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Diversity of Water Beetles (Coleoptera) Over Different Habitats in Some Provinces in Vietnam

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ABSTRACT: We conducted research on diversity indexes in different habitats of the water beetles (Coleoptera) in forest habitats, agricultural landscapes, and freshwater habitats including ponds and streams from 20 sample collection locations in Bac Kan, Lao Cai, Cao Bang, Ninh Binh and Ha Tinh provinces. Research results show that a total of 35 species belonging to 23 genera of 4 families of water beetles (Coleoptera) have been recorded. The Shannon_H index, Simpson (1-D) index, and Berger-Parker index differed among studied provinces and were highest in Lao Cai province and the lowest in Bac Kan province. The Dominance_D, Simpson_1-D, Shannon_H, Evenness_e^H/S, Brillouin, Menhinick, Margalef, Equitability_J, Fisher_alpha, Berger-Parker, Chao-1 index also differed among at 20 sample collection locations from NB1 to VQ4. The evenness of the water beetles (Coleoptera) was divided into 4 different main groups for 20 sample collection locations. The Shannon_H index, Simpson (1-D) index, species richness and individual rarefaction were higher in forest habitats than in agricultural landscapes. However, this species richness was no different in freshwater habitats including ponds and streams.

Keywords: Water beetles, Coleoptera, diversity index, forest habitats, agricultural landscapes, freshwater habitats, pond, stream.

INTRODUCTION

Freshwater habitats cover 1% of the Earth's surface and, in addition to supporting many aquatic insect species, provide foods and services of vital importance to human societies (Strayer & Dudgeon 2010; Khaghani et al., 2022). The water beetles (Coleoptera), although living in water in abroad array of habitats, also migrate back to terrestrial environments as adults, larvae, or both. This ecological variability, together with the iterative processes, has made water beetles a leading study group for their relevance to dispersal, ecological speciation, and diversification. The characteristics of water beetle indicators are richness and diversity of species, and easy fragility to small environmental changes. The water beetles are very important parts of any biotic component of any water wetlands. They are indicators of ecological diversity and habitat characteristics (Khaghani et al., 2022).

Worldwide, there are an estimated 18,000 water beetles (Coleoptera) species, belonging to about 30 families, and at least 50% of total species are considered to be entirely aquatic. These families include the Dytiscidae with nearly 4,000 described species of more than 5,000 estimated species, the Hydrophilidae with 1,800

described species of nearly 2,500 estimated species, and the Gyrinidae with 750 described species of more than 1,000 estimated species. The Oriental region with approximately 2,200 described species of over 3,580 estimated species, the Australian/Pacific Realm region with over 1,300 described species of over 2,500 estimated species, the Nearctic region with nearly 1,500 described species of over 2000 estimated species, this region the poorest in terms of water beetle diversity (Jäch & Balke 2008). The water beetles (Coleoptera) species are an integral part of food chains and nutrient cycling in freshwater ecosystems, and they are an important component of the diets of fish, amphibians, many birds and mammals. The abundance and response of the water beetles (Coleoptera) species to small changes in the environment become important indicators for monitoring human impacts on water quality (Adu & Oyeniyi 2019), and they are widely used to monitor the quality of freshwater ecosystems (Souto et al., 2019; Valladares et al., 2002; Schneider-Jacoby & Ern 1993). The diversity & abundance of water beetle (Coleoptera) species at 5 different sample collection locations in the Kolkas region in India were studied. A total of 13 species of water beetles (Coleoptera) belonging to the families Dytiscidae,

