

DIVERSITY OF WATER BUGS (HEMIPTERA) OVER DIFFERENT LANDSCAPES IN SOME PROVINCES OF NORTHERN VIETNAM

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Received 4 August 2023; accepted 25 September 2023

ABSTRACT

The studies involving water bugs (Hemiptera) biodiversity and ecology are very few and have mainly focused on taxonomy. We conducted research and evaluation of diversity indexes of water bugs (Hemiptera) in different landscapes including forest habitats, agricultural lands, ponds, streams from 16 sampling sites in Bac Kan, Lao Cai, Ninh Binh and Ha Tinh provinces. As a result, a total of 43 species of 23 genera of 10 families were recorded. The Shannon index (H'), the Simpson index (1-D), the Berger-Parker index of dominance, the Margalef index and the Fisher alpha index did not differ much between study sites. The evenness of water bugs (Hemiptera) was divided into 4 different main groups for 16 sampling sites. The Shannon index (H'), Simpson (1-D) index, species richness and individual rarefaction in forest habitats are higher than in agricultural land. However, the species richness was no different in ponds and streams.

Keywords: Water bugs, Hemiptera, diversity index, forest, agricultural lands, pond, stream.

Citation: Phan Thi Giang, Nguyen Quang Cuong, Nguyen Thanh Manh, Nguyen Thi Hanh, Nguyen Thi Thanh, Truong Xuan Lam, 2023. Diversity of water bugs (Hemiptera) over different landscapes in some provinces of Northern Vietnam. *Academia Journal of Biology*, 45(3): 111–124. <https://doi.org/10.15625/2615-9023/18621>

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INTRODUCTION

Freshwater habitats occupy 1% of the earth's surface (Strayer & Dudgeon, 2010), and in addition to supporting many species of freshwater ecosystems provide goods and services of critical importance to human society. The research on water bugs (Hemiptera) was started by the studies of Damgaard (2008), Cheng et al. (2001), Chen et al. (2008), is comprised of 23 families and more than 5,000 species of 350 genera, making it the most diverse group of hemimetabolous insects (Henry, 2009). Water bugs of the order Hemiptera are an integral part of food webs and nutrient cycles in freshwater ecosystems, and they are essential components of the diets of fish, amphibians, and many birds, and mammals (Morse, 2017) and their abundance and responses to changes in their environment make water bugs key indicators for monitoring the effects of human activity on water quality (Adu & Oyeniya, 2019), and they are widely used for freshwater ecosystem monitoring (Souto et al., 2019). Despite the low number of studies on the water bugs (Hemiptera) diversity, the influence of environmental cycles on water bugs' ecology has been relatively well studied such as The seasonal peaks in water bugs (Hemiptera) activity vary depending on the region (Anu et al., 2009), and high precipitations have been found to favour water bugs activity (Silva & Fiuza, 2000). The study evaluates a pond's influences on assemblages of aquatic Hemiptera in artificial ponds situated near Lake Steinhude in Lower Saxony (Germany), recorded 40 species of aquatic Hemiptera found in most of the ponds. The species of the families Corixidae and Notonectidae (Hemiptera) acted as pioneer species in new ponds and old ponds. The results of Canonical Correspondence Analyses (CCA) showed that among the key factors affecting the community structure of the species of the families Corixidae and Notonectidae (Hemiptera) were land, vegetation cover, insecticide, and the age of the ponds. The distribution of adjacent ponds in areas with different land uses has a positive

influence on the diversity and abundance of the aquatic Hemiptera fauna (Armin et al., 2010). The study was conducted in an 85-km stretch of the river Ganga from Brijghat to Narora in Uttar Pradesh a total of 29 species of aquatic insects were recorded, including three species of Coleoptera belonging to two families, four species of Hemiptera belonging to four families, and 22 species of Odonata belonging to three families at 14 sampling sites. The Shannon diversity index, Pielou's evenness index (J'), and Berger-Parker index of dominance were recorded. The family Gerridae was dominant in >92 % of sampling sites, and Notonectidae in >28 % of sampling sites (De et al., 2021). Renato et al. (2019) evaluated the relationship between Hemiptera diversity and habitat type, elevation, and forest size in the Neotropical rainforest, Los Tuxtlas showed that the Hemiptera species richness and abundance were significantly higher in forests than in pasturelands. The greater Hemiptera diversity observed in the forest was likely the result of more than half of the species observed in these habitats.

