SEASONAL VARIATION OF AQUATIC INSECTS' FUNCTIONAL FEEDING GROUPS DOWNSTREAM OF DONG BUA STREAM, PHU THO PROVINCE

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ABSTRACT

This study assessed the seasonal variation of aquatic insects' functional feeding groups in ecologically important waterbodies, in downstream of Dong Bua stream, in Tam Dao National Park, Phu Tho province. Specimens were collected both quantitatively and qualitatively in five sites in the study area. Results showed that: 88 species from 75 genera, 42 families, and 9 orders, including Ephemeroptera with 26 species, Odonata with 19 species, Trichoptera with 18 species, Coleoptera with 8 species, Diptera with 7 species, Hemiptera with 6 species, Plecoptera with 2 species and 1 species each of Megaloptera and Lepidoptera. The Shannon-Weaver diversity index (H') in the dry season (2.23 ± 0.18) was higher than that in the rainy season (1.81 ± 0.22). The structure of functional feeding groups included five groups: collector-gatherers (44.67%), scrapers (32.39%), collector-filterers (14.69%), predators (5.43%) and shredders (2.82%). The structure of functional feeding groups varied seasonally; the percentages of the scrapers and the collector-filterers in the dry season were lower than in the rainy season. However, the percentages of the collector-gatherers and the predators in the dry season were higher than in the rainy season. The shredders didn't almost change during all season. The functional feeding groups ratio indicated that the sampling site St3 was a highly heterotrophic site (P/R = 0.13) and the sampling site St1 was the least heterotrophic site (P/R = 2.40). Data on the structure of functional feeding groups and their seasonal variation in the downstream section of the Dong Bua stream provide valuable information for the monitoring and management of freshwater resources, as well as for the conservation of aquatic insect communities.

BIẾN ĐỔI THEO MÙA NHÓM DINH DƯỠNG CHỨC NĂNG CỦA CÔN TRÙNG THỦY SINH Ở HẠ LƯU SUỐI ĐỒNG BÙA, TỈNH PHÚ THỌ

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TỪ KHÓA

Côn trùng nước
Nhóm dinh dưỡng chức năng
Hạ lưu
Suối Đồng Bùa
Tỉnh Phú Thọ

TÓM TẮT

Nghiên cứu này đã đánh giá sự thay đổi theo mùa của các nhóm dinh dưỡng chức năng của côn trùng thủy sinh ở hạ lưu suối Đồng Bùa, thuộc Vườn Quốc gia Tam Đảo, tỉnh Phú Thọ. Các mẫu vật được thu thập cả về mặt định lượng và định tính tại năm địa điểm trong khu vực nghiên cứu. Kết quả cho thấy: 88 loài thuộc 75 giống, 42 họ và 9 bộ côn trùng thủy sinh ở hạ lưu suối Đồng Bùa. Thành phần loài bao gồm 26 loài Phù du, 19 loài Chuồn chuồn, 18 loài Cánh lông, 8 loài Cánh cứng, 7 loài Hai cánh, 6 loài Cánh nửa, 2 loài Cánh úp, 1 loài Cánh rộng và 1 loài Cánh vảy. Chỉ số Shannon-Weaver (H') vào mùa khô (2,23 ± 0,18) cao hơn so với mùa mưa (1,81 ± 0,22). Cấu trúc nhóm dinh dưỡng chức năng bao gồm năm nhóm: nhóm thu gom (44,67%), nhóm cào nạo (32,39%), nhóm thu lọc (14,69%), nhóm ăn thịt (5,43%) và nhóm cắt xé (2,82%). Cấu trúc nhóm dinh dưỡng chức năng theo mùa có sự khác biệt, tỷ lệ phần trăm của nhóm cào nạo và nhóm thu lọc trong mùa khô thấp hơn mùa mưa. Nhóm thu gom và nhóm ăn thịt trong mùa khô cao hơn hơn mùa mưa. Nhóm cắt xé hầu như không thay đổi theo mùa. Tỷ lệ nhóm dinh dưỡng chức năng chỉ ra rằng điểm St3 có tính dị dưỡng cao (P/R = 0,13) và điểm St1 là địa điểm có tính dị dưỡng thấp nhất (P/R = 2,40). Dẫn liệu về cấu trúc nhóm dinh dưỡng chức năng và sự thay đổi theo mùa của chúng ở hạ lưu suối Đồng Bùa cung cấp thông tin có giá trị cho việc theo dõi và quản lý tài nguyên nước ngọt cũng như bảo tồn quần xã côn trùng thủy sinh.

