Hidrobiológica 2024, 34 (2): 71-80

UNIVERSIDAD AUTÓNOMA METROPOLITANA
Casa abierta al tiempo
Unidad Iztapalapa

HIDROBIOLÓGICA
http:/hidrobiologica.izt.uam.mx
ISSN: 2448-7333

OPEN ACCESS
Research Article
August, 2024

Checklist and Abundance with New Records of Mayflies (Insecta: Ephemeroptera) to Sierra Maestra Mountain Range, Cuba

Listado Taxonómico y Abundancias con Nuevos reportes de Efímeras (Insecta: Ephemeroptera) para el Sistema Montañoso Sierra Maestra, Cuba

Pedro López Del Castillo[1*], Liliana María Gómez Luna[2], Janice G. Peters[3], Germán M. López Iborra[4]

Recibido: 18 de septiembre de 2023. *Aceptado:* 13 de diciembre de 2023. *Publicado:* agosto de 2024.

[1] Departamento de Zoología, Centro Oriental de Ecosistemas y Biodiversidad, Santiago de Cuba, Cuba.

[2] Centro Nacional de Electromagnetismo Aplicado, Universidad de Oriente, Santiago de Cuba, Cuba.

[3] Entomology, Florida A&M University, Florida, USA.

[4] Departamento de Ecología/IMEM Ramón Margalef, Universidad de Alicante, Alicante, España.

***Corresponding author:**
Pedro López Del Castillo: e-mail: pldelcastillo@nauta.cu

To quote as:
López Del Castillo, P., L. M. Gómez Luna, J. G. Peters & G. M. López Iborra. 2024. Checklist and Abundance with New Records of Mayflies (Insecta: Ephemeroptera) to Sierra Maestra Mountain Range, Cuba. *Hidrobiológica* 34 (2): 71-80.

DOI:10.24275/WHHX9498

ABSTRACT

Background: Mayflies are a small order of aquatic insects with nearly 3,500 species worldwide, in nearly 40 families and 460 genera. The highest diversity of mayflies is found in the Neotropics with about 900 species. Baetidae Leach, 1815 and Leptophlebiidae Banks 1900 are among the most diverse families of Ephemeroptera worldwide. Baetidae is composed of 956 species belonging to 239 genera. Leptophlebiidae has 643 species distributed among 247 genera in the Neotropical Region. Also, the Baetidae and Leptophlebiidae families are the most diverse in Cuba, with 12 and 13 species, respectively, likewise members of both families have a wide distribution in the archipelago. **Objective**: To describe the geographic distribution patterns and microhabitats used by mayfly species in both hidroclimatic periods in two rivers of the Sierra Maestra massif of four new records mayflies species. **Methods**: This study was conducted in the Yara and Nagua rivers, located on the north slope of the Sierra Maestra Mountain System, eastern Cuba. Fifteen sampling sites were established in streams from second to fourth order in both rivers. A total of five microhabitats were sampled in the pool subsystems: leaf litter, cobbles in pools, sand, and bank vegetation. Meanwhile, the riffles subsystem was assessed in the cobles in the rifles microhabitat. Mayflies were identified at the species level. **Results**: 20 species and four morphospecies are listed. Besides, new locality records to *Caribaetis alcarrazae* (Kluge,1991), *Paracloeodes lilliputian* (Kluge,1991), *Poecilophlebia pacoi* (Kluge, 1994a), and *Traverina oriente* (Kluge, 1994a) are presented for the Sierra Maestra massif range. **Conclusions**: The results of this study provide new information about the natural history, ecological and biological traits of these species, useful to implement biomonitoring programs and conservation strategies.