In Vietnam, the studies involving water bugs (Hemiptera) biodiversity and ecology are incipient in tropical ecosystems and have mainly focused on taxonomy. For example, the faunistic data on water bugs from the urban area of Ha Noi has been catalogued with a total of 23 species of 12 genera and nine families of aquatic bugs (Nepomorpha) and semi-aquatic bugs (Gerromorpha) from the studied area. The water bug fauna in Ha Noi is a typical lowland fauna in Southeast Asia mainland, comprising many species with wide distribution (Tran Anh Duc et al., 2010). The field survey conducted in selected streams in Ha Giang province has yielded a total of 44 species of water bugs (Hemiptera), belonging to 32 genera of 16 families (Tran Anh Duc et al., 2016). The investigation on aquatic insect diversity was conducted in a tropical stream in Southeast Asia with a reference stream in Northeast Asia showed that the numbers of aquatic insect taxa in Dak Pri stream in Vietnam (268 species, 230 genera, 91 families, and 9 orders) were about twice those in the

Gapyeong stream in Korea (133 species, 98 genera, 51 families, and 8 orders). The species diversity indices of the Dak Pri stream were higher than those of the Gapyeong stream, whereas the dominance indices of the Dak Pri stream were lower than those of the Gapyeong stream (Duc & Yeon, 2006). The study on the diversity of water insects (Hemiptera) was conducted in Ninh Binh province, Bac Kan province and Lao Cai province. At the study sites in Ninh Binh, Bac Kan, Gia Lai provinces, 30 species water bugs (Hemiptera) of 25 genera in 10 families were recorded; the Margalef index (d) in Ninh Binh, Bac Kan has rich diversity, Gia Lai has normal diversity; Shannon–Weiner index (H') in Ninh Binh has medium diversity, Bac Kan has medium diversity and Gia Lai has low diversity (Lam et al., 2022; Tran et al., 2022).

From field surveys in some provinces of northern Vietnam, we collected specimens, identified species, and analyzed diversity indexes in different landscapes of water bugs (Hemiptera) in forests, agricultural lands, ponds, streams.

MATERIALS AND METHODS

Water bugs surveys

The study was conducted at 16 sampling points in Bac Kan, Lao Cai, Ninh Binh, and Ha Tinh (between 18°09'28'' - 22°24'16''N and 105°51'40''- 108°30'56''E). The sites were forest habitats (tropical rainforest, secondary forest or high mountain forest) surrounded by agricultural lands (rice fields, low shrubs and weeds, or friculture fields,...). The middle elevations are between 408 m and 1,850 m (Table 1).

Table 1. Sampling sites in Northern Vietnam

Sampling site	Site name	Elevation (m)	Vegetation type	Coordinates	Habitat
NB1	Van Long, Gia Vien, Ninh Binh province	879	Agricultural lands	22°36'39''N; 105°54'40''E	Stream
NB2	Van Long, Gia Vien, Ninh Binh province	791	Agricultural lands	20°36'63''N; 105°88'01''E	Pond
NB3	Cuc Phuong National Park, Ninh Binh province	879	Tropical rainforest	22°36'38''N; 105°54'40''E	Stream
NB4	Cuc Phuong National Park, Ninh Binh province	899	Secondary forest	22°61'04''N; 105°93'32''E	Stream
BK1	Bac Ngoi village, Ba Be, Bac Kan province	408	Agricultural lands	22°28'87''N; 105°63'82''E	Pond
BK2	Nam Xuan Lac Nature Reserve, Bac Kan province	501	Agricultural lands	22°24'16''–22°27'43''N; 105°22'34''– 105°32'24''E	Stream
BK3	Nam Xuan Lac Nature Reserve, Bac Kan province	612	Tropical rainforest	22°17'12''–22°19'45''N; 105°28'31''– 105°33'20''E	Stream
BK4	Ba Be National Park, Bac Kan province	521	Secondary forest	22°45'57''N; 105°67'72''E	Stream
LC1	Bat Xat district, Lao Cai province	1050	Agricultural lands	108°30'21''E; 21°28'35''N	Pond

Sampling site	Site name	Elevation (m)	Vegetation type	Coordinates	Habitat
LC2	Bat Xat district, Lao Cai province	1780	High mountain forest	108°30'28''E; 21°28'41''N	Stream
LC3	Bat Xat district, Lao Cai province	1850	High mountain forest	108°35'45''E; 21°22'67''N	Stream
LC4	Bat Xat district, Lao Cai province	1650	High mountain forest	108°35'56''E; 21°22'82''N	Pond
VQ1	Vu Quang National Park, Ha Tinh province	618	Secondary forest	18°33'28''N; 550 105°16'–105°15'E	Pond
VQ 2	Vu Quang National Park, Ha Tinh province	853	Tropical rainforest	18°09'–21°26'N; 105°16'–105°33'E	Stream
VQ 3	Vu Quang National Park, Ha Tinh	850	Secondary forest	18°09'–21°26'N; 105°16'–105°33'E	Stream
VQ 4	Vu Quang National Park, Ha Tinh province	550	Tropical rainforest	18°09'–21°26'N; 105°16'–105°33'E	Stream

The water bugs were sampled in May, June, and November 2021; January, and September 2022; January, August, and September 2023. During this period, each pond and stream was sampled seven times. Sampling was carried out between 10 am and 6 pm, using a pond net (180 cm long extension rod, mesh size 0.5 mm). For each sampling point, the pond net was swept about 10 times through the water, so that different vegetational units, substrates, the banks of ponds, streams, and water areas were covered. All samples were preserved in 70% ethanol and brought to the laboratory for further analysis. They were later identified at the species level using a stereo-zoom microscope a Nikon SMZ 800N Digital Stereo Microscope, using Helicon Focus 7 software. The nomenclature of water bugs by the authors includes Andersen et al. (2002), Jansson (1986), Bal & Basu (1994), Schuh & Slater (1995), Berend et al. (2013), Lanna et al. (2001), Zettel et al. (2012), Zettel & Lane (2011), Lansbury (1968), Lansbury (1972), Polhemus & Polhemus (1998).

