

DATA ON SPECIES COMPOSITION OF STONEFLIES IN THE FAMILY NEMOURIDAE AND PERLIDAE (PLECOPTERA: INSECTA) IN TAM DAO NATIONAL PARK, VINH PHUC PROVINCE

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Abstract. Research on the fauna of stoneflies the family Nemouridae and Perlidae in Tam Dao National Park, Vinh Phuc province was conducted quite early. However, records of these groups were published in scattered papers. The results from this article for the first time provide the most updated and complete data on the composition of stoneflies in the family Nemouridae and Perlidae in Tam Dao National Park, Vinh Phuc province. The results show that, up to the time of publication, 6 species of the family Nemouridae belonging to 3 genera and 25 species of the family Perlidae belonging to 10 genera have been recorded in Tam Dao National Park, Vinh Phuc province. In this study, *Nemoura apicalis* Sivec & Stark, 2010 was a new record for Tam Dao National Park. Among the 31 species of stoneflies collected, 22 species are endemic to Vietnam, and 11 are endemic to the study area. In particular, *Phanoperla* sp. may be a new species to science. Now, the specimens of this species have only been found in Tam Dao National Park, Vinh Phuc province. The quantitative comparison of stonefly communities between riffle and pool habitats showed that the average number of species and the average number of individuals in riffle habitats were higher than in pool habitats ($\alpha = 0.05$).

Keywords: composition species, Nemouridae, Perlidae, Tam Dao National Park, Vinh Phuc.

1. Introduction

Plecoptera, or stoneflies, is a small order of aquatic insects; more than 3.497 species have been described so far in the world. Stoneflies are important indicators of water quality and landscape disturbance. They are among the first aquatic organisms to disappear when a watershed is disturbed by humans. The order is divided into the suborders Arctoperlaria and Antarctoperlaria and includes 16 families: 12 arctoperlarian and 4 antarctoperlarian [1].

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Stoneflies of the family Nemouridae and Perlidae spend most of their lives as nymphs in freshwater environments, such as streams, rivers, and lakes... The study of the taxonomy of these two families in Vietnam is mainly carried out by foreign scientists. Many new species have been described. Nymphs of the family Nemouridae can be easily confused with Taeniopterygidae as they both have wing pads divergent (not parallel with the body axis) but can be distinguished because the second tarsal segment of each leg of Nemouridae is much shorter in length than the first [2]. These tend to be hairy larvae with hind legs longer than the abdomen. Nymphs of the family Perlidae are recognized by the presence of highly branched thoracic gills and a flattened and often distinctively patterned body [3].

Tam Dao National Park is a protected zone in northern Vietnam, with many rivers, streams, and waterfalls. The average temperature during the year is 22.9°C. Generally, natural conditions in Tam Dao National Park facilitate the development of stoneflies in the family Nemouridae and Perlidae. In recent years, the study on the taxonomy of these two families in Tam Dao National Park has received attention. However, records of these groups in the study area were published in scattered papers.

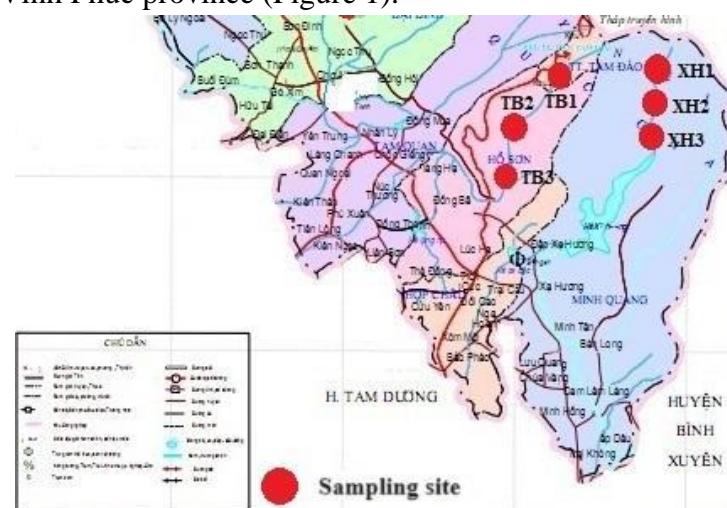
Based on the analysis of specimens at the different stages of the family Nemouridae and Perlidae collected and the study of related documents, the article provides the most up-to-date and complete data on the species composition of the Nemouridae and the Perlidae in Tam Dao National Park, Vinh Phuc province.

2. Content

2.1. Materials and methods

2.1.1. Materials

The species belonging to the different stages of the family Nemouridae and Perlidae were collected at 6 sampling sites in September 2021 and December 2021 in Tam Dao National Park, Vinh Phuc province (Figure 1).