Keywords: Baetidae, Leptophlebiidae, microhabitat, streams

RESUMEN

Antecedentes: Ephemeroptera es un pequeño orden de insectos acuáticos con cerca de 3500 especies a nivel global, de 40 familias y 460 géneros. La mayor diversidad de Ephemeroptera se encuentra en el Neotrópico, con aproximadamente 900 especies registradas. Las familias Baetidae Leach, 1815 y Leptophlebiidae Banks 1900 están entre las más diversas del orden Ephemeroptera a nivel global. Baetidae está representada con 956 especies en 239 géneros. Leptophlebiidae está representada con 643 especies pertenecientes a 247 géneros en la región Neotropical. Las familias más diversas en Cuba son Baetidae y Leptophlebiidae con 12 y 13 especies respectivamente. **Objetivos:** Describir patrones de distribución geográfica y uso de microhábitats en cuatro especies que son nuevos reportes del orden Ephemeroptera en la cadena montañosa Sierra Maestra para los dos períodos hidroclimáticos. **Métodos:** Este estudio fue realizado en los ríos Yara y Nagua, localizados en la ladera norte de la Sierra Maestra, aproximadamente a 50 km al sur de la ciudad de Bayamo provincia Granma en la región este de Cuba. Fueron considerados un total de 15 sitios de muestreos en arroyos desde segundo hasta cuarto orden. Se seleccionaron cinco microh**ábitats de los dos subsistemas remansos y** rabiones. Para remansos fueron hojarascas, guijarros, arena y vegetación de orilla. Mientras que para rabión fueron los guijarros. Las especies de Ephemeroptera fueron identificadas hasta nivel de especie y preservadas en alcohol al 70%. **Resultados:** Se registraron 20 especies y cuatro morfoespecies de efímeras. Además, nuevos reportes de localidad para *Caribaetis alcarrazae* (Kluge,1991), *Paracloeodes lilliputian* (Kluge,1991), *Poecilophlebia pacoi* (Kluge, 1994a) y *Traverina oriente* (Kluge, 1994a) son presentados. **Conclusiones:** Los resultados de este estudio proveen nueva información acerca la historia natural, rasgos ecológicos y biológicos de estas especies, útiles para implementar programas de biomonitoreos, así como estrategias de conservación a mediano y largo plazo.

Palabras claves: Baetidae, Leptophlebiidae, microhábitat, arroyos.

INTRODUCTION

Baetidae and Leptophlebiidae are among the most diverse families of Ephemeroptera worldwide. Baetidae is composed of 956 species belonging to 104 genera and Leptophlebiidae has 643 species distributed among 141 genera; in the Neotropical region are found 239 species of Baetidae and 247 species of Leptophlebiidae (Sartori & Brittain, 2015).

Despite their great diversity and the efforts to understand the evolution of this group, the internal classification of Leptophlebiidae remains controversial at all taxonomic levels. Peters (1980) presented the first attempt to create a higher classification for the Leptophlebiidae family, defining two subfamilies: Leptophlebiinae and Atalophlebiinae. Leptophlebiinae was further subdivided into Habrophlebiinae and Leptophlebiinae by (Kluge, 1994b). The categorization of Habrophlebiinae and Leptophlebiinae was not confirmed by the current genetic study conducted by (O'Donnell & Jockusch, 2008).

In the West Indies, a major contribution to the knowledge of the taxonomy of Leptophlebiidae was made by Peters (1971), resulting in the description of three new genera and eleven new species, along with a discussion of the phylogeny. Meanwhile Kluge (1994a) described seven new species of this family. Revisions of the family Baetidae were published by Kluge (1991, 1992a, 1992b).

The Greater Antilles islands are poor in species belonging this group except Cuba, which itemizes 35 species grouped in five families (Naranjo-López *et al*., 2019), and Puerto Rico with three families and 22 species (Traver, 1938; Lugo-Ortiz, McCafferty & Waltz, 1994). Hispaniola has published records of two families and three species, as does Jamaica (Peters, 1971; Allen, 1973).