Data analysis

Biodiversity indexes including Shannon–Weiner index (H'), Simpson ($1-D$), Pielou's evenness (J'), Margalef, Fisher-alpha and dominance Berger–Parker (d) were calculated using the software Fast 4.03. The dominant status of the water bugs was calculated according to Engelmann's scale (1978).

RESULTS

The diversity of water bugs (Hemiptera) in sampling sites

We recorded a total number of 769 individuals of water bugs (Hemiptera) representing 43 species of 23 genera of 10 families (Appendix 1). The most diverse hemipteran families were Gerridae with 8 species (266 individuals), Nepidae with 8 species (92), followed by Notonectidae with 6 species (105), Naucoridae with 6 species (78), Belostomatidae 4 species (93), Micronectidae 4 species (47), other families Corixidae (45), Aphelocheiridae (20), Hydrometridae (23) and Ochteridae (103) have 1–3 species. A total of 43 species of water bugs (Hemiptera) were

recorded on 16 sampling points in Northern Vietnam as Bac Kan, Lao Cai, Ninh Binh, and Ha Tinh province. The species *Enithares sinica* (Stål, 1854) was recorded in 10 sampling sites.

Four species were recorded in 8 sampling sites: *Agraptocorixa* sp., *Nychia sappho* Stål, 1859, *Gerris lacustris* (Linnaeus, 1758), *Hydrometra albolineata* (Scott, 1874).

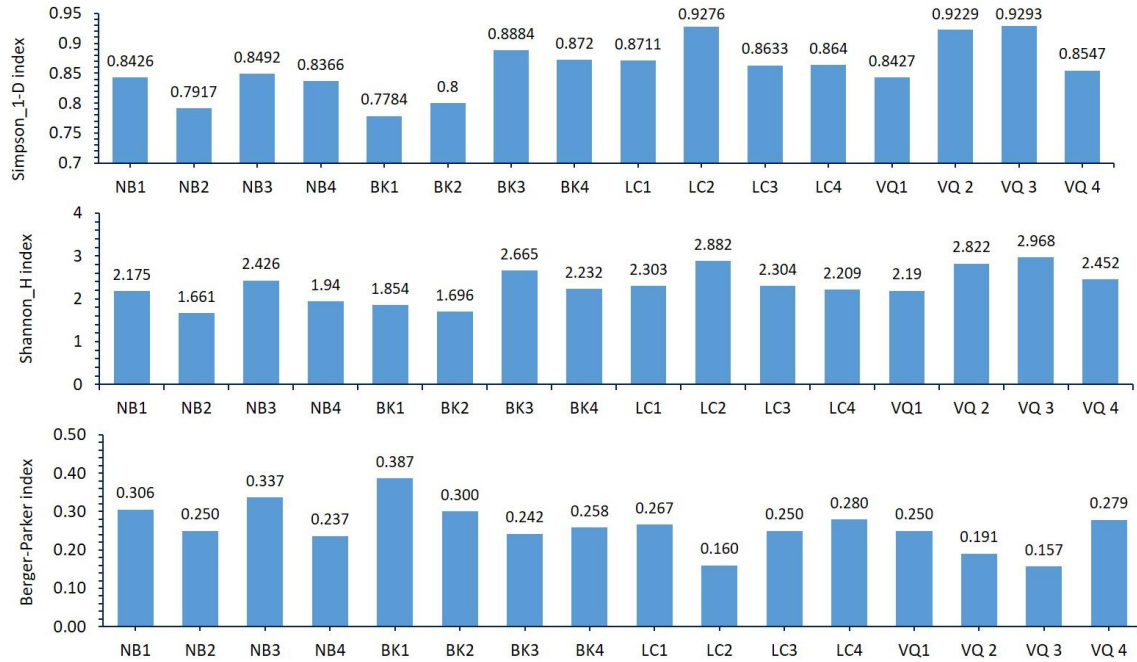


Figure 1. Variation of Simpson_1-D index, Shannon diversity index and Berger-Parker index in different sites (NB1–VQ4) of four provinces of Northern Vietnam (NB- Ninh Binh province; BK- Bac Kan province; LC- Lao Cai province; VQ- Ha Tinh province; 1–4: Sampling sites)

The Shannon–Weiner index (H') ranged from 1.661 (at NB2) to 2.968 (at VQ3) (mean = 2.267, SD = 0.099); The Shannon index (H') were high diversity at VQ3 (2.968), LC2 (2.882), were average diversity at BK3 (2.665), NB3 (2.426). The Simpson index (1-D) ranged from 0.778 (at BK1) to 0.929 (at VQ3) (mean = 0.959, SD = 0.011); The Simpson index (1-D) were high diversity at VQ3 (0.929), VQ2 (0.923), LC2 (0.928), were average diversity at VQ4 (0.855), VQ1 (0.843), LC3 (0.863), LC4 (0.864), BK4 (0.872), BK3 (0.888), BK2 (0.8), NB1 (0.842), NB3 (0.849), NB4 (0.837), and Berger-Parker index of dominance (d) ranged from 0.157 (VQ3) to 0.337 (NB3) (mean = 0.254, SD = 0.014). Variation of the Shannon diversity index (H'), Simpson index (1-D), and Berger-Parker index of dominance (d) are given in Figure 1.

