

BIOLOGICAL ASPECTS OF EPHEMEROPTERA IN RIVERS OF SOUTHWESTERN COLOMBIA (SOUTH AMERICA)

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The study involves the biodiversity of Ephemeroptera in different environments of southwestern Colombia (South America) and the relationships between water quality, expressed in terms of indexes (The National Sanitation Foundation of the United States of America, NSF - WQI), and the structure and distribution of genera in zones with varying levels of environmental degradation. Eight families and 19 genera were collected in the study area. The families Caenidae and the genus *Caenis* were reported for the first time in Colombia. *Leptohyphes* (Leptohyphidae), *Baetis* (Baetidae) and *Thraulodes* (Leptophlebiidae) were the most diverse and altitudinally widely distributed taxa collected. *Thraulodes* is sensitive to pollution conditions, while *Leptohyphes* and *Baetis* show a great tolerance to different ecosystems and water quality. *Campylocia* (Euthyplociidae), *Tortopus* and *Campsurus* (Polymitarcyidae), were found below 100 meters of elevation in streams on the Pacific Ocean. Several emergence patterns were observed for *Atopophlebia fortunensis* (Leptophlebiidae) (FLOWERS, 1980), *Callibaetis* sp. (Baetidae) and *Caenis* sp., at different times of the day in the subtropical wet forest of «Pavas» located in the Valle del Cauca. While different Ephemeroptera species usually perform a nuptial flight when mating, this phenomenon was not observed in any of the species studied in «Pavas».

INTRODUCTION

Insects of the order Ephemeroptera are widely distributed. For South America HUBBARD & PETERS (1981) reported 9 families and DOMINGUEZ *et al.* (1992) reported 14 families. In Colombia 6 families were registered by ROLDÁN (1985) and 7 by ROJAS *et al.* (1993). Ephemeroptera families and genera in temperate zones and in Central America have been well provided with keys and illustrations, however, many of the forms found in South America do not exist in Central America and therefore have not been included in studies as those of BERNER & PESCADOR (1988) and FLOWERS (1992). Literature about tropical mayfly fauna is still scattered, incomplete and subject to further revision.

Knowledge of the mayflies fauna of Colombia is still limited. ROLDÁN (1980, 1988), HERNÁNDEZ & MORENO (1982) have conducted studies on the distribution and identification of Ephemeroptera nymphs from the Antioquia rivers in northwest Colombia. GONZÁLES (1993) published a key to the imagoes of mayflies families of Colombia. ROJAS *et al.* (1995) presented both a key and feeding habits and habitat preferences of the nymphs occurring in the Valle del Cauca rivers in southwest Colombia. ROJAS DE HERNÁNDEZ *et al.* (1992) studied the altitudinal distribution of this order in the Farallones de Cali, and LOAIZA *et al.* (1994) evaluated the community structure and distribution in some rivers of the Cauca river

basin relative to water quality. Altitudinally, this order occurs from sea level up to approximately 3,500 m and its maximum diversity is found between 1,000 m and 2,000 m (ROLDÁN, 1980; ESCOBAR, 1989; ROJAS DE HERNÁNDEZ *et al.*, 1995).

In Valle del Cauca and Antioquia, Ephemeroptera species have been specifically included in water quality studies because, besides having a great adaptability to different habitats, there is also a close relationship between water quality environmental indexes and the structure and distribution of their populations (ROLDÁN, 1980; ZÚÑIGA DE CARDOSO *et al.*, 1992, 1993).

The objectives of this study were to contribute to the knowledge of the biodiversity of Ephemeroptera through a taxonomical study of the predominant genera in different environments of southwestern Colombia, and to establish possible relationships between water quality indicators and the structure and distribution of populations that prevail in zones with different environmental degradation levels.

STUDY AREA AND METHODS

This research was conducted in different rivers in the Departments of Nariño, Cauca, Valle del Cauca, Risaralda, and Quindío located in the southwestern Colombia (1.7 to 4.5 N; 79.0 to 75.6 W) (Fig. 1). These streams flow along their course through different life zones according to the climatic characterization system established by Holdridge in ESPINAL (1992).