The Baetidae and Leptophlebiidae families have the highest diversity in Cuba, containing 12 and 13 species respectively. Baetidae has five genera, while Leptophlebiidae has seven, with distribution located only in the West Indies like a singular clade including the genera *Traverina* and *Poecilophlebia* (Campos de Oliveira, 2022). The streams of the Sierra Maestra massif are the type locality for various species in these families (Kluge, 1992a, 1992b, 1994a).

This area is geographically close to Santiago de Cuba, and several studies were conducted there led by Dr. C. Carlos Naranjo. Nevertheless, the use of microhabitats and the seasonal influences on its use by mayfly species remain as knowledge gaps. Therefore, the main objectives of this study were to understand the distribution patterns and microhabitats used by four new records of mayfly species in both hydroclimatic periods in two rivers of the Sierra Maestra massif.

METHODS

Study Area. This study was conducted in the Yara and Nagua rivers systems, located on the north slope of the Sierra Maestra Mountain System, approximately 40 km SW of Bayamo city, Granma province, eastern of Cuba (20°01'18"N – 20°09'17"N and 76°56'47"E – 76°51'23"E). The two watersheds are contiguous in the upper reaches, and the watercourses converge at the Paso Malo reservoir before continuing downstream to the Guacanayabo gulf (Figure 1).

The Yara headwaters are located on the north slope of Turquino National Park. It covers a small portion of cloudy tropical forest, small patches of coffee plantations and other crop areas. The River Riverforest montane rainforest and mesophyll evergreen forest are the Yara River's predominant riparian vegetation. Whereas, in the Nagua sub-watershed the dominant riparian vegetation is the secondary forest, which also includes areas with intensive agriculture development, particularly coffee plantations, as well as mesophyll evergreen forest in the headwaters.

Sampling. A total of fifteen sampling sites were established in the streams ranging from second to fourth order in the Yara River (8 sites) and Nagua River (7 sites). Ranging stream orders were made according to (Strahler, 1957). The range altitude ranged from 150 to 575 m above sea level, and the areas of the sub-watersheds varied between 0.3 to 98 km^2 (Table 1). In the Yara River, four sites were distributed in streams of second order and the remaining four between third and fourth order. The seven sampling sites in the Nagua River were located in the streams ranging from second to fourth order (Figure 1).

The seasonality effect was studied by sampling in two time periods representing different river flow conditions. Two samplings were carried out in March and April 2010, which correspond to the end of the dry season, when river flow is at its lowest level. Additional sampling was carried out in November 2010, at the beginning of the dry season. However, water levels were still high this month; October had the highest rainfall and the highest number of rainy days (INRH, 2011).

A total of five microhabitats were sampled in two subsystems: pools and riffles. Microhabitats were defined according to their components, the Wentworth grade scale modified (Cummins, 1962; Vilenica *et al*., 2018), and the heterogeneity and depth of substrates (Dudgeon, 1982). The pool subsystem was the most heterogeneous substrate, with four microhabitats: cobbles, sand, leaf litter, and bank vegetation, occurring at all sampling sites.

In the riffle subsystem cobbles were the only microhabitat present at all sampling sites while other microhabitats were limited and poorly represented. Sampling in the pools was carried out using four methods, one for each microhabitat. a) directly picking-up out of 15 cobbles in pools of no more than 20 cm depth; b) sand was sampled in pools using a homemade D-net (0.5 mm mesh size) by shaking the bottom in an

Table 1. Main features and location of sampling sites.