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1. Introduction

Aquatic insects are insect species that inhabit freshwater environments, including swamps, ponds, lakes, streams, and rivers. Approximately 8600 species of aquatic insects, classified into 12 orders and 150 families, are known to occupy diverse freshwater ecosystems [1]. These insects play crucial ecological roles as primary consumers, detritivores, and predators in aquatic habitats. Due to their high abundance, rapid birth rate with short generation times, substantial biomass, and quick colonization of freshwater habitats, aquatic insects serve as model organisms for analyzing the structure and function of freshwater ecosystems [2].

The classification of Functional Feeding Groups (FFGs) is based on the morphological and behavioral traits associated with food acquisition. Aquatic insects are categorized into five groups according to their feeding strategies and consumption of various food resources: shredders (sh), collector-gatherers (c-g), collector-filterers (c-f), predators (p), and scrapers (sc) [3]. Seasonal changes are key drivers of biodiversity and ecosystem processes, influencing species composition, trophic interactions, and resource availability. Understanding these variations is essential for assessing ecosystem stability and resilience. Seasonal variations, particularly dry and rainy seasons, significantly influence the abundance, diversity, and activity of these groups by creating dynamic shifts in freshwater ecosystems, influencing the composition and function of aquatic insect communities [4]. While some FFGs thrive under specific conditions, others face challenges requiring adaptive strategies such as diapause, migration, or habitat selection. Understanding these seasonal impacts is crucial for freshwater conservation, habitat management, and predicting responses to climate variability [5].

Dong Bua stream is one of the most important streams located in Tam Dao National Park, Phu Tho province, and provides rich habitats for various freshwater organisms, including aquatic insects. However, the insect fauna of Dong Bua stream remains largely unexplored. Nguyen et al. [6] documented the altitudinal distribution of aquatic insects in Thac Bac Creek, marking the first comprehensive faunistic study of aquatic insects in the Tam Dao locality. Subsequent studies including [7] - [12] had investigated the aquatic insect fauna in this area. However, no published research has yet examined the biodiversity and FFGs of aquatic insects in downstream of Dong Bua stream. This is the first aiming to analyze FFGs to determine the functional role of the ecosystem, assessing the diversity of aquatic insects and their FFGs in Dong Bua stream in the administrative area of Tam Duong Bac commune, Phu Tho province.

2. Materials and methods

The aquatic insect specimens larvae and nymphs were collected at five sampling sites from downstream of Dong Bua stream, in Phu Tho province covering the two different seasons, which include the dry season (December 2023) and the rainy season (June 2024).

The samples were collected using a pond net and a hand net for qualitative sampling and a Surber net (30 cm × 30 cm, mesh size 0.2 mm) for quantitative sampling. Two quantitative samples were taken from riffle and pool habitats at each sampling site. Geographic location and altitude were recorded at all sampling sites by GPS (Table 1).

Table 1. *Sampling sites from Dong Bua stream*

Site	Latitude "N"	Longitude "E"	Altitude (m)	Landscape
S1	$21^0 26' 41,5''$	$105^0 36' 32,8''$	117	Forest
S2	$21^0 26' 39,2''$	$105^0 36' 31,4''$	104	Forest
S3	$21^0 26' 28,7''$	$105^0 36' 26,9''$	98	Forest
S4	$21^0 26' 25,2''$	$105^0 36' 19,7''$	80	Village
S5	$21^0 26' 15,7''$	$105^0 36' 13,1''$	67	Village

The samples were preserved in 80% ethanol. The collected specimens have been deposited in the Lab of Zoology, Hanoi Pedagogical University 2.

The aquatic insects were identified to the genus or species level based on available identification keys [4], [13]-[18].

Using FFGs ratios as bioindicators of stream ecological attributes. The aquatic insects were classified into FFGs by using the criteria of Cummins [3]. Table 2 retrieved from Cummins et al. [19] represents the ratios with their criteria ratio levels.