Hydrophilidae and Gyrinidae were recorded. The diversity index in sample collection locations I was the richest (11 species), followed by sample collection locations II and III (10 species each), sample collection locations V (9 species) and sample collection locations IV (8 species). The richness ranking in sample collection locations IV had fewer rare species and more common species than the other sites. The species composition and overall community structure at sample collection locations I and II were more similar than III and IV while sample collection locations V was completely different from these two groups (Vaibhao et al., 2011). A field survey bout water beetle (Coleoptera) species was conducted in 6 different ponds in the Lonjsko Polje Nature Park. The water beetles (Coleoptera) species were collected using D-shaped sweep nets. In total, 341 specimens belonging to 29 species of the genus Hydradephaga were recorded. The highest species richness was recorded in Pond 3, with 15 species. No species were found in all investigated ponds (Martina et al., 2007). Studies on different types of water bodies of a river valley recorded 112 species of water beetles (Coleoptera). The diversity of water bodies in a river valley is beneficial for species richness. Factors limiting the migration of water beetles (Coleoptera) populations are topographic obstacles, dense forests and large trees (Joanna et al., 2016). A study on the diversity, distribution and habitat of the water beetles (Coleoptera) at 10 sample collection locations in Chambok Commune, Kampong Speu province, Cambodia collected 152 individuals of 22 species, 10 genera belonging to9 families. The family Scirtidae had the highest number of species at the 10 sample collection locations. Non-metric multidimensional analysis between families of the water beetles (Coleoptera) and their habitats found that the family Scirtidae was positively associated with forest and tree canopy, but negatively associated with agricultural land use. The family Limnichidae was positively associated with elevation and erosion, while the Dytiscidae was positively associated with streambeds characterized by small stones, but negatively associated with water depth and streambeds characterized by large stones (Doeurk et al., 2022).Comparing the populations of water beetle (Coleoptera) species in rice fields cultivated under different management regimes including direct seeding without furrow (DS) and conventional management, it was shown that DS fields supported higher densities of water beetles than conventional fields. DS fields showed a higher abundance of water beetles, but this effect varied for each species: 7 species were more abundant in DS than in conventional fields, while 2 species showed the opposite trend (Kohei et al., 2013). In Vietnam, research on the diversity of the water beetle (Coleoptera) species is limited. The first study on water beetles was by Fairmaire (1888) with a new species of the Dryopidae family. Pic (1968) published results on the Dryopidae and Elminthidae families in Nghe An province, and the author also described 20 new species (Deleve, 1968). The families Noteridae and Dytiscidae were studied by Sato (1972), the author provides a list of species composition of these two families and

records 6 species belonging to the family Noteridae in Lao Cai, Bac Kan, Tuyen Quang, Nghe An, Quang Ngai, Kon Tum, Hoa Binh, Quang Tri, Ninh Thuan, Dak Lak, Gia Lai, Lam Dong provinces. Gray & Kelly (2016) and Jung (2008) studied the 3 families, and provided keys in Quang Ngai, Kon Tum, Quang Tri, Ninh Thuan, Dak Lak, Gia Lai, Lam Dong provinces provided a list of 15 species belonging to 11 genera. The study on water insects (Coleoptera) was conducted in Cuc Phuong National Park, Ninh Binh province; Ba Be National Park and Nam Xuan in Bac Kan province: Vu Quang, Ha Tinh province showed that the study sites, 19 species of 11 genera in 3 families were recorded of water beetles (Coleoptera) in both undisturbed and disturbed ecosystems. The protecting undisturbed ecosystem has relatively high Margalef (d) and Shannon - Weiner (H') diversity coefficients, respectively d=2.23-3.87 (good diversity) and H'=2.15-3.85 (medium diversity). Record 6 indicator species of undisturbed aquatic ecosystems at the study sites. These species indicate undisturbed ponds, lakes, marshes and lakes with dirty water, indicators of wetland and bush ecosystems, reeds and undisturbed natural flows, streams, rivers, and clean water (Truong Xuan Lam et al., 2023). Recently, Nguyen et al. (2024) studied the genus Cybister Curtis, 1827 in Vietnam, and recorded and described 5 species. Keys of species belonging to the genus Cybister Curtis, 1827 in Vietnam are provided. The species Cybister convexus Sharp, 1882 and Cybister danxiaensis Zhuo-Yin Jiang, 2023 were recorded for the first time in Vietnam.

