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THE STUDY ON SPECIES COMPOSITION OF MAYFLIES (EPHEMEROPTERA: INSECTA) IN TAM DAO DISTRICT VINH PHUC PROVINCE

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Abstract. Based on a field survey in December 2021, the present study has recorded 45 species, 28 genera, and 8 families of mayflies in Tam Dao district, Vinh Phuc province. Dominant families included Baetidae and Heptageniidae with 15 and 13 species, respectively. Other families, Caenidae, Ephemerellidae, Ephemeridae, Leptophlebiidae, Polymitarcyidae, and Teloganodidae were found with 1-6 species. Two species *Polyplocia orientalis* Nguyen & Bae 2003 and *Teloganodes tristis* (Hagen, 1858) were new records of the Mayfly fauna of the Tam Dao district. This study also provides data on the level of similarity in species composition and biodiversity index between study areas.

Keywords: composition species, Mayflies, Tam Dao district, Vinh Phuc province.

1. Introduction

Mayfly (order Ephemeroptera) is any member of a group of insects known for their extremely short life spans and emergence in large numbers. Other common names for the winged stages are shadfly, sandfly, dayfly, fishfly, and drake. The aquatic immature stage, called larvae, is widely distributed in freshwater, such as rivers, streams, ponds, lakes, and other artificials. Mayfly larvae are slender and soft-bodied, like adults. However, they lack wings, have a series of leaflike or feathery external gills attached along the sides or on the top rear portion of the abdomen, have smaller eyes than adults, and often have a flattened head that helps them to adhere to rocks in fast-flowing water. Mayfly larvae possess 2 or 3 cerci, antenna-like appendages extending from the tip of the abdomen [1].

Tam Dao is a rural district of Vinh Phuc province in the Red River Delta region of northern Vietnam. It is bounded by Thai Nguyen, Tuyen Quang provinces, and Lap Thach, Tam Duong, and Binh Xuyen districts (Vinh Phuc province). The topography of the Tam Dao district is mostly mountainous, with many rivers, streams, lakes, and waterfalls. Generally, natural conditions in the Tam Dao district facilitate the

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development of mayflies. In recent years, the study on the taxonomy of mayflies in the Tam Dao district has received attention. However, the study on these groups is done mainly in Tam Dao National Park. Therefore, the main goal of this study was to provide complete data on mayflies in this district up to the time of publication.

2. Content

2.1. Materials and methods

2.1.1. Materials

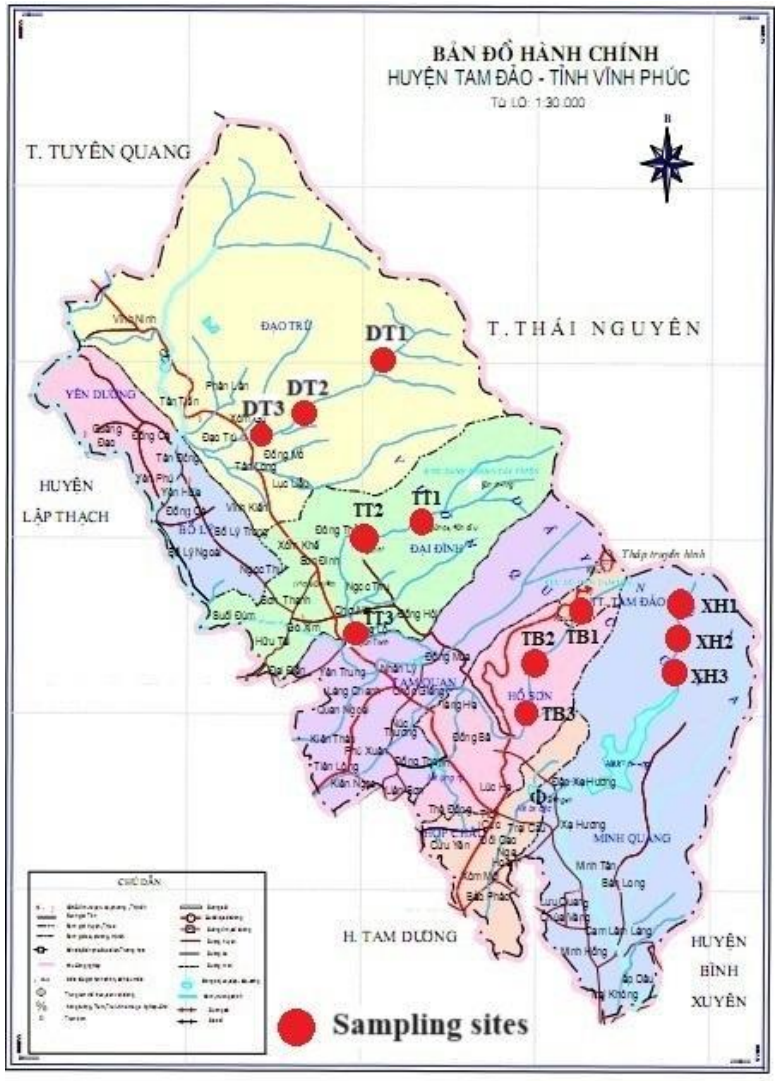
The species belonging to the larvae of mayflies were collected at 12 different sampling sites in December 2021, as listed below and in Table 1, Figure 1.

