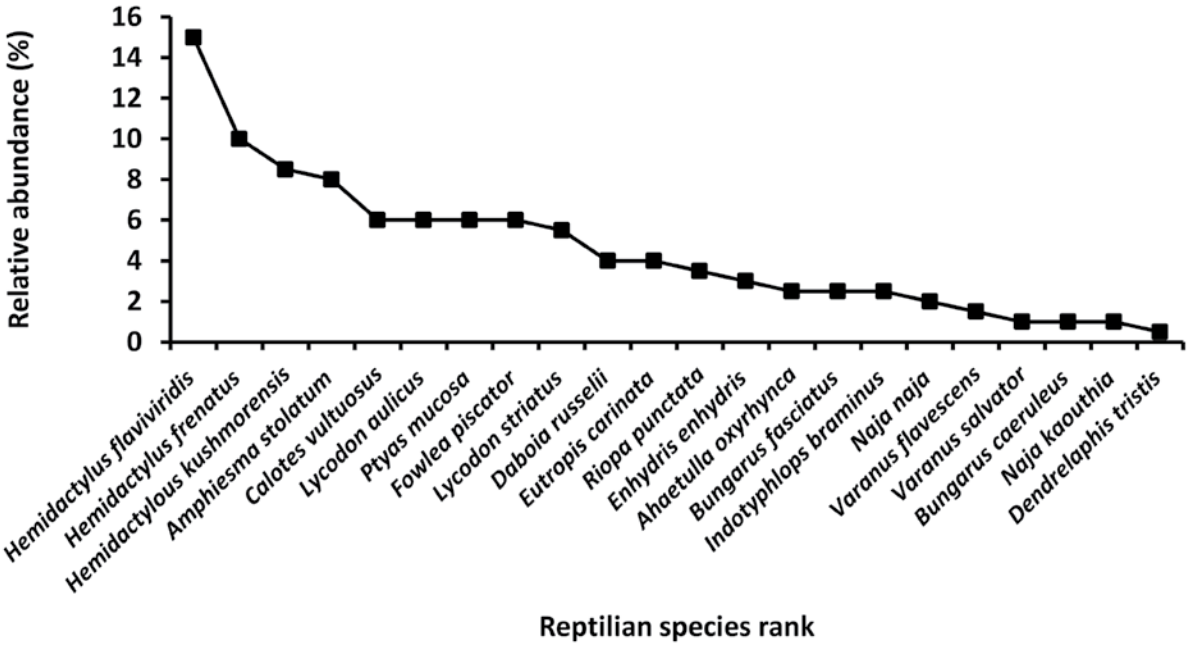

Figure 8. Rank abundance curve (Whittaker plot) of reptilian species of Haripal block, Hooghly, W.B., India.

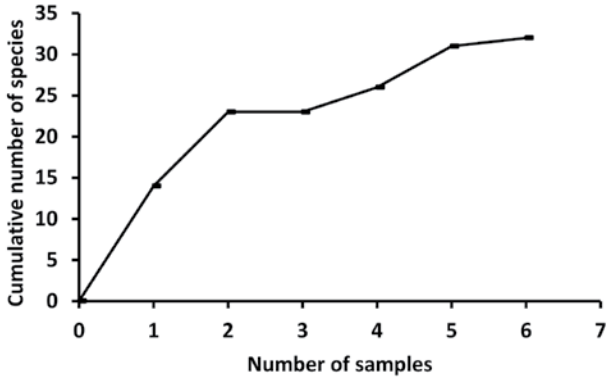

Figure 9. Species accumulation curve of Herpetofauna recorded in Haripal block, Hooghly, W.B., India.

Table 2. Diversity indices for amphibian and reptilian species in Haripal block, Hooghly District, W.B., India.

Diversity indices	Amphibia	Reptilia
Simpson's dominance index (D)	0.23	0.07
Simpson's diversity index (1–D)	0.77	0.93
Shannon index ($\overline{H}$)	1.8	2.79
Evenness index (J')	0.60	0.78

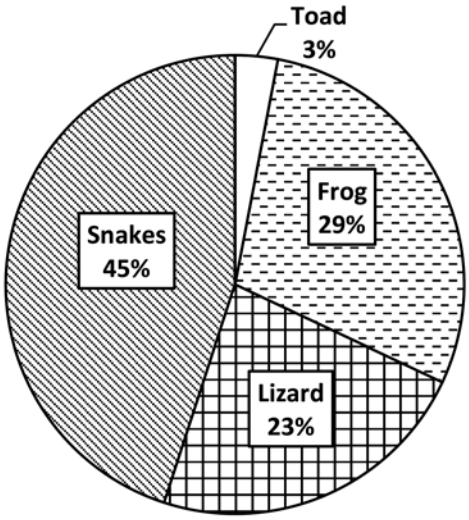

Figure 10. Herpetofaunal composition in the Haripal block, Hooghly, W.B., India.

DISCUSSION

The present study reports only 25% of the total amphibian species and 15% of the total reptilian species reported earlier from the state of West Bengal (Sanyal et al. 2012). However, it has significance since there has never been a comprehensive record of the herpetofauna in this rural area of Hooghly district, West Bengal. Besides, it is important to repeat such field studies or conduct them in newer places as additional species can be included in the herpetofaunal databases. It is also important to record changes in the sighting frequency of a region's herpetofauna.