In this study, survey and collection of water beetle (Coleoptera) species in several provinces in Vietnam, we analyzed diversity indices in different habitats of the water beetles (Coleoptera) in forest habitats, agricultural landscapes, and freshwater habitats including ponds and streams.

MATERIALS AND METHODS

Water beetles (Coleoptera) surveys. The study was conducted at 20 sample collection locations at different habitats in forest habitats, agricultural landscapes, and freshwater habitats including ponds and streams in Bac Kan, Lao Cai, Cao Bang, Ninh Binh and Ha Tinh provinces. The different habitats were forest habitats (tropical rainforest, secondary forest or high mountain forest), agricultural landscapes (rice fields, low shrubs and weeds, or fruticulture field) and freshwater habitats including ponds and streams. The middle elevations are between 91 m and 1850 m (Table 1). The water beetles were collected in May, June, and November 2021, January, and September 2022, January, August, and September 2023 and June 2024. During this period, each forest habitat, agricultural landscapes, and freshwater habitat including ponds and streams were sampled at seven sampling points. For each sampling point, the hand-held racket was swept about 10 times through the water, so that different vegetational units, substrates, the banks of ponds, streams, and water areas were covered (McCafferty, 1983). The collecting tool is a hand-held racket with stainless steel, handle the flexible racket handle can change the length (from 1 m

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to 2 m). The diameter of the net racket is 30 cm, cylindrical with a depth of 40 cm. The mesh size is 0.5 mm. All samples were preserved in 70% ethanol and brought to the laboratory for further analysis. They were later identified at the species level by a stereozoom microscope a Nikon SMZ 800N Digital Stereo Microscope (using Helicon Focus 7 software). The nomenclature of water beetles by the authors includes Delève (1968); Brancucci (1983); Mazzoldi (1995); Jäch (1998); Jäch & Balke (2003); Komarek (2003); Grey & Kelly (2016).

Data analysis. Biodiversity indexes includingDominance_D, Simpson_1-D, Shannon_H, Evenness_e^H/S, Brillouin, Menhinick, Margalef, Equitability_J, Fisher_alpha, Berger-Parker, Chao-1 were calculated using the software Fast 4.03.

Sampling site	Site name	Elevation (m)	Vegetation type	Coordinates	Habitat	
NB1	Cuc Phuong National Park, Ninh Binh province	879	Forest habitats	20°20′68″ N; 105°38′ 40″E	Stream	
NB2	Van Long, Gia Vien, Ninh Binh province	91	Agricultural landscapes	20°33′ 63″ N; 105°88′ 01″E	Pond	
NB3	Cuc Phuong National Park, Ninh Binh province	680	Forest habitats	20°36′ 38″ N; 105°54′ 40″E	Stream	
NB4	Cuc Phuong National Park, Ninh Binh province	899	Forest habitats	20°61′ 04″N; 105°93′ 32″E	Stream	
LC1	Bat Xat district, Lao Cai province	1780	Forest habitats	108°30′21″ E ; 21°28′35″ N,	Stream	
LC2	Bat Xat district, Lao Cai province	1050	Forest habitats	108°30′28″ E ; 21°28′ 41″ N	Pond	
LC3	Bat Xat district, Lao Cai province	1850	Forest habitats	108°35 '45" E ; 21°22'67" N	Stream	
LC4	Bat Xat district, Lao Cai province	1650	Forest habitats	108°35′56″ E ; 21°22′ 82″ N	Stream	
CB1	Nguyen Binh district, Cao bang province	672	Agricultural landscapes	22°35′21″ N; 105°53′01″ E	Pond	
CB2	Nguyen Binh district, Cao bang province	789	Agricultural landscapes	22°15′32″ N; 105°33′23″ E	Pond	
CB3	Nguyen Binh district, Cao bang province	892	Agricultural landscapes	22°25′39″ N; 105°23′13″ E	Pond	
CB4	Ho Thang Hen, Nguyen Binh district, Cao bang province	1012	Agricultural landscapes	22°55′ 67″ N; 105°53′54″ E	Pond	
BK1	Nam Xuan Lac, Bac Kanprovinc	408	Forest habitats	22°28′87″N; 105°63′82″E.	Stream	
BK2	Nam Xuan Lac, Bac Kan province	612	Forest habitats	22°19′45″N; 105°33′20″ E	Stream	
BK3	Ba Be National Park, Bac Kan province	521	Forest habitats	22°45′57″N; 105°67′ 72″E.	Stream	
BK4	Bac Ngoi village, Ba Be, Bac Kanprovince	501	Agricultural landscapes	22°24'16"N; 105°22'34"E	pond	
VQ1	Vu Quang National Park, Ha Tinh province	853	Forest habitats	18°09′23″N; 105°16′41″E	Stream	
VQ2	Vu Quang National Park, Ha Tinh province	618	Forest habitats	18°31′26″N; 105°12′48″E	Pond	
VQ 3	Vu Quang National Park, Ha Tinh	850	Forest habitats	18°09′18″ N; 105°16′36″E	Pond	
VQ3	Vu Quang National Park, Ha Tinh province	550	Forest habitats	18°09″22″ N 105°16″36″ E	Stream	