Dao Tru stream, 03 sampling sites: DT 1, DT 2, DT 3; Tay Thien stream, 03 sampling sites: TT 1, TT 2, TT 3; Thac Bac stream, 03 sampling sites: TB 1, TB 2, TB 3; Xa Huong stream, 03 sampling sites: XH 1, XH 2, XH 3.

Table 1. Environmental parameters of the sampling sites in the Tam Dao district

Site	Location	Altitude (m)	Wid (m)	Dep (cm)	Cov (%)
DT 1	N: $21^0$29,996’ E: $105^0$33,72’	88	12 - 13	10 - 20	0 - 5
DT 2	N: $21^0$29,833’ E: $105^0$33,528’	59	6 - 7	8 - 15	0 - 5
DT 3	N: $21^0$29,556’ E: $105^0$32,786’	47	5 - 6	10 - 12	0 - 5
TT 1	N: $21^0$28,595’ E: $105^0$36,483’	351	6 - 7	15 - 25	60 - 75
TT 2	N: $21^0$28,232’ E: $105^0$35,477’	90	9 - 14	10 - 20	10 - 15
TT 3	N: $21^0$26,486’ E: $105^0$34,320’	28	15 - 20	15 - 25	10 - 12
TB 1	N: $21^0$27,097’ E: $105^0$38,517’	789	4 - 7	8 - 15	80 - 85
TB 2	N: $21^0$26,220’ E: $105^0$37,649’	195	7 - 9	10 - 20	70 - 80
TB 3	N: $21^0$25,442’ E: $105^0$37,562’	100	8 - 12	15 - 25	5 - 10
XH 1	N: $21^0$24,907’ E: $105^0$38,768’	97	2 - 3	10 - 12	5 - 10
XH 2	N: $21^0$24,847’ E: $105^0$38,542’	83	5 - 7	12 - 15	3 - 5
XH 3	N: $21^0$24,652’ E: $105^0$38,478’	68	8 - 12	15 - 25	2 - 4

Explication: Wid - Width of stream, Dep - Depth of stream, Cov - Coverage



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

Figure 1. Location of sampling sites in Tam Dao district

2.1.2. Methods

The specimens were taken by using hand nets, pond nets, and surber nets according to methods illustrated by Edmund (1982) [1], and Nguyen Xuan Quynh et al. (2004) [2]. The specimens were collected by placing the mouth of the racket 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 with many bushes, hand nets were used to collect samples. In places where there are large rocks at the bottom that cannot be collected, nets were kicked, the rocks were lifted, and samples stuck to the bottom were collected with a soft pint to avoid crushing the sample. Qualitative sampling was performed in both riffles and pools. In many places where there are aquatic shrubs, a racquet was used to scour the shrubs and tree roots along the stream banks. In small water areas or narrow streams, sampling was carried out with a hand net.

The quantitative samples of mayflies were taken using the Surber net (50cm x 50cm), one sample for riffles and one for pools in each site. All the materials were preserved in 80% ethanol, and deposited in the Lab of Zoology, Hanoi Pedagogical University 2. In addition, this study also used specimens deposited in Hanoi University of Science (VNU). Specimens are classified based on the external morphology of larvae. Identification of specimens followed taxonomic publications of respective taxa [3-8].

The similarity Sorensen index, Margalef's richness index (d), and Shannon - Weaver species diversity index (H'$\log_e$) were calculated according to Smith and Smith (2001) [9].