Rivers	Samples sites	Stream Order	Altitude (m)	Drainage area (km^2)
Yara	Brazo Derecho	2	594	2.7
Yara	Brazo Izquierdo	2	558	2.5
Yara	La Jeringa	3	394	8.6
Yara	San Francisco	2	517	2.7
Yara	El Mogo	2	637	0.3
Yara	Santo Domingo	4	268	26.1
Yara	Providencia	4	116	75.2
Yara	Palma Criolla	3	134	14.7
Nagua	Los Lirios	3	266	10.7
Nagua	Rancho Claro	3	259	22.7
Nagua	Los Lajales	4	231	36.6
Nagua	Frio Nagua	4	168	55.1
Nagua	Guasimilla	3	178	17.6
Nagua	Las Cuevas	2	187	4.6
Nagua	Sierrita de Nagua	4	96	98.7

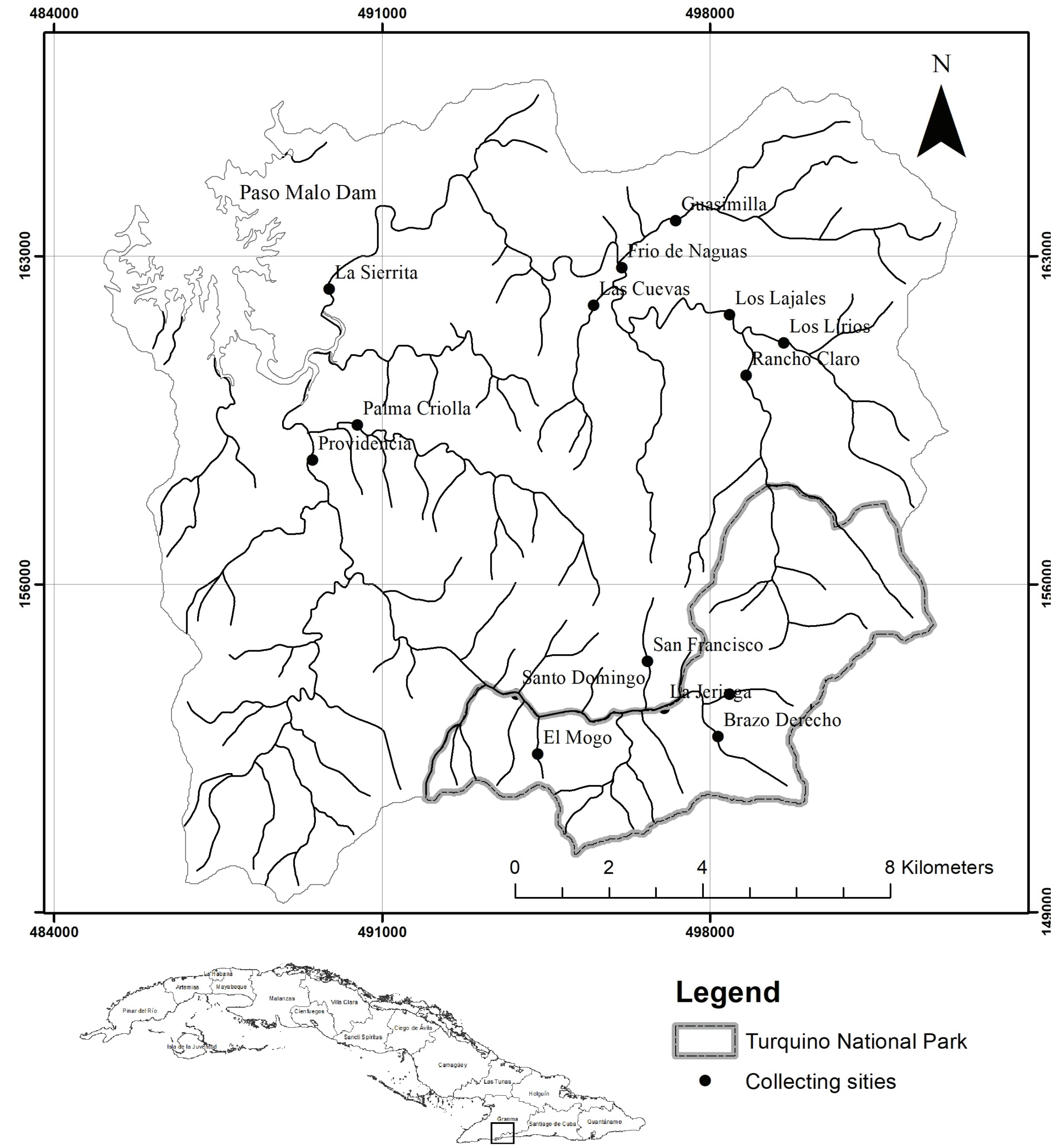


Figure 1. The drainage area of the Yara and Nagua rivers system and distribution of the sampling sites (n=15).