RESULTS

The diversity of water beetles (Coleoptera) in study sites. We collected 542 individuals of water beetles (Coleoptera) representing 35 species of 23 genera of 4 families (Appendix 1). The most diversity families of water beetles (Coleoptera) were family Dytiscidae with 16 species (46% of the total species with 253 individuals), Hydrophilidae with 12 species (34% of the total species with 226 individuals), followed by family Gyrinidae with 5 species (14% of the total species with 40 individuals) and family Noteridae with 2 species (6% of the total species with 23 individuals). Of the total 35 species of water beetles (Coleoptera) recorded at 20 sample collection locations at different habitats in Bac Kan, Lao Cai, Cao Bang, Ninh Binh and Ha Tinh, species Sternolophus rufipes (Fabricius, 1792) of the family Hydrophilidae was recorded at 12 sampling point and Cybister convexus Sharp, 1882 of the Dytiscidae family was recorded at 11 sampling point. Three species were recorded at 10 sampling points Hyphydrus lyratus Swartz, 1808; Cybister guerini Aubé, 1838; Cybister limbatus (Fabricius, 1775).

The Dominance_D, Simpson_1-D, Shannon_H, Evenness_e^H/S, Brillouin, Menhinick, Margalef, Equitability_J, Fisher_alpha, Berger-Parker, Chao-1 3

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index differed among at 20 sample collection locations from NB1 to VQ4 (Appendix 2) in which the Shannon_H index ranged from 1.58 (NB2) to 2.88 (VQ2); The Simpson_1-D index ranged from 0.60 (BK1) to 0.93 (VQ1, VQ2) and Berger-Parker index ranged from 0.11 (VQ1) to 0.62 (BK1).

The Shannon_H index, Simpson_1-D index and Berger-Parker index differed among in study provinces (Fig. 1). The Shannon_H index was high diversity at Lao Cai (LC) (3.21), Cao Bang (CB) (3.05) and Vu Quang (3.04). Shannon_H index was low diversity at Bac Kan (BK) (2.50), and Ninh Binh (NB) (2.81). The Simpson_1-D index and Berger-Parker index also had high diversity at Lao Cai (LC), Cao Bang (CB) and Vu Quang, which had low diversity at Bac Kan (BK), Ninh Binh (NB).



Fig. 1. Simpson _1-D index, Shannon diversity index and Berger-Parker index of water beetles (Coleoptera) in five provinces in Vietnam (NB-Ninh Binh province; BK-Bac Kan province; CB-Cao Bang province; LC-Lao Cai province; VQ-Ha Tinh province).