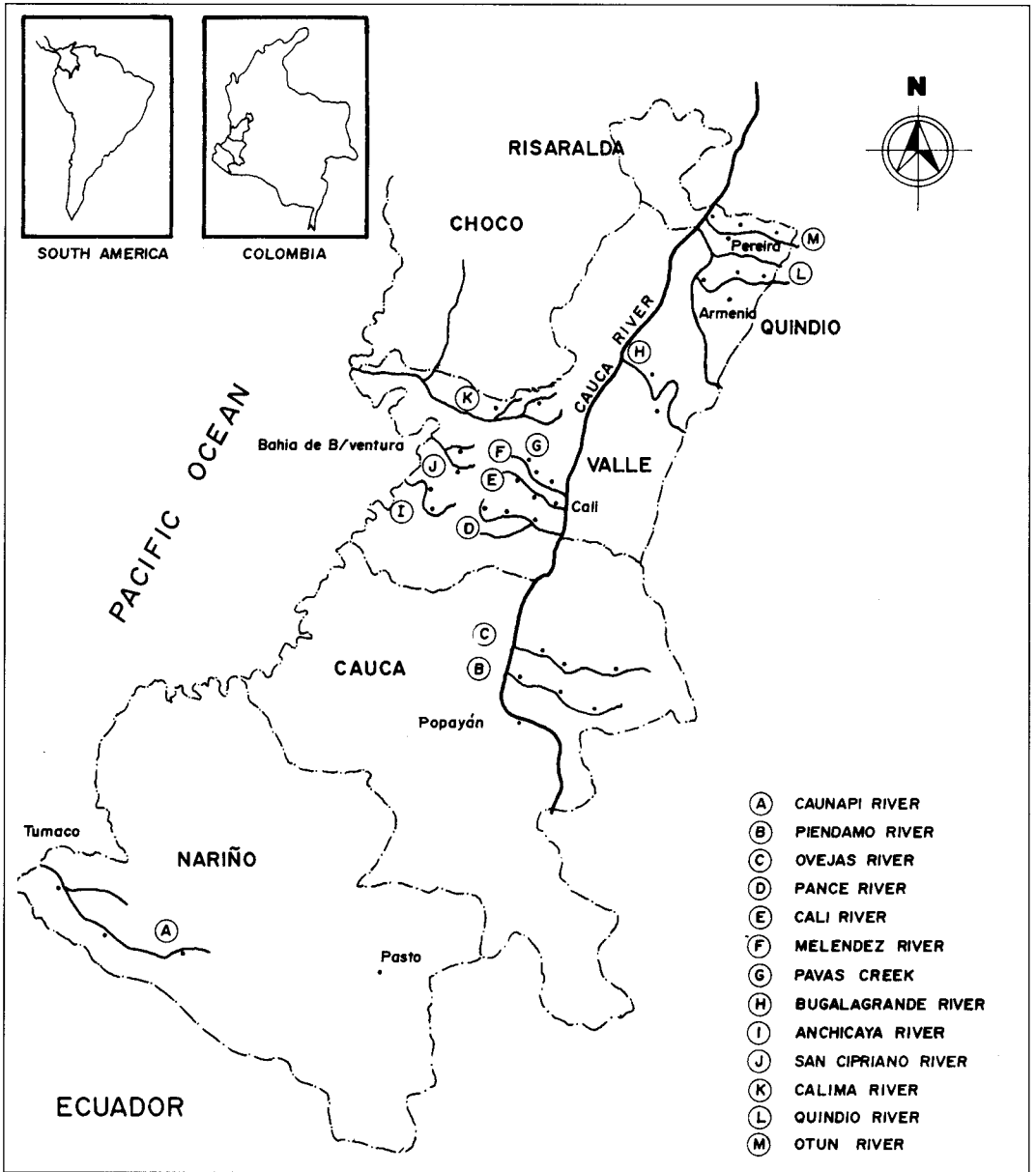


Fig. 1. Study Area in the Southwest of Colombia Sampling stations.