area of 30x30 cm, 20 cm deep; c) for leaf litter. a pack of 30x30 cm, at 10 cm depth was collected; d) bank vegetation sampled by sweeping the submerged bank vegetation or roots systems into the D-net along 3 m of the bank.

The sampling in the microhabitat cobbles in riffles was made in the shallow "erosional zone", where waters have a high flow speed. Thus, two complementary methods were used in this microhabitat to compensate for the loss of individuals that could be carried away by the current: a) Direct picking-up out of cobbles; taking 15 cobbles of similar size (about 10 cm) and shape, as in pools; b) a D-Net was used to collect the mayflies dragged by the flow when we agitated the cobbles in an area of 30x30 cm from the same area.

The material was deposited in the collection of the Zoology Department of the Centro Oriental de Ecosistemas y Biodiversidad (BIOECO), Santiago de Cuba.

Taxonomic identification. We preserved all samples in ethanol 90% from the time of sampling to the time of identification. The species of mayflies were identified under a stereomicroscope (Carl Zeiss Stemi

2000-C, Germany) and stored in 70% ethanol. We used several keys and taxonomical description criteria (Peters 1971; Kluge & Naranjo-López, 1990; Kluge, 1991, 1992a, 1992b, 1994a; Naranjo-López *et al.*, 2019). Also, information concerning historical distribution were consulted to compare with these new records. We follow the proposal of Naranjo-López & Peters (2016) to recognize several subgenera within the Leptoplebiidae family at the genus level.

RESULTS

Collecting samples. A total of 12,331 specimens belonging to 24 different mayfly species (including four morph-species) from four families and ten genera were collected. The family with the greatest abundance and taxonomic diversity was Baetidae, with 5,504 specimens and 11 species. The second most abundant family was Leptohyphidae, with 4,301 nymphs from four species. Despite having nearly half the number of specimens of Baetidae, Leptophlebiidae was the second most diverse family, with eight species. The Caenidae family has only one species reported in Cuba to date, 190 nymphs of this species were collected. *Tricorythodes sacculobranchis* and *Caribaetis planifrons* were the most abundant species, with 3,766 and 3,083 specimens respectively. *Tricorythodes* was the most diverse genus, containing four species (Table 2).

Taxonomy

Family Baetidae (Leach, 1815)

Caribaetis alcarrazae (Kluge,1992a) pp. 18.

Figures 2A and 2B.

Holotype information:

Baetis (Caribaetis) alcarrazae (Kluge, 1992a)

Male imago, Province Santiago de Cuba, La Alcarraza (Guamá), Kluge leg 4-II-1989.

Development stages know: Male and female imagos, nymph, egg.

Taxonomy references: (Kluge, 1992a; Lugo-Ortiz *et al.*, 1994; Kluge & Novikova, 2014).

Distribution. Holotype: 2 Male and 1 female Imago, La Alcarraza (Guamá municipality), Santiago de Cuba Province, Kluge leg 4-II-1989. This

Table 2 Taxonomic list of mayflies species reported from the Yara and Nagua Rivers, with abundance per species and per rivers. Data for the low flow period are the average of two sampling (D) and the high flow period (R). NR new records, * endemic to Cuba, • endemic to eastern Cuba.