Correspondence analysis of water beetles in different sites (NB1– VQ4) in five provinces of Vietnam shows that the distances between diversity index very similar values in different sample collection locations (NB1– VQ4) in five provinces, except the sample collection locationsVQ4, VQ3, VQ2, VQ1 (Ha Tinh province), NB2, NB4, (Ninh Binh province), LC3, LC2, LC1 (Lao Cai province) and BK1, BK4 (Bac Kan province) (Fig. 2).



Fig. 2. Correspondence analysis of water beetles (Coleoptera)in different sample collection locations (NB1– VQ4) in five provinces in Vietnam(NB-Ninh Binh province; BK-Bac Kan province; CB-Cao Bang province; LC-Lao Cai province; VQ-Ha Tinh province; 1-4:Sample collection locations)



Fig. 3. Evenness distance (Evenness index) of water beetles (Coleoptera) in different sample collection locations (NB1– VQ4) in five provinces in Vietnam (NB-Ninh Binh province; BK-Bac Kan province; CB-Cao Bang province; LC-Lao Cai province; VQ-Ha Tinh province; 1-4:Sample collection locations).

Evenness distance (Evenness index) in different sample collection locations (NB1– VQ4) in Bac Kan, Lao Cai, Cao Bang, Ninh Binh, and Ha Tinh provinces in Fig. 3. At 20sample collection locations, the Evenness index of species was divided into 4 different main groups, including main group 1 (VQ2, VQ3, BK1, BK4), main group 2 (LC3), main group 3 (NB3, CB2, CB4, CB3, BK3, BK2, LC4, NB4, CB1, NB1, VQ1, LC1, LC2, VQ4) and main group 4 (NB2) (Fig. 3). The main group 1 was divided into 2 different groups, including VQ2, VQ3 and BK1 & BK4. The main group 3 was divided into many different groups, including NB3and BK3 & VQ1. The main group 3 was divided into 4 different groups, including NB4 & LC1, LC2, VQ4, LC1, and LC2.

The diversity of water beetles (Coleoptera) in different landscapes. In sample collection locations of agricultural landscapes and forest habitats, we recorded 29 species (agricultural landscapes) and 35 species (forest habitats). On the pond and stream, we recorded 31 species on the ponds and 33 species on the streams. The Dominance D, Simpson 1-D, Shannon H, Evenness_e^H/S, Brillouin, Menhinick, Margalef, Equitability_J, Fisher_alpha, Berger-Parker, Chao-1 index did differ between agricultural landscapesand forest habitats, and between pond and stream (Appendix 3). The Shannon_Hindex differed among agricultural landscapes and forest habitats and did not differ among ponds and streams. The Simpson_1-D index did not differ among agricultural landscapes and forest habitats, ponds and streams (Fig. 4).



Fig. 4. Variation of Simpson_1-D D index, Shannon_H index of water beetles (Coleoptera) in agricultural landscapes and forest habitats, ponds and streams in five provinces in Vietnam.

The species richness of water beetles (Coleoptera) was higher in forest habitats than in agricultural landscapes (Fig. 5a). However, this species richness did not differ among ponds and streams (Fig. 5c). In addition, individual rarefaction of water beetles (Coleoptera) was significantly higher in forest habitats and streams than in the agricultural lands and ponds (Figs. 5b, d).



Fig. 5. Species richness and individual rarefaction of water beetles (Coleoptera)in agricultural landscapes and forest habitats, ponds and streams (mean ± 95% confidence intervals). Different letters indicate significant differences (a, c. species richness; b, d. individual rarefaction).