Malaise and light traps were used for sampling Ephemeroptera subimagos and adults. Also, the vegetation adjacent to the water bodies were sampled by sweep net. Light trap samplings were conducted between 6 and 10 p.m. The subimagos and imagos collected were placed in glass jars containing 70% ethyl alcohol. The nymphs were sampled by a three-person team in a period of 45 minutes and in a 2-square meter area for each station. In shallow and muddy bed locations, an Eckman dredge and

dragging nets were used. The nymphs were preserved in 70% ethyl alcohol for subsequent identification. Live nymphs were also brought into the laboratory and were kept under conditions of temperature and oxygen similar to their environment, in order to associate the nymphal and adult stages to facilitate their identification. These organisms are stored as reference material at the Museum of Entomology and the Laboratory of Biological Assays of Universidad del Valle.

Table 1. Ecological aspects and distribution of families and genera of Ephemeroptera in the Southwest of Colombia, South America (January 1990-June 1995). Legend for the rivers A-M see in Fig. 1.

FAMILIES	GENERA	ECOLOGICAL ASPECTS	DISTRIBUTION
Euthyplociidae	Euthyplocia Eaton 1817	Clean oxygenated, cold and flowing water. Sandy and rocky bottom. Shaded areas. Low population frequency.	Valle del Cauca (E)(F) Meters above sea level: 600 - 2000 m
	Campylocia Needham & Murphy 1924	Warm and rapid water. Sandy bottom. Clean and oxygenated water. Rarely found organism.	Valle del Cauca (K) Meters above sea level: 130 - 50 m
Polymitarciidae	Campsurus Eaton 1868	In mud, sediment, running water or river shores. Clean water and good dissolved oxygen level habitats.	Nariño (A) Valle del Cauca (Y) Meters above sea level: 100 - 40 m
	Tortopus Needham & Murphy 1924	Mud or sandbar burrower that drill wide holes. Filtering organisms.	Valle del Cauca (I) Meters above sea level: 100 - 40 m
Oligoneuriidae	Lachlania Hagen 1868	Clean, oxygenated, cold and rapid water, Filtering organisms; clean water indicators that live under fallen leaves, tree trunks, and stones at the head of streams.	Valle del Cauca (E)(F)(K) Meters above sea level: 1000 - 2000 m
Leptohiphidae	Leptohiphes Eaton 1982	Poor swimmers that live under fallen leaves, tree trunks, and stones. Calm, warm, and cold water. They feed on algae and have a great ability to adapt to different kinds of environments and water conditions. Wide range of altitudinal distribution and population frequency. Clean or slightly contaminated water.	Nariño (A) Cauca (B)(C) Valle del Cauca (D)(E)(F) (H)(I) (J)(K) Quindío (L) Risarlada (M) Meters above sea level: 1000 - 2000 m
	Haplohiphes Allen 1966	Live under fallen leaves and stones. Clean water organisms. Low population frequency	Valle del Cauca (A)(B)(C) (D)(E)(F) Risarlada (M) Meters above sea level: 1200 - 2000 m
	Tricorythodes Ulmer 1920	Live in both warm and cold water. Filtering organisms. Slightly contaminated water.	Nariño (A) Cauca (B)(C) Valle del Cauca (B)(C)(D) (E)(F)(H) (I)(J)(K) Quindío (L) Risarlada (M) Meters above sea level: 30 - 2500 m
Heptageniidae	Epeorus Eaton 1881	Cold, running and oxygenated water. Very low population frequency. Live under fallen leaves and stones. Restricted to high altitude areas.	Valle del Cauca (E) Meters above sea level: 1600 - 2000 m
Caenidae	Caenis Stephens 1835	On fallen leaves; muddy bed. Cold and clean water. Rarely seen organism found in middle elevation areas.	Valle del Cauca (G) Meters above sea level: 1200 m

Table 1. Continued.