At 16 sampling points in Bac Kan, Lao Cai, Ninh Binh, and Ha Tinh provinces of Northern Vietnam, the Margalef index and Fisher_alpha index are the measures of the species abundance. Margalef index ranges from 2.012 (at NB2) to 6.11 (at VQ3). The Fisher alpha index ranged from 3.725 (at NB4) to 16.71 (at VQ3). The sampling points have high species abundance as VQ3, VQ2, LC2, BK3. The sampling points have average species abundance as NB3, and low species abundance were NB1, NB2, NB4, BK1, BK2, BK4, LC1, LC3, LC4 (Fig. 2).

Evenness distance (Evenness index) in different sites (NB1– VQ4) at 16 sampling points in Bac Kan, Lao Cai, Ninh Binh, and Ha Tinh provinces in Figure 3. At 16 sampling points, the Evenness index of species was divided into 4 different main groups, including

main group 1 (BK1, LC3, VQ3 and NB1), main group 2 (NB3, VQ4, BK3 and VQ1), main group 3 (NB4, LC1, LC2, BK4, LC4 and VQ2) and main group 4 (BK2, NB2) (Fig. 3). The main group 1 was divided into 3 different groups, including BK1 (Pond -Agricultural lands), LC3 (Stream) and NB1 & VQ3 (Stream). The main group 2 was divided into 2 different groups, including NB3 & VQ4

(Stream) and BK3 & VQ1 (Stream and pond in the forest). The main group 3 was divided into 4 different groups, including NB4 & LC1 (Stream and pond in Agricultural lands and forest), LC2 (Stream), BK4 & VQ1 (Stream and pond in the forest) and VQ2 (Stream). The main group 4 was divided into 2 different groups, including BK2 (Agricultural lands) and NB2 (Agricultural lands).

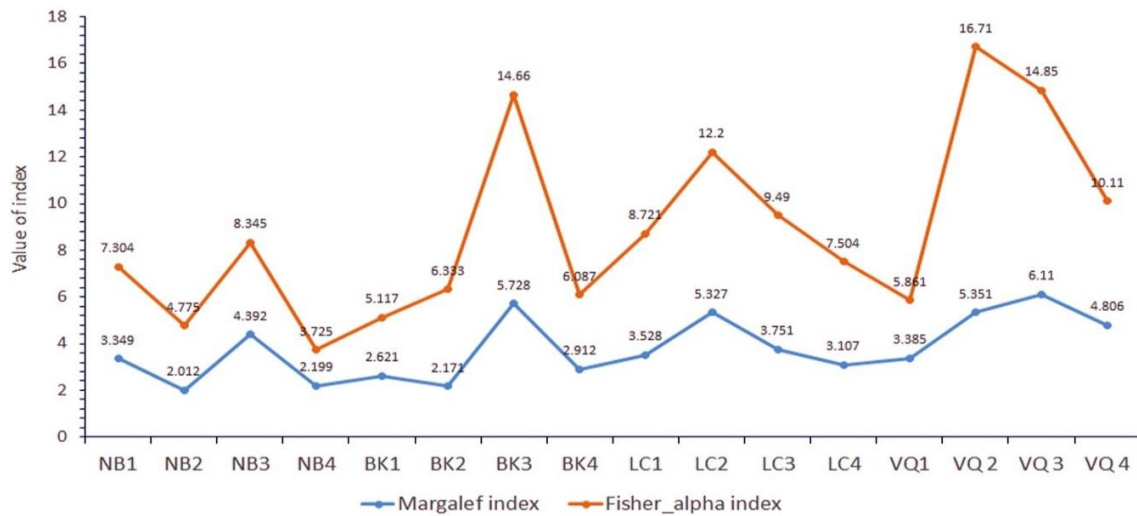


Figure 2. Variation of Margalef index and Fisher alpha index in different sites (NB1–VQ4) in 4 provinces of Northern Vietnam (NB- Ninh Binh province; BK- Bac Kan province; LC- Lao Cai province; VQ- Ha Tinh province; 1–4: Sampling sites)