Table 2. *Ratios of the FFGs used as surrogates of ecosystem stream function* [19]

Symbols	FFG ratios for attributes	General criteria ratio levels
P/R	sc/(shredders+total collectors)	Autotrophic > 0.75
CPOM/FPOM	sh/total collectors	Shredder (sh) association with functioning riparian area > 0.25
TFPOM/BFPOM	c-f/c-g	FPOM transport > 0.50
Channel Stability	(sc+c-f)/(sh+c-g)	Stable substrates plentiful > 0.50
Pr	Predators to total all other groups	Typical predators-to-prey balance 0.10 - 0.20

The number of individuals in each taxon was counted for diversity measurement. Shannon-Weaver diversity index (H') was calculated according to Smith et al. [20]. The level of biodiversity based on the H'-index is shown in Table 3.

Table 3. *The level of biodiversity based on the H'-index*

H' - index	Level
> 3.0	Good
2.0 - 3.0	Rather
1.0 - 2.0	Normal
< 1.0	Least

Data processing: Data was processed using Microsoft Office Excel® 2019 software from Microsoft Corporation® to calculate means and standard deviations (SD), and mean comparisons were performed using the t-Test ($\alpha = 0.05$). The diversity index (H′) was calculated using PRIMER v6 software.

3. Results

3.1. Biodiversity of aquatic insects

Identification of quantitative and qualitative samples of both larvae and nymph stages, we recorded a total number of 88 species, 75 genera, 42 families, and 9 orders of aquatic insects from downstream of Dong Bua stream. Nine orders of aquatic insects were classified mostly to the genus level. Ephemeroptera (26 species, 29.54%), Odonata (19 species, 21.59%), and Trichoptera (18 species, 20.45%) constituted the three major aquatic insect groups. The other minor groups included: Coleoptera (8 species, 9.09%), Diptera (7 species, 7.96%), Hemiptera (6 species, 6.82%), Plecoptera (2 species, 2.27%), Lepidoptera (1 species, 1.14%), and Megaloptera (1 species, 1.14%).

Compared with previous studies, the number of aquatic insect species from Dong Bua stream was lower [5], [21]-[25]. The orders Ephemeroptera, Odonata, and Trichoptera had the highest species numbers in the studied area. These orders usually dominate in stream ecosystems.

In the dry season, the diversity index (H') indicated that all sites were higher than in the rainy season. The highest diversity index amount was found at site St3 (H' = 2.38) and the lowest was found at site St2 (H' = 1.63). The diversity index (H') in the dry season was from 1.91 to 2.38 (average 2.23 ± 0.18) and in the rainy season from 1.63 to 2.19 (average 1.81 ± 0.22). The level of biodiversity in the dry season (Rather) was higher than that in the rainy season (Normal) with P(T<=t) two-tail < 0.05, $\alpha = 0.05$.

In the riffle habitats, the average numbers of species (8.00 ± 2.16) and the number of individuals (24.90 ± 16.51) were higher than that in pool habitats (5.20 ± 3.19) and (11.10 ± 8.82). The number of species and individuals at each sampling site were significantly different (P(T<=t) two-tail < 0.05, α = 0.05 respectively) between the habitat types. The aquatic insects are often distributed at riffles, where oxygen is high, and water quality is usually good [26].

3.2. Functional feeding groups

Based on the FFGs, 88 taxa of aquatic insects were categorized with five FFGs (Figure 1). Collector-gatherers (c-g) and predators (p) were the dominant groups, accounting for more than 50% of all individuals, primarily consisting of Ephemeroptera, Trichoptera, and Odonata taxa. The proportions of collector-filterers (c-f) and scrapers (sc) were 14.69% and 32.39%, respectively. Collector-filterers were mainly represented by taxa of Trichoptera, while scrapers included many taxa of Ephemeroptera and Trichoptera. Shredders were the least dominant group among all aquatic insects. This result shows that the source of nutrients supplied to the stream is rich and diverse.