FAMILIES	GENERA	ECOLOGICAL ASPECTS	DISTRIBUTION
Leptophlebiidae	Thraulodes Ulmer 1920	Good swimmers that live in both slow and rapid water. They feed on vegetable matter. Wide range of altitudinal distribution and population frequencies. Sensitive to organic contamination and oxygen deficiency.	Nariño (A) Cauca (B)(C) Valle del Cauca (D)(E)(F) (H)(I)(K) Quindío (L) Risaralda (M) Meters above sea level: 30 - 3130 m
	Traverella Edmunds 1948	Poor swimmers that live in warm and muddy water, under fallen leaves and stones. Very low population frequency.	Nariño (A) Valle del Cauca (E)(K) Meters above sea level: 40 - 100 m and 1600 - 2000 m
	Atopophlebia Flowers 1987	Running, cold oxygenated and clean water. Under fallen leaves and stones. Very low population frequency.	Valle del Cauca (E) Meters above sea level: 1200 - 2000 m
Baetidae	Paracloeodes Day 1955	Running water swimmers that live under fallen leaves and stones. Sensitive to oxygen deficiencies. Very low population frequency. Found in high altitude areas.	Valle del Cauca (E) Meters above sea level: 1600 - 2000 m
	Camelobaetidium Demoulin 1967	Detritivores, superficial vegetable matter scrapers which live under tree trunks, fallen leaves and stones, and attached to immersed vegetation. Sandy bottom. Good swimmers. Clean or slightly contaminated water.	Nariño (A) Cauca (B)(C) Valle del Cauca (D)(E)(F) (H) Quindío (L) Risaralda (M) Meters above sea level: 30 - 3100 m
	Callibaetis Eaton 1881	Rapid and clean water organisms that live on tree trunks and fallen leaves.	Valle del Cauca (G) Meters above sea level: 1200 m
	Baetodes Needham & Murphy 1924	Rapid water organisms that live on fallen leaves and stones. Adapted to different types of water quality.	Nariño (A) Cauca (B)(C) Valle del Cauca (D)(E)(F) (I)(K) Quindío (L) Risaralda (M) Meters above sea level: 40 - 2000 m
	Moribaetis Waltz & McCafferty 1985	Low populations frequency: found in high elevation areas. In cold running and well oxygenated water. On stones. Very active nymphs.	Nariño (A) Valle del Cauca (D)(E)(F) (I)(K) Meters above sea level: 600 - 2000 m
	Baetis Leach 1915	Wide range of altitudinal distribution and population frequency. Able to adapt to different types of environment and water quality. Organisms that live under tree trunks, fallen leaves, and stones. Attached to immersed vegetation.	Nariño (A) Cauca (B)(C) Valle del Cauca (D)(E)(F) (H)(I)(J)(K) Quindío (L) Risaralda (M) Meters above sea level: 30 - 3130 m

Each of the variables in relation to the physico-chemical aspects of water quality involved in the index proposed by the U. S. National Sanitation Foundation (NSF-WQI), OTT (1981), was determined according to the Standardized Methods for Water and Waste Water Analysis, APHA. AWWA.WPCF (1989). This index establishes a grading scale for which classification ranges were proposed and standardized by ROJAS (1991), based on the Colombian National Sanitation regulations for water bodies, as water supply sources and flora and fauna protection. Water quality indexes were related to the distribution of immature stadia of Ephemeroptera prevailing in 30 stations located at different altitudinal levels and environmental deterioration levels.

RESULTS AND DISCUSSION

The number of mayfly genera, collected from January 1990 to June 1995 in the Departments of Nariño, Cauca, Valle del Cauca, Risaralda and Quindío in southwestern Colombia, is shown in Table 1. This table also includes information on feeding preferences as well as some ecological aspects related to their habitats. 8 families and 19 genera were collected in the study area. The family Caenidae and the genus *Caenis* represent a new record for Colombia.

The family Heptageniidae, and the genus *Epeorus*, were first registered in Colombia by ROJAS DE HERNÁNDEZ *et al.* (1993). The genera *Haplohyphes* (Leptohyphidae), *Atopophlebia* (Leptophlebiidae), *Callibaetis* and *Paracloeodes* (Baetidae) were also new records for Colombia.

The results from the physico-chemical and bacteriological evaluation, expressed in terms of indexes (NSF-WQI), are shown in Table 2 and correspond to the period from January 1990 to June 1993.

Based on the organisms collected in different stations, it was found that the streams that form the Cauca river basin feature a benthic fauna that are diversified and stratified not only in relation to weather conditions, but also in terms of organic load and oxygen deficiency caused by anthropogenic activities (Fig. 2).