	Families	Genera	Species	Yara		Nagua	
				D	R	D	R
1	Baetidae	*Americabaetis*	*naranjoi* (Kluge, 1992)* •	0	4	0	6
2	Baetidae	*Callibaetis*	*floridanus Banks, 1900*	7	0	0	0
3	Baetidae	*Cloeodes*	*superior* Kluge, 1991	33	197	3	10
4	Baetidae	*Cloeodes*	*inferior* Kluge, 1991	17	6	8	10
5	Baetidae	*Caribaetis*	*planifrons* (Kluge, 1992)	476	532	295	1011
6	Baetidae	*Caribaetis*	*alcarrazae* (Kluge, 1992) NR *	108	25	126	37
7	Baetidae	*Caribaetis*	sp.	42	1	0	0
8	Baetidae	*Fallceon*	*longifolius* (Kluge, 1992)	10	11	1	10
9	Baetidae	*Fallceon*	*poeyi* (Eaton, 1885)	92	260	126	634
10	Baetidae	*Fallceon*	sp.	0	2	0	0
11	Baetidae	*Paracloeodes*	*lilliputian* Kluge, 1991 NR *	3	0	3	63
12	Leptophlebiidae	*Farrodes*	*bimaculatus* Peters and Alayo, 1971*	86	97	19	20
13	Leptophlebiidae	*Hagenulus*	*morrisonae* Peters and Alayo, 1971*	159	26	258	53
14	Leptophlebiidae	*Turquinophlebia*	sp.	0	0	0	1
15	Leptophlebiidae	*Poecilophlebia*	*pacoi* (Kluge, 1994) NR * •	0	10	0	4
16	Leptophlebiidae	*Careospina h.*	*sierramaestrae* (Kluge, 1994)*	102	53	124	492
17	Leptophlebiidae	*Careospina*	*baconaoi* (Kluge, 1994)*	2	6	12	43
18	Leptophlebiidae	*Traverina*	*oriente* (Kluge, 1994) NR * •	2	1	8	0
19	Leptophlebiidae	*Traverina*	sp.	2	0	0	0
20	Leptohyphidae	*Tricorythodes*	*cubensis* Kluge & Naranjo, 1990*	14	37	33	148
21	Leptohyphidae	*Tricorythodes*	*grallator* Kluge & Naranjo, 1990*	13	11	17	35
22	Leptohyphidae	*Tricorythodes*	*montanus* Kluge & Naranjo, 1990* •	56	30	4	3
23	Leptohyphidae	*Tricorythodes*	*sacculobranchis* Kluge & Naranjo, 1990*	807	703	617	217
24	Caenidae	*Caenis*	*cubensis* Malzacher, Naranjo, González-Lazo & Kluge, 2007*	30	15	43	30

species is restricted to La Alcarraza in the southern hills of the Sierra Maestra, in the Eastern Region of Cuba.