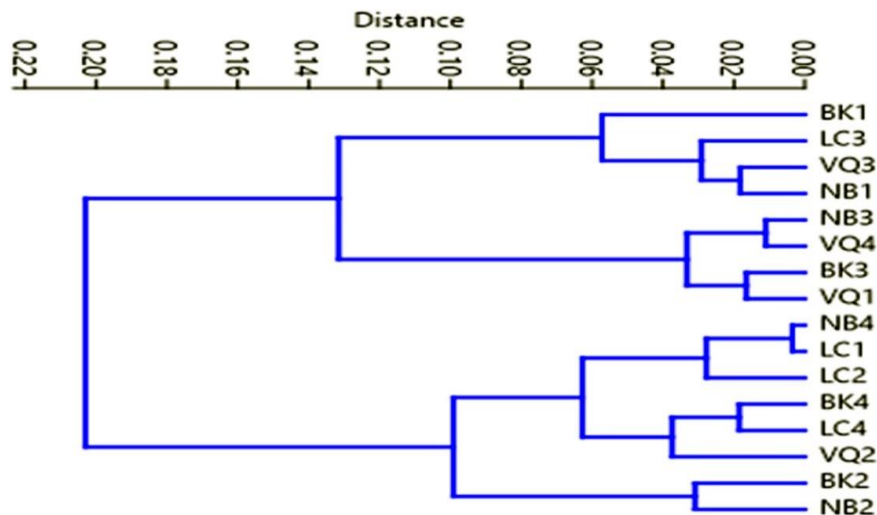


Figure 3. Evenness distance (Evenness index) in different sites (NB1– VQ4) in 4 provinces of Northern Vietnam (NB- Ninh Binh province; BK- Bac Kan province; LC- Lao Cai province; VQ- Ha Tinh province; 1–4: Sampling sites)

The diversity of water bugs (Hemiptera) in different landscapes

In sampling sites of agricultural lands and forests, we recorded 19 species (agricultural lands) and 33 species (forest habitats). The hemipteran families with the highest number of species (number of individuals) in forest habitats were Gerridae with 7 species (240), Notonectidae with 5 species (90) and other families with 1–4 species (15–81). In sampling sites of agricultural lands, the families of Hemiptera with the low number of species

(number of individuals) were Notonectidae, Nepidae, Gerridae with 3 species (9, 11, 26 respectively). On the pond and stream, we recorded 26 species on the pond and 31 species on the streams. The families with the highest number of species (number of individuals) were Gerridae with 7 species (147), Notonectidae with 5 species (77) (streams) and Gerridae with 5 species (119) (ponds). The families of Hemiptera with the low number of species (number of individuals) on the ponds have 1–3 species (9–52) (Fig. 4).

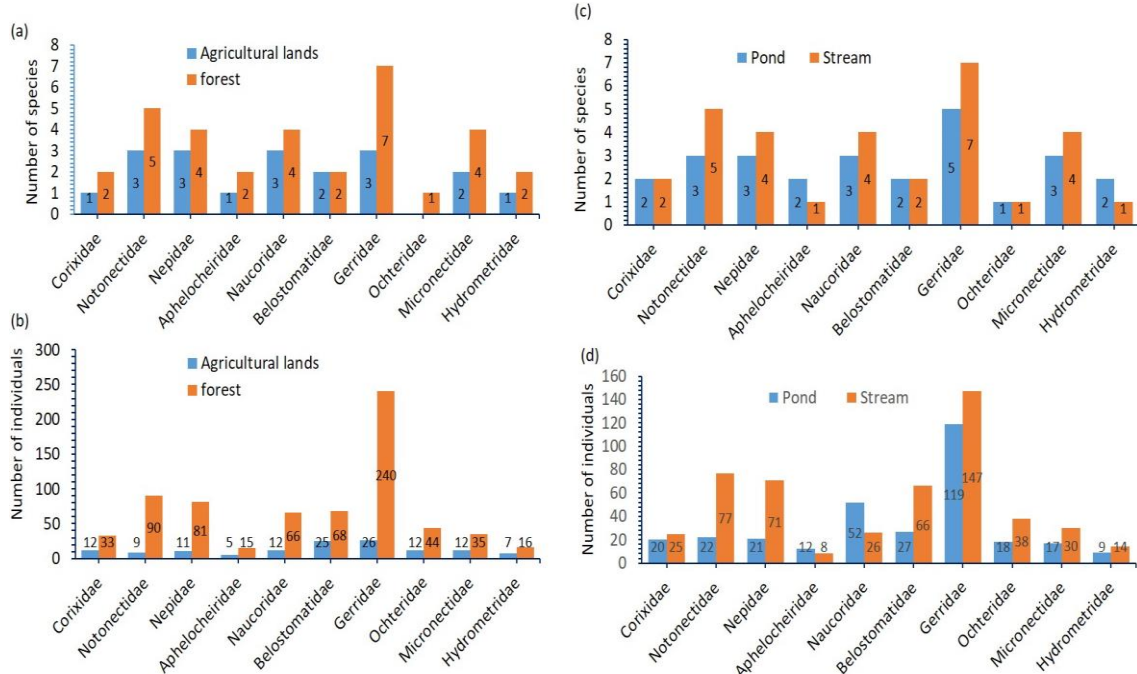


Figure 4. The number of species and individuals of water bugs (Hemiptera) in families were recorded in agricultural lands, forest habitats, ponds and streams in 4 provinces of Northern Vietnam (a, c. The number of species; b, d. The number of individuals)

The diversity index of water bugs (Hemiptera) in agricultural lands, forest habitats, ponds and streams are shown in Appendix 2. The Shannon diversity index (H') was 3.425 (forest), 2.879 (Agricultural land), 3.462 (stream) and 2.845 (pond). The Simpson (1-D) index ranged from 0.829 to 0.975. The Berger-Parker index of dominance (d) was 0.094 (forest), 0.158 (Agricultural land), 0.106 (stream) and 0.186 (pond) (Appendix 2). The species richness of water

bugs (Hemiptera) was significantly higher in forest habitats than in agricultural lands (Fig. 5a). However, this species richness was no different in ponds and streams (Fig. 5c). In addition, individual rarefaction of water bugs (Hemiptera) was significantly higher in forest habitats and streams than in the agricultural lands and ponds (Figs. 5b, d).