The amphibian species reported in the present study have shared a close similarity with the records of Sarkar (1984) from the same Hooghly district for eight amphibian species: *Duttaphrynus melanostictus*, *Uperodon globulosus*, *Microhyla ornata*, *Euphlyctis cyanophlyctis*, *Euphlyctis hexadactylus*, *Hoplobatrachus tigerinus*, *Minervarya agricola*, *Polypedates maculatus*. Deuti et al. (2017) documented 21 amphibian species belonging to 15 genera and 5 families from the Duars, northern West Bengal, in which species richness was the highest in the Dicroglossidae family. In another study conducted by Pal et al. (2012), a total of 9 amphibian species and 24 reptilian species were recorded from the Durgapur industrial area, Paschim Bardhaman district, West Bengal, and shared 9 amphibian species and 18 reptilian species as common herpetofauna with the present study area. Dutta and Mukhopadhyay (2013) also reported 9 anuran amphibian species under 4 families from Durgapur, Paschim Bardhaman district, West Bengal. In the present study, the highest number of species was found in the family Dicroglossidae of amphibians and the family Colubroidea of reptiles. Sinha et al. (2021) supported this observation. More than two-thirds of snake species are members of the Colubroidea (Vitt and Cladwell 2014). Reptilian diversity was observed more in the study area than amphibian diversity, which closely matched the findings of Sinha et al. (2021). This is likely due to reptiles' superior adaptability, higher tolerance for seasonal variation, ability to survive for long periods of time on dry land, viviparous nature, and complete lung-breathing.

However, loss of habitat, indiscriminate use of pesticide in agriculture, pollution, climate change, intentional killing, road kills, etc. are the major threats to herpetofauna as observed during the tenure of the study. Similarly, Pal et al. (2012) pointed out anthropogenic impacts, invasive species, and climate change as the contributing factors to the fast loss of herpetofauna populations and ranges around the world. Dutta et al. (2016) also blamed road-kill as a major factor behind the considerable herpetofaunal casualties. An impact assessment of each of the individual factors may yield ideas for fruitful conservation policies to secure the future of herpetofauna. So far as the present study is concerned, all the recorded herpetofauna are classified as Least Concern (LC) by the IUCN Red List, with the exception of *Varanus flavescens* (Hardwicke and Gray, 1827), which is classified as Endangered (EN). Freshwater frogs (*Rana* spp.) are protected under Schedule IV of the Wildlife Protection Act (1972). *Varanus flavescens* (Hardwicke and Grey, 1827) is protected under Schedule I, while Schedule II (Part II) protects *Varanus salvator* (Laurenti, 1768), *Ptyas mucosa* (Linnaeus, 1758), *Fowlea piscator* (Schneider, 1799), *Naja naja* (Linnaeus, 1758), *Naja kaouthia* (Lesson, 1831), and *Daboia russelii* (Shaw and Nodder, 1797); Schedule IV protects *Ahaetulla nasuta* (Lacépède, 1789), *Amphiesma stolatum* (Linnaeus, 1758), *Dendrelaphis tristis* (Daudin, 1803), *Lycodon aulicus* (Linnaeus, 1758), *Lycodon striatus* (Shaw, 1802), *Bungarus caeruleus* (Schneider, 1801), *Bungarus fasciatus* (Schneider, 1801), *Indotyphlops braminus* (Daudin, 1803), and *Enhydris enhydris* (Schneider, 1799). Among the recorded species, *Hoplobatrachus tigerinus* (Daudin, 1802) and *Euphlyctis hexadactylus* (Lesson, 1834) come under Appendices II; *Varanus flavescens* (Hardwicke and Grey, 1827) comes under Appendices I; *Varanus salvator* (Laurenti, 1768), *Ptyas mucosa* (Linnaeus, 1758), *Naja naja* (Linnaeus, 1758) and *Naja kaouthia* (Lesson, 1831) come under Appendices II; *Fowlea piscator* (Schneider, 1799), and *Daboia russelii* (Shaw and Nodder, 1797) come under Appendices III of CITES (2021).

Based on the Shannon index: 1.8 (Amphibia) and 2.79 (Reptiles), and Pielou's evenness index: 0.60 (Amphibia) and 0.78 (Reptiles) it can be stated that the study area holds a rich herpetofaunal species diversity and shows evenness. The Shannon index (1.8), Simpson's

dominance index (0.22), and evenness index (0.60) in the present study are close to the diversity indices as calculated by Dutta and Mukhopadhyay (2013) for amphibian species in Durgapur, Paschim Bardhaman, West Bengal: Shannon index: 1.31–1.93, Simpson's dominance index: 0.16–0.28, and evenness index: 0.81–0.93.

CONCLUSION

In the present study, a total of 32 species of herpetofauna belonging to 23 genera, 13 families, and two orders were recorded. This is the first attempt to document the species composition and diversity of reptiles and amphibians found in an agro-ecosystem in the Gangetic plain (Haripal, Hooghly, West Bengal, India). The results showed that the area has a rich herpetofaunal diversity. Heightened community awareness and their active participation may be required for conservation and mitigation of negative interactions between humans and the herpetofauna of this area. However, further systematic and intense field studies may add a few more species to the database of this area.

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DECLARATIONS

There is no conflict of interest. No funding was received for this study. No animals were captured or harmed for this study.

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