Material examined. CUBA/ Granma • three nymphs; Brazo derecho; 20°01'22"N, 76°50'49"W; 594 m a.s.l.; 16. IV. 2010; PLDelC leg; Cobbles in riffles microhabitat; dry season. • seven nymphs; Brazo izquierdo; 20°02'08"N, 76°50'46"W; 558 m a.s.l.; 16. IV. 2010; PLDelC leg; Cobbles in riffles microhabitat; dry season • 136 nymphs; La Jeringa; 20°01'54"N, 76°51'45"W; 394 m a.s.l.; 15. IV. 2010; PLDelC leg; Cobbles in riffles microhabitat; dry season • three nymphs; San Francisco; 20°02'02"N, 76°51'53"W; 517 m a.s.l.; 15. IV. 2010; PLDelC leg; Cobbles in riffles microhabitat; dry season • nine nymphs; El Mogo; 20°01'51"N, 76°53'29"W; 637 m a.s.l.; 14. IV. 2010; PLDelC leg; Cobbles in riffles microhabitat; dry season • five nymphs; Santo Domingo; 20°02'28"N, 76°54'09"W; 268m a.s.l.; 14. IV. 2010; PLDelC leg; Cobbles in riffles microhabitat; dry season • 41 nymphs; Providencia; 20°04'54"N, 76°55'57"W; 116 m a.s.l.; 12. IV. 2010; PLDelC leg; Cobbles in riffles microhabitat; dry season • 20 nymphs; Los Lirios; 20°06'11"N, 76°50'14; 266 m a.s.l.; 07. IV. 2010; PLDelC leg; Cobbles in riffles microhabitat; dry season • 25 nymphs; Rancho Claro; 20°05'48"N, 76°50'39"W; 259 m a.s.l.; 07. IV. 2010; PLDelC leg; Cobbles in riffles microhabitat; dry season • 107 nymphs; Los Lajales; 20°06'31"N, 76°50'51"W; 231 m a.s.l.; 08. IV. 2010; PLDelC leg; Cobbles in riffles microhabitat; dry season • 22 nymphs; Frio de Nagua; 20°06'45"N, 76°52'11"W; 168 m a.s.l.; 09. IV. 2010; PLDelC leg; Cobbles in riffles microhabitat; dry season • 54 nymphs; Guasimilla; 20°07'18"N, 76°52'01"W; 178 m a.s.l.; 09. IV. 2010 PLDelC leg; Cobbles in riffles microhabitat; dry season • 22 nymphs; Las Cuevas; 20°06'33"N, 76°52'33"W; 187 m a.s.l.; 09. IV. 2010; PLDelC leg; Cobbles in riffles microhabitat; dry season • 12 nymphs; La Sierrita; 20°07'44"N, 76°55'13"W; 96 m a.s.l.; 11. IV. 2010; PLDelC leg; Cobbles in riffles microhabitat; dry season • six nymphs; La Jeringa; 20°01'54"N, 76°51'45"W; 394 m a.s.l.; 21. XI. 2010; PLDelC leg; cobbles in riffles microhabitat; rainy season. • 19 nymphs; Providencia; 20°04'54"N, 76°55'57"W; 116 m a.s.l.; 25. XI. 2010; PLDelC leg; cobbles in riffles microhabitat; rainy season. • four nymphs; Los Lirios; 20°06'11"N, 76°50'14; 266 m a.s.l.; 28. XI. 2010; PLDelC leg; Cobbles in riffles microhabitat; rainy season • nine nymphs; Los Lirios; 20°06'11"N, 76°50'14; 266 m a.s.l.; 28. XI. 2010; PLDelC leg; sand microhabitat; rainy season • two nymphs; Los Lajales; 20°06'31"N, 76°50'51"W; 231 m a.s.l.; 30. XI. 2010; PLDelC leg; cobbles in riffles microhabitat rainy season • 13 nymphs; Guasimilla; 20°07'18"N, 76°52'01"W; 178 m a.s.l.; 29. XI. 2010; PLDelC leg; cobbles in pools microhabitat; rainy season. • seven nymphs; La Sierrita; 20°07'44"N, 76°55'13"W; 96 m a.s.l.; 26. XI. 2010; PLDelC leg; cobbles in riffles microhabitat; rainy season.

Diagnosis. Specimens were determined using a combination of characters provided by (Kluge, 1992a) and additional information from (Naranjo-López *et al.*, 2019): Claws with visible denticles, frontal margin (fronts) of head flat, without keel between antennal bases. Also, it is distinguished by its highly contrasting color pattern with abdominal terga 2 and 6–7 uniformly dark brown and terga 4 and 9 pale, other terga variable but usually with some submedian markings (Figures 2A and 2B).

Paracloeodes lilliputian (Kluge,1991)

Figures 3A and 3B.

Paracloeodes lilliputian (Kluge,1991), pp 134-135.

Holotype information:

Paracloeodes lilliputian (Kluge,1991)

Female imago, Province Guantánamo, Río Duaba (Baracoa), Kluge leg 15-III-1989.

Development stages know: Female imagos and nymph, male unknown.