35 species were collected in forest habitats and 29 were collected in agricultural landscapes including Sternolophus rufipes (Fabricius, 1792) (67 individuals), Cybister guerini Aubé, 1838 (19 individuals), mixtus (Blanchard, Sandracottus 1843)(19 individuals), and they were the dominant species in forest habitats, while Cercyon incretus Orchymont, 1941 (21 individuals)was dominant in the agricultural landscapes. We recorded 31 species on the pond and 33 species on the streams including the species Sternolophus rufipes (Fabricius, 1792) (50 individuals) and Cybister guerini Aubé, 1838 (18 individuals) were the dominant species in streams, and the species Cercyon incretus Orchymont, 1941 (26 individuals), Hydaticus vittatus (Fabricius, 1775) (22 individuals) were the dominant species in ponds.

DISCUSSION

In this study, 35 species of 23 genera of 4 families were recorded at 20 sample collection locations in Bac Kan, Lao Cai, Cao Bang, Ninh Binh, and Ha Tinh provinces of Vietnam different from the study of Deleve (1968) research in Nghe An province with 20 species of families Noteridae and Dytiscidae, and different from the study of Gray & Kelly (2016) and Jung (2008) when studied this 3 families in Quang Ngai, Kon Tum,

Quang Tri, Ninh Thuan, Dak Lak, Gia Lai, Lam Dong provinces with a list of 35 species belonging to 11 genera. Sato (1972) records 6 species belonging to the family Noteridae in Lao Cai, Bac Kan, Tuyen Quang, Nghe An, Quang Ngai, Kon Tum, Hoa Binh, Quang Tri, Ninh Thuan, Dak Lak, Gia Lai, Lam Dong provinces higher than in this study (records 2 species belonging to the family Noteridae). The number of species was recorded at 20 sample collection locations in Bac Kan, Lao Cai, Cao Bang, Ninh Binh, and Ha Tinh provinces higher than in this study of Truong Xuan Lam et al. (2023) when research in Cuc Phuong National Park, Ninh Binh province; Ba Be National Park and Nam Xuan Lac in Bac Kan province; Vu Quang, Ha Tinh province with 19 species of 11 genera in 3 families in both undisturbed and disturbed ecosystems. Investigated the diversity, distribution and habitat associations of aquatic beetles in Chambok Commune of Kampong Speu province, southwest Cambodia shows that family Dytiscidae was positively associated with stream substrates characterised by small stones, but negatively associated with water depth and substrates characterised by large stones (Doeurk et al., 2022) as in this study, species of family Dytiscidae in streams by small stones are the highest accounting for 46% of the total species.

CONCLUSIONS

At 20 sample collection locations in Bac Kan, Lao Cai, Cao Bang, Ninh Binh, and Ha Tinh provinces were collecteda total of 542 individuals of water beetles (Coleoptera) representing 35 species of 23 genera of 4 families. The most diverse Coleopteran family were the family Dytiscidae with 16 species (46% of the total species).

The Dominance_D, Simpson_1-D, Shannon_H, Evenness_e^H/S, Brillouin, Menhinick, Margalef, Equitability_J, Fisher_alpha, Berger-Parker, Chao-1 index differed among 20 sample collection locations from NB1 to VQ4, and high diversity at Lao Cai, Cao Bang and Vu Quang. Evenness distance (Evenness index) in different sample collection locations (NB1– VQ4) was divided into 4 different main groups

The Dominance_D, Simpson_1-D, Shannon_H, Evenness_e^H/S, Brillouin, Menhinick, Margalef, Equitability_J, Fisher_alpha, Berger-Parker, Chao-1 index differed among agricultural landscapes and forest habitats, between pond and stream. In the Shannon_H index,Simpson_1-D index, the species richness were higher in forest habitats than in agricultural landscapes. However, this species richness was no different in ponds and streams. The individual rarefaction of water beetles (Coleoptera) was significantly higher in forest habitats and streams than in agricultural landscapes and ponds.