Immature stages of insects that belong to orders Trichoptera (30.7%), Ephemeroptera (26%), and Plecoptera (14.2%), prevail at the river headwaters between 1,600 m and 3,130 m above sea level. A group of Ephemeroptera genera of low population frequencies (lower

than 5%) is found in these zones. Some of these genera are *Epeorus* (Heptageniidae), *Lachlania* (Oligoneuriidae), *Paracloeodes*, *Callibaetis* and *Moribaetis* (Baetidae), *Euthyplocia* (Euthyplociidae), *Atopophlebia* and *Traverella* (Leptophlebiidae).

With respect to water quality, the highest diversity of Ephemeroptera genera was found in zones with average indexes ranging from 87.0 to 75.6 units, (clean, clear water with dissolved oxygen levels between 103.6% and 91.8%). These oxygen levels facilitate the growth of populations of the genera described above and of *Thraulodes*, which has a wide range of altitudinal distribution, specially from 1100 meters, a high population frequency, and a high sensitivity to oxygen deficiencies and residual organic load (Fig. 2).

Campylocia (Euthyplociidae), *Tortopus* and *Campsurus* (Polymitarciidae) are found below 100 meters of elevation in streams belong to the Pacific Ocean basin with good water quality indexes. *Tortopus* showed a great tolerance to different water qualities.

The downstream deterioration caused by discharges coming from residential sewers and country farms becomes evident. Also, a decrease in the diversity of Ephemeroptera is observed, but the existent species show significant high population densities. These zones are characterized by having water quality indexes ranging from 60.0 to 35.0 units, which correspond to inadequate and acceptable indexes respectively.

Nevertheless, the oxygenation levels still permit the development of the genera *Baetis*, *Camelobaetidius* and *Baetodes* (Baetidae), *Leptohyphes* and *Tricorythodes* (Leptohyphidae). These genera have a great tolerance to different water quality conditions. *Baetis* survives the highest increase in organic load and environmental degradation. *Leptohyphes* is the genus with the highest population frequency (45% to 32%) in the order.

The lowest water quality indexes, ranging from 35.0 to 20.0 units, correspond to the low basins of the studied rivers, the oxygen saturation levels depending on the river depth and turbulence. The organic load increase is due to waste water discharges coming from urban centers. This situation causes the diminution of all mayfly representatives in the study area.

Table 2. Characteristics of sampling stations in some rivers in the Southwestern Colombia South America (January 1990 - June 1993).

SAMPLING STATION	m.a.s.l.	Climate Zones	T°C	DISSOLVED OXIGEN(%)	WATER QUALITY INDEX	CALCSIFICATION WATER QUALITY
			\bar{X}	\bar{X}	\bar{X}	
PIENDAMO RIVER (1)						
*LA CAMPANA	2900	bmh - MB	12.0	97.6	70.5	GOOD
*SILVIA	2680	bh - MB	18.0	93.2	69.3	GOOD
*PINDAMO	1430	bh - PM	21.0	87.6	54.0	GOOD
OVEJAS RIVER (2)						
*CABECERA	1580	bmh - PM	22.0	85.7	54.0	GOOD
*CALDONO	1570	bmh - PM	23.0	83.8	51.3	GOOD
*PESCADOR	1430	bh - PM	20.0	79.0	50.3	GOOD
PANCE RIVER (3)						
*HATO VIEJO	1810	bmh - MB	19.0	92.0	82.0	OPTIMUM
*LA VORAGINE	1280	bh - ST	20.0	92.3	70.5	GOOD
*LA VIGA	1080	bs - T	23.0	92.0	72.0	GOOD
MELLENDEZ RIVER (4)						
*VILLA CARMELO	1800	bmh - ST	17.5	93.9	75.6	GOOD
*POLVORINES	1100	bh - ST	23.0	86.8	55.7	GOOD
*PUENTE SIMON BOLIVAR	950	bs - T	22.0	68.9	40.4	ACCEPTABLE
CALI RIVER (5)						
*PEÑAS BLANCAS	2000	bmh - MB	15.0	91.8	80.0	OPTIMUM
*BOCATOMA	1100	bs - ST	20.0	88.9	66.9	GOOD
*PUENTE CALIMA	940	bs - T	23.0	0.0	20.0	VERY BAD
QUINDIO RIVER (6)						
*GUAYAQUIL	3130	bmh - M	11.0	103.6	87.0	OPTIMUM
*COCORA	2120	bh - MB	14.5	96.8	61.9	GOOD
*BOQUIA	1630	bh - ST	20.0	102.5	56.6	GOOD
OTUN RIVER (7)						
*LA PASTOTA	2400	bmh - MB	14.0	97.4	81.7	OPTIMUM
*NUEVO LIBARE	1550	bh - ST	19.0	98.6	80.0	OPTIMUM
*ESTAC. PEREIRA	890	bh - T	23.0	97.0	61.7	GOOD
CAUNAPI RIVER (8)						
*INDA	105	bmh - T	22.0	95.0	83.8	OPTIMUM
*ESPRIELLA	40	bmh - T	25.0	80.0	77.2	GOOD
*TANGARIAL	30	bmh - T	25.0	76.5	71.9	GOOD