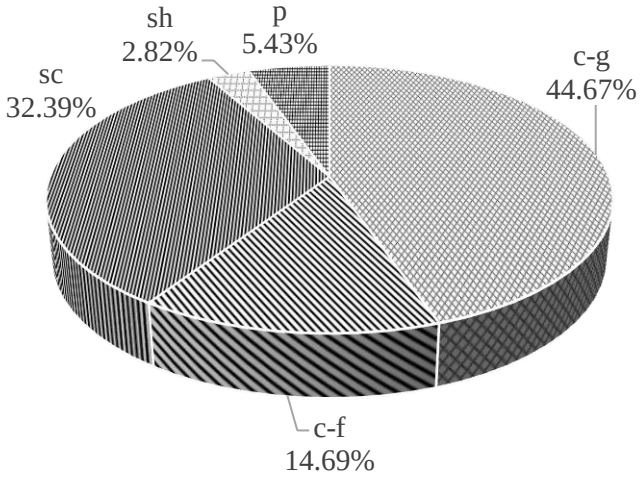

Figure 1. *Percentages (%) of aquatic insect's FFGs from all seasons*

Collector-gatherers were high numbers of individual samples of Caenidae and Baetidae contributing to the dominant taxa of the collector-gatherers at each site. This feeding group comprised 44.67% of all collected samples. The dominance of the collector-gatherer group reflects the presence of fine, bottom-settling or suspended matter components in the stream. The collector-gatherers group (c-g) composition is also dominant in other research results, such as in Mae Sot (Thailand) the group accounts for 55% [26], in North - western Rif with 39.47% [27], this can be considered a similarity between upstream and downstream flows, in Dak Pri stream, in Krong No (Vietnam) the group accounts for over 40% of individuals [28]; in upstreams of Da Nhim River (Vietnam), the group accounts for 46% [29].

Seasonal variation was observed in the structure of FFGs, the percentages of the scrapers (sc) increased from 27.41% (12/2023) to 34.25% (6/2024) and collector-filterers (c-f) increased from 5.93% (12/2023) to 17.96% (6/2024); the collector-gatherers (c-g) decreased from 51.85% (12/2023) to 41.99% (6/2024) and the predators (p) decreased from 11.11% (12/2023) to 3.31% (6/2024). The shredders (sh) remained nearly unchanged across seasons.

Collector-gatherers also show significant seasonal changes. This can be explained by seasonal shifts that increase or decrease flow, leading to changes in the composition of fine particles present in the water environment. Along with the variability of the above ecosystem, this causes fluctuations in the composition of materials drifting downstream [29].

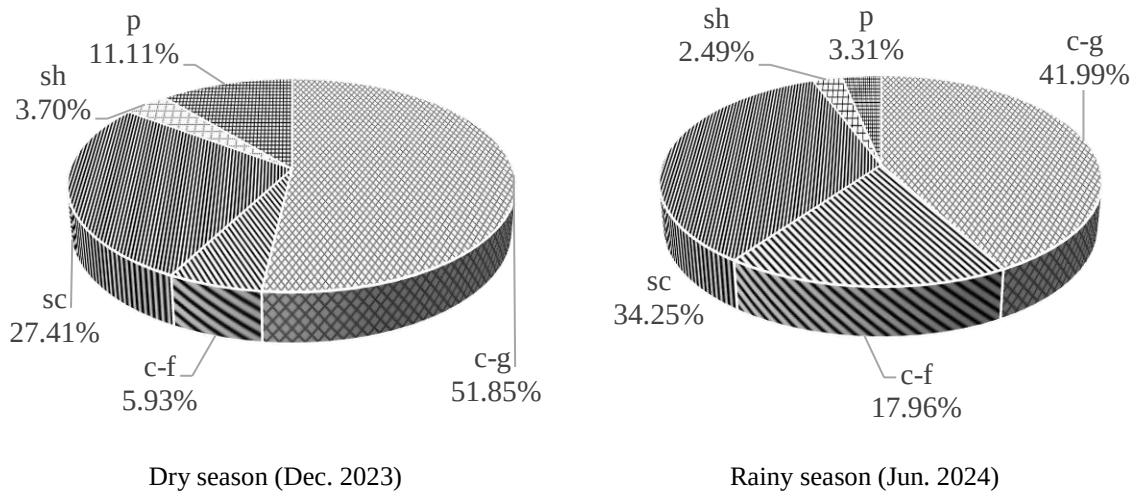

Figure 2. *Percentages (%) of aquatic insect's FFGs from dry season and rainy season*

Collector-filterers were primarily composed of hydropsychid caddisflies, with several genera represented, particularly *Cheumatopsyche* sp., which was the most abundant within this feeding group. The species *Habrophlebiodes prominens* was the most significant contributor to the scraper. Other species, such as *Goera* sp. and *Eubrianax* sp., also played a role in this group. Percentages of scrapers and collector-filterers during the rainy season were always higher than in the dry season, as filtering collectors and scrapers require stable surfaces for attachment and grazing. Consequently, flooding may impact channel stability. This finding aligns with the study by Bui et al. [29], which also observed that the proportion of collector-filterers and scrapers tends to be higher in the rainy season compared to the dry season.