Listof water The number individuals																					
No.	beetles	NB1	NB2	NB3	NB4	LCI	LC2	LC3	LC4	CB1	CB2	CB3	CB4	BK1	BK2	BK3	BK4	VQ1	VQ	VQ	VQ
т	Ho Dytiscidoo																		2	3	4
1	Hyphydrus byratus																				
1.	Swartz, 1808	2				1	1		2	1			1		3				2	3	1
2.	chinensis	1		2		6		4	1			2		1				1		2	
3	Rhantus sp	1					3								3		2		1		3
1	Cybister sugillatus	2		1			1		2				2	1	5			1	1		1
т.	Erichson, 1834 Cybister	-					1		-				2	1				1			1
5.	tripunctatus lateralis (Fabricius, 1798)						3		4		1		1		1		3	2		1	3
6.	Cybister danxiaensis Zhuo- Yin Jiang, 2023																		2	1	
7.	Cybister convexus Sharp, 1882	1		1		1	1		2			1			1			2	1	1	3
8.	Cybister guerini Aubé, 1838	1					3		12	1		1	1		2		1	3		1	
9.	Cybister limbatus (Fabricius, 1775)		1	1			1		2			2			1		6		4	2	1
10.	Hydaticus bipunctatus Wehncke, 1876			4				1			3				1			1	1		2
11.	Hydaticus ricinus Wewalka, 1979			3			2		1	1	2		1								
12.	Hydaticus pacificus Aubé, 1838		1								3		2			2		1			2
13.	Hydaticus vittatus (Fabricius, 1775		3			1	2	2		1							1		2	13	
14.	Sandracottus mixtus (Blanchard, 1843)			4					2							2			1	9	1
15.	Agabus sp.					1	2	2	1							1		4		6	
16.	Platambus regulae					2		3											8		
	Brancucci, 1991																				
Π	Họ Gyrinidae																				
17.	Regimbart, 1883		1					1				2		1				3	1	1	
18.	Gyrinus distinctus Aubé, 1838			1																	
19.	Gyrinus distinctus Aubé, 1838	4			1		1				1		1	1				1	2		
20.	Gyrinus sp.			1		1	1			1	1			2	2		1	2	1		
21.	Patrus sp.					3	1	5			1			2			1		1	2	
III	Họ Hydrophilidae																				
22.	Berosus sp.			1																	
23.	Cercyon incretus Orchymont, 1941		15		1		2			3	1			1	1			3		2	
24.	Cercyon sp.		1			1			2			1				2			2	1	ļ
25.	Cryptopleurum sulcatum Motsch., 1863				1						1			1			1		1	1	
26.	Dactylosternum hydrophiloides (MacLeay, 1825		1		5	3		2			1		2		1		2		2		
27.	Enochrus sp.						2	1													
28.	Helochares sp.					1	2				1			1	1			3		2	
29.	Hydrochara sp.							1				1				2			2	1	
30.	Laccobius sp.				3	1	5			1			2			1		1	2		
31.	Pachysternum sp.		1	2		3		2		1		2		1		2		2			-
32.	Peltocercyon sp.		6				2	1										4		2	
33.	Sternolophus rufipes (Fabricius, 1792)	4		1	5		10	15		7		2		19		1	20		1	21	
IV	Noteridae																				
34.	Canthydrus sp.	1		1		1	1		2			1			1			2	1	1	3
35.	Hydrocanthus sp.	1	I	I	1	l I	1	1	l I	1	1	1	1	1	1	1	1	1	2		i i

Appendix 1. List and number individuals of water beetles (Coleoptera) in different sample collection locations in five provinces of Vietnam.

Note: NB-Ninh Binh province; BK-Bac Kan province; LC-Lao Cai province; CB- Cao Bang; VQ-Ha Tinh province; 1-4: Sample collection locations

Appendix 2. The diversity index of water beetles (Coleoptera) in different sample collection locations in five provinces of Vietnam.