33 species were collected in forest habitats and 19 were collected in agricultural lands

including *Enithares sinica* (Stål, 1854), *Nychia sappho* Stål, 1859, *Gerris lacustris* (Linnaeus, 1758), *Aquarius paludum* (Fabricius, 1794) were the dominant species in forest habitats, while *Diplonychus rusticus* (Fabricius, 1781), *Aquarius paludum* (Fabricius, 1794) were dominant in the agricultural lands. Four species (*Nychia*

sappho Stål, 1859, *Diplonychus rusticus* (Fabricius, 1781), *Gerris lacustris* (Linnaeus, 1758), *Aquarius paludum* (Fabricius, 1794)) were dominant in streams, and four species (*Iliocoris* sp., *Diplonychus rusticus* (Fabricius, 1781), *Aquarius paludum* (Fabricius, 1794), *Eotrechus vietnamensis* Tra & Yan, 2006) were the dominant in ponds.

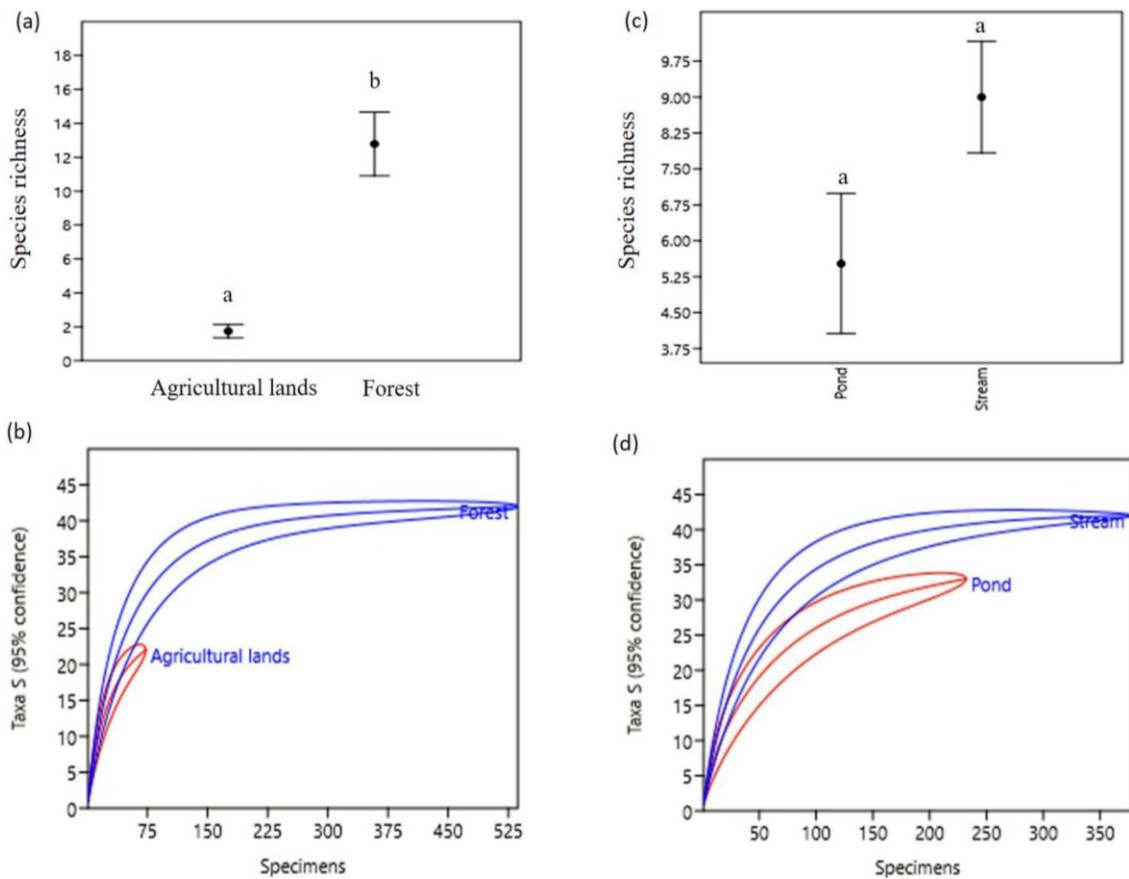


Figure 5. Species richness and individual rarefaction of water bugs (Hemiptera) in agricultural lands and forest habitats, ponds and streams in northern Vietnam (mean \pm 95% confidence intervals). Different letters indicate significant differences (a, c. species richness; b, d. individual rarefaction)

DISCUSSION

If a habitat becomes polluted or altered, tolerant species of water bugs (Hemiptera) will thrive and sensitive ones will move to a more suitable habitat (Medina et al., 2007), because insects can move from unfavourable habitats to favourable ones. The natural process or anthropogenic impacts can shape

invertebrate communities of water bugs (Hemiptera), and they exhibit differential tolerance to changes in environmental conditions (Adu & Oyeniya, 2019).