Table 2. The level of biodiversity is based on d-index and H'-index

d - index	Level	H' - index	Level
> 3.5	Very rich	> 3.0	Good
2.6 - 3.5	Rich	2.1 - 3.0	Rather
1.6 - 2.5	Relatively good	1.0 - 2.0	Normal
0.6 - 1.5	Normal	< 1.0	Least
< 0.6	Least		

2.2. Results and discussion

2.2.1. The species composition of mayflies in Tam Dao district

Recent field surveys in Tam Dao district, Vinh Phuc province have resulted in the records of 45 species, 28 genera, and 8 families of mayflies. A checklist of the species composition of mayflies in the Tam Dao district is shown in Table 3.

Table 3. The species composition of mayflies in the Tam Dao district

No.	Taxon	TB	XH	DT	TT
	Family Baetidae Leach, 1815				
1	*Acentrella lata* Muller & Liebenau, 1985	+	+	+	+
2	*Acentrella* sp.	+	+	-	-
3	*Baetiella bispinosa* Tong & Dudgeon, 2000	-	+	-	-
4	*Baetiella trispnata* Tong & Dudgeon, 2000	-	-	+	+
5	*Baetiella* sp.	+	-	-	+
6	*Baetis* sp.1	+	+	+	+
7	*Baetis* sp.2	+	+	+	+
8	*Baetis* sp.3	+	+	+	+
9	*Centroptella* sp.	+	-	-	-
10	*Labiobaetis* sp.1	+	+	+	+
11	*Labiobaetis* sp.2	+	+	+	+
12	*Nigrobaetis* sp.1	+	+	+	+
13	*Nigrobaetis* sp.2	+	+	+	+

No.	Taxon	TB	XH	DT	TT
14	*Platybaetis edmundsi* Muller & Liebenau, 1980	+	+	+	+
15	*Procloeon spinosum* Tungpairojwong, Nguyen & Bae, 2006	+	-	-	+
	Family Caenidae Newman, 1853				
16	*Caenis cornigera* Kang & Yang, 1994	+	+	+	+
17	*Caenis* sp.	+	+	+	+
	Family Ephemerellidae Klapálek, 1909				
18	*Teloganopsis jinghongensi* (Xu, You & Hsu, 1984)	+	+	+	+
19	*Torleya coheri* (Allen & Edmunds, 1963)	+	+	+	+
20	*Torleya nepalica* (Allen & Edmunds, 1963)	+	+	-	+
	Family Ephemeridae Lattreille, 1810				
21	*Eatonigenia* sp.	-	-	-	+
22	*Ephemera longiventris* Navas, 1922	-	+	-	-
23	*Ephemera serica* Eaton, 1871	+	+	+	+
24	*Ephemera* sp.	+	-	-	-
	Family Heptageniidae Nedham & Betten, 1901				
25	*Aforunus meo* Nguyen & Bae, 2003	-	-	+	-
26	*Aforunus mnong* Nguyen & Bae, 2003	-	-	+	-
27	*Asionurus primus* Braasch & Soldán, 1986	+	+	+	+
28	*Ecdyonurus cervina* Braasch & Soldán, 1984	+	+	+	+
29	*Ecdyonurus landai* Braasch & Soldán, 1984	+	+	+	+
30	*Epeorus hieroglyphicus* Braasch & Soldán, 1984	-	-	+	+
31	*Epeorus tiberius* Braasch & Soldán, 1984	+	-	+	+
32	*Iron martinus* Braasch & Soldán, 1984	+	-	-	+
33	*Rhithrogena parva* Ulmer, 1912	-	-	+	+
34	*Rhithrogeniella tonkinensis* Braasch & Soldán, 1986	-	-	-	+
35	*Paegniodes dao* Nguyen & Bae, 2004	-	+	-	+
36	*Thalerosphyrus vietnamensis* Dang, 1967	+	-	-	+
37	*Trichogenia maxillaries* Braasch & Soldan, 1988	-	-	+	+
	Family Leptophlebiidae Banks, 1990				
38	*Choroterpes proba* Ulmer, 1939	-	-	-	+
39	*Choroterpes trifurcata* Ulmer, 1939	+	+	-	+
40	*Choroterpes vittata* Nguyen & Bae, 2003	-	-	+	+