Source map: <https://tamdao.vinhphuc.gov.vn>

Figure 1. Location of sampling sites in the study area

- 03 sampling sites belonging to Thac Bac stream (TB 1, TB 2, TB 3), which flows from Tam Dao town to Ho Son commune, Tam Dao district, Vinh Phuc province. The length of the stream is about 6 km. The stream has water all year round.

+ TB 1: The substrate is mainly boulders, gravel, and sand. The water is quite clear, occasionally with a few standing water spots. On both sides of the stream are primeval forests.

+ TB 2: The substrate is mainly small stone, gravel, and sand. On both sides of the stream are primeval forests.

+ TB 3: The substrate is mainly small stone, gravel, and sand. On both sides of the stream are secondary forests. This sample collection site is near the headquarters of Tam Dao National Park.

- 03 sampling sites belong to the Xa Huong stream (XH 1, XH 2, XH 3) in Minh Quang commune, Tam Dao district, Vinh Phuc province. The length of the stream is about 3 km.

+ XH 1: The substrate of the stream is mainly stones and small pebbles, with occasional large boulders. The water is quite clear. On both sides of the stream, there are many bushes.

+ XH 2: On both sides of the stream are secondary forests. The flow rate is slow. The substrate is mainly boulders, pebbles, a little gravel, and a lot of plant humus.

+ XH 3: The substrate is mainly large boulders, loose mud with many rotten tree branches, and occasionally small rocks. Some stillwaters are quite large and deep.

2.1.2. Methods

The samples were collected according to methods illustrated by McCafferty & Provonsha (1981) [4]. In the field, pond nets, hand nets, and surber nets were used for collecting nymphs. The nymphs of stoneflies were collected by placing the mouth of pond nets, hand nets, and surber nets against the water flow and using the foot to kick in front of the racket for a few minutes (collect the kick nets). In places where there are large rocks, the rocks were lifted, and samples stuck to the bottom were collected with a soft pint. Qualitative sampling was performed in both riffles and pools. In small water areas or narrow streams, sampling is carried out with a hand net.

Adults were collected by portable light traps. The quantitative samples of stoneflies were taken using the Surber net (50 cm x 50 cm), one sample for riffles and one for pools in each site.

The specimens were stored in 80% ethanol, and deposited in the Lab of Zoology, Hanoi Pedagogical University 2. In addition, this study also used specimens deposited in the Institute of Ecology and Biological Resources (VAST), Hanoi University of Science (VNU), and Hanoi Pedagogical University 2. This paper combined with inheritance of documents related to the study area, especially the egg and adult stages [2], [3], [5-9].

Specimens were identified to species based on the external morphology of nymph and adult in the available references, such as Sivec & Stark (2010) [5-7]; Fochetti & Massimo (2017) [8]; Cao Thi Kim Thu (2008) [9].

2.2. Results and discussion

2.2.1. The species composition of stoneflies in Tam Dao National Park

From the samples collected from Tam Dao National Park, Vinh Phuc province, a total number of 31 species of stoneflies were found, belonging to 13 genera and 2 families Nemouridae and Perlidae. This data is considered to be the most complete and up-to-date on the species composition of the stoneflies in the study area up to the time of publication. The species composition of stoneflies in Tam Dao National Park, Vinh Phuc province is shown in Table 1.

Table 1. The species composition of stoneflies in Tam Dao National Park, Vinh Phuc province

No	TAXON	SPECIMENS	TB	XH
	(I) Family Nemouridae Newman, 1853			
	1. Genus Amphinemura Ris, 1902			
1.	<i>Amphinemura tamdao</i> Stark & Sivec, 2010 *	A (Re)	+	-
2.	<i>Amphinemura viet</i> Stark & Sivec, 2010 **	A (Re)	+	-
	2. Genus Indonemoura Baumann, 1975			
3.	<i>Indonemoura angulata</i> Stark & Sivec, 2010 *	A (Re)	+	-
4.	<i>Indonemoura clavata</i> Stark & Sivec, 2010 *	A (Re)	+	-
	3. Genus Nemoura Latreille, 1796			
5.	<i>Nemoura apicalis</i> Sivec & Stark, 2010 ***	A (Sa)	+	-
6.	<i>Nemoura clavaloba</i> Sivec & Stark, 2010 *	A (Re)	+	-
	(II) Family Perlidae Latreille, 1802			
	1. Genus Acroneuria Pictet, 1814			
7.	<i>Acroneuria apicalis</i> Stark & Sivec, 2008 *	A (Re)	+	-
	2. Genus Chinoperla Zwick, 1980			
8.	<i>Chinoperla rhododendrona</i> Cao & Bae, 2007 **	A (Sa)	+	-
9.	<i>Chinoperla gorohovi</i> Sivec & Stark, 2010 *	A (Re)	+	-
10.	<i>Chinoperla sila</i> Sivec & Stark, 2010 *	A (Re)	+	-
	3. Genus Etrocōrema Klapálek, 1909			
11.	<i>Etrōcorema nigrogeniculatum</i> (Enderlein, 1909)	E (Re), N (Sa), A (Re)	+	+
	4. Genus Flavoperla Chu, 1929			
12.	<i>Flavoperla aesuosa</i> Cao & Bae, 2007 **	A (Sa)	+	+
	5. Genus Hemacroneuria Enderlein, 1909			