m.a.s.l. : Meters above sea level
 bs - ST : Subtropical dry forest
 bs - T : Tropical dry forest
 bh - ST : Subtropical humid forest

bh - T : Tropical humid forest.
 bh - MB : Humid forest in the lower mountainous region.
 bmh - T : Tropical very humid forest .

bh - PM : Humid forest in the pre montainous region.
 bmh - PM : Very humid forest in the pre montainous region.

bmh - M : Very humid forest in the pre montainous region.
 bmh - MB : Very humid forest in the lower mountainous region

(1) Sep - Nov 1993 (n=3)
 (2) Sep - Nov 1993 (n=3)

(3) Jan 1991 - Jun 1992 (n=4)
 (4) Jan 1990 - Jun 1993 (n=8)

(5) Jan 1990 - Jun 1993 (n=8)
 (6) Mar - May 1992 (n=3)

(7) Apr - Dec 1992 (n=3)
 (8) Sep - Dec 1992 (n=3)

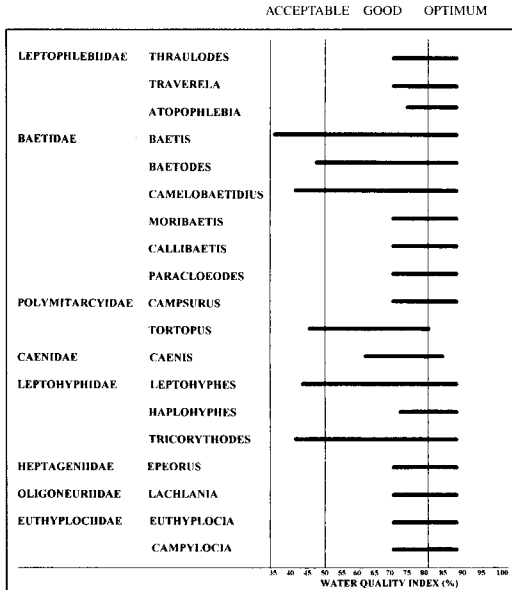


Fig. 2. Distribution of Ephemeroptera genera related to water quality in the Southwest of Colombia (South America).

Several emergence patterns in three mayfly species from «Pavas» (Valle del Cauca) were observed:

Atopophlebia fortuneensis (FLOWERS, 1980): The subimagos emerged between 8 and 9 p.m., and moulted to imagos 24 hours later. The greatest number of emerging individuals was observed after the end of a rain period. No swarm was observed.

Callibaetis sp.: Subimagos emerged between 2 and 3 p.m. The males moulted to imagos around midnight, and the females shortly after midnight. Females were observed laying eggs between 8 and 9.30 a.m. on sunny days. The highest emergence peaks occurred in dry periods. No swarm was observed.

Caenis sp.: Females and males adults emerged on poorly illuminated days, between 6 and 7.30 a.m., and the time from subimago to imago in the males was very short (5-6 minutes). The mating flight was slow and irregular, with individuals dispersed. Females ovoposited a few minutes after emergence and were not observed moulted from subimago to imago. The highest number of individuals emerging was observed during rain intervals.

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