In this study, 43 species of 23 genera of 10 families were recorded at 16 sampling points in Bac Kan, Lao Cai, Ninh Binh, and Ha Tinh provinces of Northern Vietnam

different from the study of Tran Anh Duc et al. (2010, 2016) when research on the streams in Ha Noi city and Ha Giang province were recorded 31 species, lower than the survey on Dak Pri stream in Dak Lak province with 69 species of 13 families (Duc & Yeon, 2006). Furthermore, in this study 43 species recorded in Bac Kan, Lao Cai, Ninh Binh and Ha Tinh provinces (including 6 new species recorded at the study site) were higher than recorded by Lam et al. (2022) and Tran et al. (2022) about 30 species in Ninh Binh, Bac Kan and Lao Cai.

In Bac Kan, Lao Cai, Ninh Binh, and Ha Tinh provinces the Shannon index (H'), the Simpson index (1-D), the Berger-Parker index of dominance, the Margalef index and the Fisher alpha index did not differ much between sampling sites, probably because of uniform geomorphological features of the area, as geomorphological heterogeneity plays a major role in determining species richness (Nichols et al., 1998).

In sampling sites of agricultural lands and forests, the heteropteran families with the high number of species (number of individuals) were Gerridae, Notonectidae. This result is also consistent with the study of De et al. (2021) on the river Ganga from Brijghat to Narora in Uttar Pradesh. In sampling sites of agricultural lands and forests, the heteropteran families with the high number of species (number of individuals) were Gerridae, Notonectidae. This result is also consistent with the study of De et al. (2021) on the river Ganga from Brijghat to Narora in Uttar Pradesh.

The number of species of water bugs in agricultural land (19 species) is lower than in forest habitats (33 species). One of the reasons for the decrease in the number of species (number of individuals) of water bugs (Hemiptera) in agricultural ecosystems is the face of different threats such as waste, pesticides, discharge, treatment, wastewater, agricultural runoff, fishing and riverbank erosion in agricultural ecosystems. The diversity index of water bugs (Hemiptera) in forest habitats and streams is always higher

than that in agricultural lands and ponds in Bac Kan, Lao Cai, Ninh Binh, and Ha Tinh provinces. This result is also consistent with the study of Renato et al. (2019) evaluated the relationship between Hemiptera diversity and habitat type in the Neotropical rainforest, Los Tuxtlas, which showed that the Hemiptera species richness and abundance in forests were significantly higher than in pasturelands.

CONCLUSION

At 16 sampling points in Bac Kan, Lao Cai, Ninh Binh, and Ha Tinh province a total of 769 individuals of water bugs (Hemiptera) were recorded, representing 43 species of 23 genera of 10 families. The Hemipteran families with the highest number of species (number of individuals) were Gerridae, Nepidae, and Notonectidae. The Shannon-Weiner index (H'), the Simpson index (1-D), the Berger-Parker index of dominance, the Margalef index, and the Fisher_alpha index did not differ much between study sites. At sampling points, the Evenness index of species was divided into 4 different groups including main group 1 (BK1, LC3, VQ3 and NB1), main group 2 (NB3, VQ4, BK3 and VQ1), main group 3 (NB4, LC1, LC2, BK4, LC4 and VQ2) and main group 4 (BK2, NB2).

The Shannon index (H'), Simpson (1-D) index, the species richness were higher in forest habitat than in agricultural land. However, this species richness was no different in ponds and streams. The individual rarefaction of water bugs (Hemiptera) was significantly higher in forest habitats, streams than in agricultural lands, ponds.

Acknowledgements: This research was supported by a grant from the Vietnam Academy of Science and Technology (NVCC 09.03/23–23) for the senior researcher, Truong Xuan Lam.

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Appendix 1. List and number individuals of water bugs (Hemiptera) in different sampling sites of four provinces of Northern Vietnam

No.	Sampling sites	The number individuals															
		Ninh Binh				Bac Kan				Lao Cai				Ha Tinh			
		NB1	NB2	NB3	NB4	BK1	BK2	BK3	BK4	LC1	LC2	LC3	LC4	VQ1	VQ2	VQ3	VQ4
I	Family Corixidae																
1.	<i>Agraptocorixa</i> sp.		1			2		1			2		1		2	3	1
2.	<i>Sigara distorta</i> (Distant, 1910)	5						6		4				1		2	
3.	<i>Sigara</i> sp.			5					3				2		1		3
II	Family Notonectidae																
4.	<i>Enithares sinica</i> (Stål, 1854)		3	2			2		3		4	1	2	2		1	3
5.	<i>Anisops breddini</i> Kirkaldy, 1901			8				1							2	4	
6.	<i>Anisops</i> sp.						2		1		2	1	2	2	1	1	3
7.	<i>Nychia sappho</i> Stål, 1859	1		2			1		3		12	2		3		1	
8.	<i>Notonecta</i> sp.1				1						8					2	1
9.	<i>Notonecta</i> sp.2			1							7				1		
III	Family Nepidae																
10.	<i>Cercotmetus asiaticus</i> Amy. & Ser., 1843			1				1						1			2
11.	<i>Ranatra gracilis</i> Dallas, 1850	1				2			3	1			1		2	13	
12.	<i>Ranatra varipes</i> Stal, 1861							1				2			1	9	1
13.	<i>Ranatra</i> sp.1			4							3			4		6	
14.	<i>Ranatra</i> sp.2			3						1	2				8		
15.	<i>Laccotrephes pfeifferiae</i> (Ferrari, 1888)					1		1			3		2				
16.	<i>Laccotrephes longicaudatus</i> Nie., Zet. & Che., 2009		3				1			1					1		
17.	<i>Laccotrephes</i> sp.			4				2									