No	TAXON	Specimens	TB	XH
13.	<i>Hemacroneuria malickyi</i> Stark & Sivec, 2008 *	A (Re)	+	-
	6. Genus <i>Kamimuria</i> Klapálek, 1907			
14.	<i>Kamimuria atrocephala</i> Stark & Sivec, 2008 *	A (Re)	+	-
15.	<i>Kamimuria atra</i> Stark & Sivec, 2008	A (Sa)	+	-
	7. Genus <i>Neoperla</i> Needham, 1905			
16.	<i>Neoperla cavaleriei</i> (Navás, 1922)	A (Sa)	+	+
17.	<i>Neoperla dao</i> Stark & Sivec, 2008 *	A (Re)	+	-
18.	<i>Neoperla hubleyi</i> Stark & Sivec, 2008 **	A (Re)	+	-
19.	<i>Neoperla multispinosa</i> Stark & Sivec, 2008 *	A (Re)	+	-
20.	<i>Neoperla mnong</i> Stark, 1987	A (Re)	+	-
21.	<i>Neoperla sungi</i> Cao & Bae, 2007 **	A (Re)	+	-
22.	<i>Neoperla tamdao</i> Cao & Bae, 2007 **	E (Re), A (Sa)	+	+
23.	<i>Neoperla yao</i> Stark, 1987	A (Re)	+	-
24.	<i>Neoperla yentu</i> Cao & Bae, 2007 **	E (Re), N (Sa), A (Sa)	+	+
	8. Genus <i>Neoperlops</i> Bank, 1939			
25.	<i>Neoperlops obscuripennis</i> Banks, 1939	E (Re), N (Sa), A (Sa)	+	-
26.	<i>Neoperlops vietnamensis</i> Cao & Bae, 2008 **	N (Sa)	+	+
	9. Genus <i>Phanoperla</i> Banks, 1938			
27.	<i>Phanoperla melinh</i> Cao & Bae, 2008 **	A (Sa)	+	+
28.	<i>Phanoperla</i> sp.	N (Re, Sa)	+	+
	10. Genus <i>Togoperla</i> Klapálek, 1907			
29.	<i>Togoperla clavata</i> Stark & Sivec, 2008 *	A (Re)	+	-
30.	<i>Togoperla noncoloris</i> Du et Chou, 1999	E (Re), N (Sa), A (Sa)	+	+
31.	<i>Togoperla poilanira</i> (Navás, 1934)	A (Sa)	+	-
Total			31	9

Notes: +: present; -: no present; E: Egg; N: Nymph; A: Adult; Re: References; Sa: Samples; *, **, ***: endemic species to Vietnam; *: endemic species in the study area; ***: new record to the Tam Dao National Park; TB: Thac Bac stream; XH: Xa Huong Stream

- *In terms of genera composition:* in the study area, the family Nemouridae had 03 genera (23.1% of the total genus number): *Amphinemura*, *Indonemoura* và *Nemoura*. The family Perlidae had 10 genera (76.9% of the total genus number): *Acroneuria*, *Chinoperla*, *Etrocōrema*, *Flavoperla*, *Hemacroneuria*, *Kamimuria*, *Neoperla*, *Neoperlops*, *Phanoperla* và *Togoperla*.

- *In terms of species composition:* a total number of 31 species of stoneflies are in the study area. The family Nemouridae had 06 species (19.4% of the total species number). The family Perlidae had 25 species (80.6% of the total species number). Compared with Nguyen Van Hieu et al. (2015) in Hoang Lien National Park, Lao Cai province, the number of species of stoneflies belonging to the family Nemouridae and Perlidae collected in the study area is lower. In Hoang Lien National Park, Lao Cai province, the family Nemouridae had 17 species and the family Perlidae had 33 species [10]. However, compared with Nguyen Van Hieu (2020) in the Tay Thien stream, the number of species of stoneflies in the study area is higher. 03 species of stonefly family Perlidae were recognized in the Tay Thien stream [11].