Predators, such as Odonata, Plecoptera, Megaloptera, and Hemiptera, are considered a balancing factor in the community of aquatic insects. The percentage of this group was higher in the dry season. The increase in the percentage of predators during the dry season is explained by the increase in the number of individuals of the family Gomphidae (Odonata). The increase in the abundance of Gomphidae larvae during the dry season can be primarily attributed to higher prey density, increased habitat stability, and reduced predation pressure.

Shredders occupy a very low percentage (3.70% in the dry season, 2.49% in the rainy season) but remain stable within the feeding functional structure. The presence of this group shows that there are such as leaves, branches, tree trunks, etc. in the stream from the riparian vegetation. The position of the shredding group in other studies also confirms whether the riparian plant factor and canopy cover are intact or not. Furthermore, the seasonal stability of the shredders indicates characteristics of tropical flows in the region that do not experience significant seasonal fluctuations [30].

Based on the results of Table 4, the sampling sites St2, St3, and St4 were heterotrophic during the dry season. While the sampling sites St3 and St5 were heterotrophic during the rainy season. However, sampling site St1 was found to be autotrophic during all seasons. The results indicate that sampling site St3 depended on the external organic matter, while sampling site St1 did not. These sampling sites show stability in the source of organic matter seasonally, while the other sampling sites exhibit changes in the source of organic matter throughout the seasons.

The CPOM/FPOM ratio indicated that only the sapling site St5 in the dry season had an abundant shredder population, highlighting a connection between riparian vegetation and stream ecosystem function. The TFPOM/BFPOM ratio, which represents the proportion of suspended FPOM (TFPOM) available to support filtering collector populations, showed that sampling sites St4 and St5 in the dry season, as well as sampling sites St1 and St2 in the rainy season,

significantly supported TFPOM. In contrast, other sites fell below the threshold, indicating inadequate support for filtering collectors.

Table 4. *FFG ratio analysis from Dong Bua sites*

Seasons	Sites	P/R (>0.75)	CPOM/FPOM (>0.25)	TFPOM/BFPOM (>0.50)	Channel Stability (>0.50)	Pr (0.10-0.20)
Dry season	St1	0.81	0.03	0.03	0.87	0.16
	St2	0.17	0.09	0.10	0.27	0.07
	St3	0.13	0.03	0.11	0.25	0.03
	St4	0.50	0.20	0.67	1.25	0.11
	St5	1.00	0.50	1.00	2.00	0.50
Rainy season	St1	2.40	0.25	3.00	7.50	0.12
	St2	0.84	0.06	5.00	7.75	0.09
	St3	0.65	0.09	0.07	0.76	0.05
	St4	1.21	0.12	0.06	1.33	0.02
	St5	0.31	0.01	0.48	0.92	0.01

Regarding channel stability, most sampling sites had ratios above the threshold, except for sampling sites St2 and St3 in the dry season, which were below the 0.5 threshold. In terms of top-down predator control, the ratio was high at sampling site St5 during the dry season. However, at most other sites, there was an imbalance between predators and their prey. Notably, sampling site St1 remained balanced across all seasons.

4. Conclusion

A total number of 88 species, belonging to 75 genera, 42 families, and 9 orders of aquatic insects were recorded in Dong Bua stream.

The riffle habitats had larger species and individual numbers than in pool habitats. Shannon-Weaver diversity index (H') in the dry season was higher than in the rainy season.

The FFGs included five groups: collector-gatherers, scrapers, collector-filterers, predators, and shredders. The structure of FFGs exhibited significant seasonal variation. Seasonal variation in the structure of FFGs reflects shifts in habitat conditions and resource availability. These patterns provide important ecological indicators for assessing environmental changes and guiding conservation efforts in the Dong Bua stream.

The sampling site St3 was a highly heterotrophic site and the sampling site St1 was the least heterotrophic site. There was a balance at sampling sites St1 and St3 across all seasons. These findings can support the development of site-specific conservation strategies and effective water quality management within the downstream of the Dong Bua stream.

This study was conducted at two time points corresponding to the dry and rainy seasons in the downstream section, thus providing an overview of the seasonal variation in the structure of FFGs. Future studies should incorporate a greater number of sampling periods to more accurately assess the dynamic trends of the aquatic insect communities. Additionally, expanding the study area to include upstream reaches is essential for generating a comprehensive understanding of the structure of FFGs across the entire Dong Bua stream.

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