No.	Taxon	TB	XH	DT	TT
41	*Choroterpes* sp.	-	+	-	+
42	*Habrophlebiodes prominent* Ulmer, 1939	+	+	-	+
43	*Isca janiceae* Peters & Edmund, 1970	+	-	-	-
	Family Polymitarcyidae Bank, 1900 *				
44	*Polyplocia orientalis* Nguyen & Bae 2003 *	-	+	-	-
	Family Teloganodidae McCafferty & Wang, 1997 *				
45	*Teloganodes tristis* (Hagen, 1858) *	-	+	-	+
Total		**29**	**27**	**25**	**36**

*Note: +: present; -: no present; *: new records to the Tam Dao district.*
TB: Thac Bac stream, XH: Xa Huong stream,
DT: Dao Tru stream, TT: Tay Thien stream

Among these 45 species, 31 species were identified to species. The taxonomic composition of the order Ephemeroptera in the Tam Dao district is shown in Table 4.

Table 4. The taxonomic composition of mayflies in the Tam Dao district

No.	Family	Genus		Species	
		Number	Percentage	Number	Percentage
1	Baetidae	8	28.6%	15	33.3%
2	Caenidae	1	3.6%	2	4.4%
3	Ephemerellidae	2	7.1%	3	6.8%
4	Ephemeridae	2	7.1%	4	8.9%
5	Heptageniidae	10	35.7%	13	28.9%
6	Leptophlebiidae	3	10.7%	6	13.3%
7	Polymitarcyidae	1	3.6%	1	2.2%
8	Teloganodidae	1	3.6%	1	2.2%
Total		**28**	**100%**	**45**	**100%**

- *At the generic level***:** the family Heptageniidae was the most diverse group with 10 genera (35.7% of the total genus number). There were 8 genera (28.6% of the total genus number) belonging to the family Baetidae. The remaining families were represented by one to three genera each. In this study, 3 families -Caenidae, Polymitarcyidae, and Teloganodidae - were the least diverse group with only one genus.

- *At the species level***:** the family Baetidae was the family with the highest number of species, 15 species (33.3% of the total species number). Among these 15 species of the family Baetidae, 10 species were not determined to be species (form sp.). In general, the larvae of these species have a small body length (about 2-6 mm); the taxonomic system

of the family Batidae in Vietnam and the world is still limited. Heptageniidae was the second richest family with 13 species (28.9% of the total species number). The third richest family was Leptophlebiidae with 6 species (13.3%). All of them were identified as species. Ephemeridae was represented with 4 species (8.9%),family Caenidae and family Ephemerellidae with 2 and 3 species, respectively. The last two families are Polymitarcyidae and Teloganodidae with only one species each (Table 4). Compared with Nguyen Van Vinh et al. (2016), the number of species of mayflies collected in the study area is lower. This study has not yet encountered these families Isonychiidae, Neoephemeridae, Potamanthidae, and Vietnamellidae [10]. However, compared with Nguyen Van Hieu (2020), the number of species of mayflies in this research is higher. According to Nguyen Van Hieu (2020), Dai Dinh Town has 32 species, 19 genera, and 6 families and has not yet encountered the family Teloganodidae [11].

The survey results show two species *Polyplocia orientalis* Nguyen & Bae 2003 and *Teloganodes tristis* (Hagen, 1858) were new records to Tam Dao district (Figure 2). The species *Polyplocia orientalis* Nguyen & Bae 2003 was collected in the Xa Huong stream and *Teloganodes tristis* (Hagen, 1858) was found in the Xa Huong stream and Tay Thien stream. Before, in Vinh Phuc province, specimens of these species had only been encountered at Me Linh Station for Biodiversity [12].

Polyplocia orientalis Nguyen & Bae 2003

Teloganodes tristis (Hagen, 1858)

***Figure 2. The larvae (dorsal) of Polyplocia orientalis* Nguyen & Bae 2003 *and Teloganodes tristis* (Hagen, 1858)**

Source: Nguyen Van Hieu, 2021

Larvae of *Teloganodes tristis* (Hagen, 1858) can be distinguished from other species by the following combination of characters: abdominal tergites 1-10 each with median posterior tubercles, gills present on segments 2 - 5, first pair of gills largest and operculate,wo caudal filaments [8].

Some characteristics of larvae of the *Polyplocia orientalis* Nguyen & Bae 2003: body relatively large, tusks cylindrical with numerous long hairlike setae dorsally and laterally, and apical extension of tibiae of forelegs nearly one-fourth of tarsi [13].