Compared with the study of Cao Thi Kim Thu (2019), this study has identified the species *Nemoura apicalis* Sivec & Stark, 2010, a new record of the fauna of stoneflies in Tam Dao National Park, Vinh Phuc province. Previously, the specimens of this species were only caught in Hoang Lien National Park, Lao Cai province. Some characteristics of adults of the *Nemoura apicalis* Sivec & Stark, 2010: a few sensilla basiconica scattered on tergum 10; epiproct short, broad basally in dorsal aspect and bearing a small apical notch; cercal apices curved outward at the tip forming a truncate, foot shaped structure; paraproct inner lobes slender and essentially parallel to one another, outer lobes large and triangular in outline; vesicle about 3 times long as wide.

Of the 31 species of stoneflies identified, 22 species (70.9% of the total number of species) are endemic to Vietnam encountered in the study area and 11 species (35.9% of the total number of species) are endemic to Tam Dao National Park, Vinh Phuc province, including:

+ Four species belonging to family Nemouridae: *Amphinemura tamdao* Stark & Sivec, 2010; *Indonemoura angulata* Stark & Sivec, 2010; *Indonemoura clavata* Stark & Sivec, 2010; *Nemoura clavaloba* Sivec & Stark, 2010.

+ Seven species belonging to family Perlidae: *Acroneuria apicalis* Stark & Sivec, 2008; *Chinoperla gorohovi* Sivec & Stark, 2010; *Chinoperla sila* Sivec & Stark, 2010; *Hemacroneuria malickyi* Stark & Sivec, 2008; *Kamimuria atrocephala* Stark & Sivec, 2008; *Neoperla dao* Stark & Sivec, 2008; *Neoperla multispinosa* Stark & Sivec, 2008.

In particular, the species *Phanoperla* sp. may be a new species to science; the specimens of this species have only been found in Tam Dao National Park, Vinh Phuc province, belonging to nymphs. The nymph of *Phanoperla* sp. can be separated from other species of the genus *Phanoperla* by the combination of the following characteristics: general body color yellowish brown, small body size, body length 3.2-5.1 mm; head width 1.0-1.6 mm, head with dark brown markings along anterior margins to the central area, between ocelli, and behind the occipital ridge. Antennae are slender, 1.5-2.5 mm long, nearly half as long as body length, and yellowish. The compound eye is large and black.

Two small ocelli, contacted with transverse occipital ridge. Anal gills are present. Cerci stout, length 1.2-2.5 mm, is covered with fine hairs, and without swimming hairs.

2.2.2. Comparison of species and individual number of stoneflies in riffle and pool habitats in Tam Dao National Park

Along with qualitative samples to determine the presence of the species in the studied area, we carried out quantitative samples in both riffle and pool habitats to investigate the distribution of stoneflies according to the characteristics of the streams. Survey results are shown in Table 2.

Table 2. The number of species and individuals in each sampling site in Tam Dao National Park, Vinh Phuc province

Sampling site	The number of species/0.5 m ²		The number of individuals/0.5 m ²	
	Riffle	Pool	Riffle	Pool
TB 1	3	1	5	2
TB 2	4	1	7	1
TB 3	3	1	5	1
XH 1	1	2	2	3
XH 2	2	0	2	0
XH 3	1	0	3	0
<i>Average ± SD</i>	2.3 ± 1.2	0.8 ± 0.8	4.0 ± 2.0	1.2 ± 1.2

Explication: SD: Standard deviation

As in Table 2, the number of stonefly species or individuals in the riffle habitat was generally higher than that in the pool habitat of the same sampling site. The exception was in site XH 1, where the number of species and number of individuals in the riffle habitat was lower than in the pool habitat.

Overall, the average numbers of species in the riffle habitat and pool habitat of 6 sites were 2.3 ± 1.2 and 0.8 ± 0.8 respectively, and the average numbers of individuals were 4.0 ± 2.0 in riffle and 1.2 ± 1.2 in pool habitats. When using statistical means of spot-checking with $\alpha = 0.05$, we found that the difference between the number of species in riffle habitat and pool habitat was statistically significant (t Stat > t Critical two-tail). Besides, the difference between the number of individuals in riffle habitat and pool habitat was also statistically significant.

3. Conclusions

In Tam Dao National Park, Vinh Phuc province, a total number of 31 species of stoneflies belong to 13 genera and 2 families Nemouridae and Perlidae. Family Nemouridae had 6 species and family Perlidae had 25 species.

Nemoura apicalis Sivec & Stark, 2010 was a new record species of the stoneflies fauna of the Tam Dao National Park, Vinh Phuc province. The species *Phanoperla* sp. may be a new species to science.

22 species encountered in the study area are endemic to Vietnam and 11 species of the family Nemouridae and family Perlidae are endemic to Tam Dao National Park, Vinh Phuc province.

The average number of species (2.3 ± 1.2) and the average number of individuals (4.0 ± 2.0) in the riffle habitat were higher than that in the pool habitat (number of species: 0.8 ± 0.8 ; number of individuals: 1.2 ± 1.2) with the statistics mean $\alpha = 0.05$.

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