Diversity index	NB1	NB2	NB3	NB4	LC1	LC2	LC3	LC4	CB1	CB2	CB3	CB4	BK1	BK2	BK3	BK4	VQ1	VQ2	VQ3	VQ4
Taxa_S	10	9	13	8	14	21	13	13	9	13	10	11	12	13	8	11	18	22	20	10
Individuals	19	30	23	20	26	48	41	34	18	18	15	16	34	19	13	41	37	42	74	20
Dominance_D	0.15	0.31	0.11	0.20	0.11	0.09	0.19	0.17	0.25	0.10	0.11	0.10	0.40	0.10	0.14	0.30	0.07	0.07	0.15	0.12
Simpson_1-D	0.85	0.69	0.89	0.81	0.89	0.91	0.81	0.83	0.75	0.90	0.89	0.90	0.60	0.90	0.86	0.70	0.93	0.93	0.85	0.88
Shannon_H	2.08	1.58	2.39	1.82	2.41	2.75	2.08	2.20	1.78	2.45	2.25	2.34	1.56	2.45	2.03	1.71	2.77	2.88	2.37	2.20
Evenness_e'H/S	0.80	0.54	0.84	0.77	0.80	0.74	0.62	0.69	0.66	0.89	0.94	0.94	0.40	0.89	0.95	0.50	0.88	0.81	0.53	0.90
Brillouin	1.58	1.28	1.83	1.42	1.87	2.25	1.73	1.78	1.33	1.78	1.63	1.70	1.23	1.81	1.47	1.42	2.23	2.31	2.04	1.69
Menhinick	2.29	1.64	2.71	1.79	2.75	3.03	2.03	2.23	2.12	3.06	2.58	2.75	2.06	2.98	2.22	1.72	2.96	3.40	2.33	2.24
Margalef	3.06	2.35	3.83	2.34	3.99	5.17	3.23	3.40	2.77	4.15	3.32	3.61	3.12	4.08	2.73	2.69	4.71	5.62	4.41	3.00
Equitability_J	0.90	0.72	0.93	0.88	0.91	0.90	0.81	0.86	0.81	0.95	0.98	0.98	0.63	0.96	0.98	0.71	0.96	0.93	0.79	0.95
Fisher_alpha	8.54	4.36	1238	4.94	1236	1424	6.56	7.69	7.16	2100	13.11	1554	6.61	18.15	8.86	4.93	1383	18.66	9.00	7.96
Berger-Parker	0.26	0.50	0.17	0.30	0.23	0.23	0.39	0.35	0.44	0.17	0.13	0.13	0.62	0.16	0.15	0.51	0.11	0.19	0.30	0.15
Chao-1	15.0	24.0	2233	11.0	32.0	25.5	15.0	1375	30.0	35.5	11,67	13.5	24.0	25.0	8.50	13.5	21.5	26.09	25.14	12.00

Note: NB-Ninh Binh province; BK-Bac Kan province; LC-Lao Cai province; CB- Cao Bang province; VQ-Ha Tinh province; 1-4:Sample collection locations

Appendix 3. The diversity index of water beetles (Coleoptera) in agricultural landscapes, forest habitats, ponds and streams.

Diversity index	Forest habitats	Agricultural landscapes	Ponds	Streams
Taxa_S	33	29	31	33
Individuals	377	181	332	281
Dominance_D	0.06	0.09	0.07	0.06
Simpson_1-D	0.94	0.91	0.93	0.94
Shannon_H	3.23	2.94	3.16	3.20
Evenness_e^H/S	0.72	0.63	0.71	0.72
Brillouin	3.06	2.69	2.97	3.00
Menhinick	1.80	2.23	1.81	2.03
Margalef	5.73	5.58	5.51	5.85
Equitability_J	0.91	0.86	0.90	0.91
Fisher_alpha	9.43	10.25	9.11	10.12
Berger-Parker	0.18	0.23	0.20	0.18
Chao-1	38.00	30.00	33.00	35.50

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