2.2.2. Some characteristics of mayflies between the streams in the studied areas

This study was conducted in 4 streams: Thac Bac, Xa Huong, Tay Thien, and Dao Tru, with 3 sampling sites in each stream (Figure 1). The taxon number of mayflies between the streams in the studied areas is shown in Table 5.

Table 5. The taxon number of mayflies between the streams in the studied areas

Taxonomic rank	Thac Bac	Xa Huong	Dao Tru	Tay Thien
Family	6	8	6	7
Genus	20	17	17	24
Species	29	27	25	36

The results in Table 5 showed that there were clear differences in the number of genera and species of mayflies between the streams in the studied area. The number of taxa found in the Dao Tru stream was lower (25 species, 17 genera, 6 families) than those in the other streams. The Tay Thien stream had the highest number of species and genera with 36 species and 24 genera.

The Sorensen similarity index in Table 6 and Figure 3 is calculated based on the similarities of species composition of mayflies between four streams. The results showed that the values of similarity were relatively high, ranging from 65.4% to 76.9%. The species composition of order Ephemeroptera in the Dao Tru stream is the most different from the other streams.

Table 6. The Sorensen similarity index (%) of mayfly communities between the streams in the studied areas

Streams	Thac Bac	Xa Huong	Dao Tru	Tay Thien
Thac Bac				
Xa Huong	75.0			
Dao Tru	66.7	65.4		
Tay Thien	76.9	73.0	75.4	

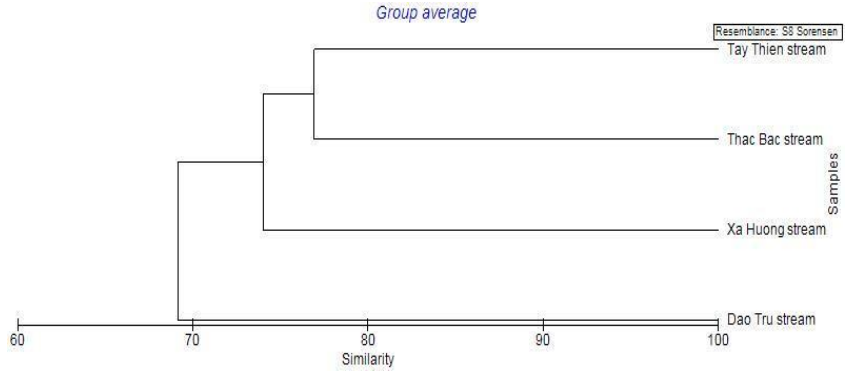


Figure 3. The level of similarity of mayfly species composition is based on the Sorensen index

d - index and H' - index are two biodiversity indexes identified in this research. The results of the d - index and H ' - index are shown in Table 7.

Table 7. The value of the d - index and the H' - index of the mayflies in the streams

Streams	S	N	d	Level	H'	Level
Thac Bac	11	62	2.4	Relatively good	2.2	Rather
Xa Huong	12	47	2.9	Rich	2.3	Rather
Dao Tru	9	38	2.2	Relatively good	2.0	Normal
Tay Thien	18	88	3.8	Very rich	2.7	Rather
$\overline{X} \pm SD$	*12.5 ± 3.9*	*58.8 ± 21.9*	*2.8 ± 0.7*	*Rich*	*2.3 ± 0.3*	*Rather*

Explication: S: Number of species; N: Number of individuals; SD: Standard deviation

The value of the d-index and the H' - index was the lowest at the Dao Tru stream with 2.2 and 2.0, respectively. The value of the indexes was the highest in the Tay Thien stream with 3.8 and 2.7, respectively. The values of the d- index and H'- index have a proportional relationship with the number of species obtained in the streams. The higher the number of species, the higher the values of the d- index and H'- index also tend to increase.

3. Conclusions

From the samples collected from Tam Dao district, Vinh Phuc province, a total of 45 mayfly species, 28 genera, and 8 families were identified. Baetidae and Heptageniidae were the richest families, with 8 genera, 15 species, and 10 genera, 13 species, respectively.

Two species *Polyplocia orientalis* Nguyen & Bae 2003 and *Teloganodes tristis* (Hagen, 1858) were new records to the Mayfly fauna in this area.

The Tay Thien stream had the highest number of species with 36 species. The value of the d - index and the H' - index was the lowest at the Dao Tru stream (d - index: 2.2 and H' - index: 2.0) and the highest in the Tay Thien stream (d - index: 3.8 and H' - index: 2.7).

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