No.	Sampling sites	The number individuals															
		Ninh Binh				Bac Kan				Lao Cai				Ha Tinh			
		NB1	NB2	NB3	NB4	BK1	BK2	BK3	BK4	LC1	LC2	LC3	LC4	VQ1	VQ2	VQ3	VQ4
IV	Family Aphelocheiridae																
18	<i>Aphelocheirus femoratus</i> Polhemus & Polhemus, 1988	2						1			1					2	1
19	<i>Aphelocheirus</i> sp.									3			3		4		3
V	Family Naucoridae																
20	<i>Ctenipocoris asiaticus</i> Montandon, 1897							2		2		2	1			2	
21	<i>Gestroiella limnocoroides</i> Mont.1897							1			1				1		1
22	<i>Gestroiella</i> sp.											1				1	
23	<i>Naucoris scutellaris</i> Stal, 1860			1				1		1		1			1		2
24	<i>Heleocoris strabus</i> Montandon, 1897	2				2		4			2			1	2	1	
25	<i>Iliocoris</i> sp.	2			2					3			7	10			18
VI	Family Belostomatidae																
26	<i>Diplonychus rusticus</i> (Fabricius, 1781)	11		32		12		11	3		1				2		1
27	<i>Diplonychus</i> sp.											7				6	
28	<i>Lethocerus indicus</i> (Serville, 1825)	1				1			2		1				1		1
VII	Family Gerridae																
29	<i>Gerris lacustris</i> (Linnaeus, 1758)			5	7	7		5	8		6			7		9	
30	<i>Gerris</i> sp.			5	7											3	
31	<i>Amemboa intermedia</i> Zettel & Chen, 1996	1		4	5			1		2	5	8		6	1	2	
32	<i>Aquarius paludum</i> (Fabricius, 1794)	6		11				16		8		2		21		1	
33	<i>Eotrechus vietnamensis</i> Tra. & Yan., 2006			1	9			2			4			2		1	2
34	<i>Limnogonus fossarum</i> (Fabricius, 1775)				1	1		1	2	1				1		2	3
35	<i>Metrocoris acutus</i> Chen & Nieser, 1993			1				2			2	1			2		2
36	<i>Ptilomera</i> sp.							1			2		2			2	5

No.	Sampling sites	The number individuals															
		Ninh Binh				Bac Kan				Lao Cai				Ha Tinh			
		NB1	NB2	NB3	NB4	BK1	BK2	BK3	BK4	LC1	LC2	LC3	LC4	VQ1	VQ2	VQ3	VQ4
VIII	Family Ochteridae																
37	<i>Ochterus marginatus</i> (Latreille, 1804)				1				2		1				3	1	1
IX	Family Micronectidae																
38	<i>Micronecta quadristrigata</i> Breddin, 1905	1		1				1		1	1				1	2	
39	<i>Micronecta ludibunda</i> Breddin, 1905		1	1			1	1			2	2		1	2	1	
40	<i>Micronecta scutellaris</i> (Stål, 1868)		3	1	5			1			2			1		1	2
41	<i>Micronecta tarsalis</i> Chen, 1960	2				1		1		2		1		2		2	
X	Family Hydrometridae																
42	<i>Hydrometra albolineata</i> (Scott, 1874)	1		2			3	1			1	1			3		2
43	<i>Hydrometra annamana</i> Hunger & Evans, 1934		1			2			1				2			2	1

Note: NB- Ninh Binh province; BK- Bac Kan province; LC- Lao Cai province; VQ- Ha Tinh province; 1-4: Sampling sites.

Appendix 2. The diversity index of water bugs (Hemiptera) in agricultural lands, forest habitats, ponds and streams

Index	Agricultural lands	Forest habitats	Pond	Stream
Taxa_N	23	41	33	42
Individuals	76	543	232	378
Dominance (D)	0.070	0.044	0.092	0.040
Simpson (1-D)	0.829	0.975	0.867	0.959
Shannon (H')	2.879	3.425	2.845	3.462
Evenness_e^H/S	0.774	0.715	0.521	0.759
Margalef	5.081	6.678	5.875	6.908
Fisher_alpha	11.21	10.96	10.52	12.09
Berger-Parker	0.158	0.094	0.186	0.106