Taxonomy references: (Kluge,1991)

Distribution. Río Duaba (Baracoa), Province Guantánamo, Kluge leg 15-III-1989, type locality. Río Yaquimo, Amancio, in Las Tunas (Benítez, 2007).

Material examined. CUBA/ Granma • five nymphs; Los Lajales; 20°06'31"N, 76°50'51"W; 231 m a.s.l.; 08. III. 2010; PLDelC leg; sand microhabitat microhabitat; dry season • one nymph; La Sierrita; 20°07'44"N, 76°55'13"W; 96 m a.s.l.; 11. III. 2010; PLDelC leg; sand microhabitat microhabitat; dry season • six nymphs; Palma Criolla; 20°05'15"N, 76°55'33"W; 134 m a.s.l.; 07. IV. 2010; PLDelC leg; sand microhabitat; dry season. • seven nymphs; Los Lirios; 20°06'11"N, 76°50'14; 266 m a.s.l.; 12. XI. 2010; PLDelC leg; leave litter microhabitat; rainy season. • four Los Lirios; 20°06'11"N, 76°50'14; 266 m a.s.l.; 12. XI. 2010; PLDelC leg; sand microhabitat; rainy season. • three nymphs; Rancho Claro; 20°05'48"N, 76°50'39"W; 259 m a.s.l.; 12. XI. 2010; PLDelC leg; sand microhabitat; rainy season. • 18 nymphs; Los Lajales; 20°06'31"N, 76°50'51"W; 231 m a.s.l.; 12. XI. 2010; PLDelC leg; sand microhabitat; rainy season. • four nymphs; Frio de Nagua; 20°06'45"N, 76°52'11"W; 168 m a.s.l.; 14. XI. 2010; PLDelC leg; sand microhabitat; rainy season. • 21 nymphs; Guasimilla; 20°07'18"N, 76°52'01"W; 178 m a.s.l.; 14. XI. 2010; PLDelC leg; leave litter; rainy season. • five nymphs; Guasimilla; 20°07'18"N, 76°52'01"W; 178 m a.s.l.; 14. XI. 2010; PLDelC leg; sand microhabitats. • one nymph; La Sierrita; 20°07'44"N, 76°55'13"W; 96 m a.s.l.; 16. XI. 2010; PLDelC leg; cobbles in pool; rainy season.

Diagnosis. The combination of characters provided by (Kluge, 1991; Naranjo-López *et al.*, 2019) was used to identify nymphs. The tarsal claws have two rows of tiny denticles basally and the apical setae of the paraglossae are arranged in a row. The head has a longitudinal keel between the antennae. The abdominal terga have median maculae contrasting with the otherwise pale coloration of the margins, and the contrast between the darker tergum and the small white lateral maculae on tergum 9 is an excellent diagnostic character for the species (Figures 3A and 3B).

Family Leptophlebiidae (Banks, 1900)

Poecilophlebia pacoi (Kluge, 1994a) pp. 269

Figures 4A, 4B and 4C

Holotype information:

Hagenulus (Poecilophlebia) pacoi (Kluge 1994a)

Male imago, Province Santiago de Cuba, Arroyo Paco (Río Palma Mocha), Kluge leg 22-II-1989.

Development stages know: Male and female imagos, nymph, egg.

Taxonomy references: (Kluge, 1994a; Naranjo-López & Peters, 2016).

Distribution. Male imago, Province Santiago de Cuba, Arroyo Paco (Río Palma Mocha), Kluge leg 22-II-1989; 34 nymphs: Dos palmas Arroyo-3 06-XII-2005, Megna leg, 15, Arroyo-1, 05-XII 2005. Megna leg, 16, Presa Gilbert, 06-XII-2005. Megna leg, three (Deler-Hernández *et al.*, 2007). one ♀ mature nymph, Gran Sofía tributary of Río Baconao 14.VII.2020 (Salazar-Salina & Torres-Cambas, 2021).

Material examined. CUBA/Granma • 10 nymphs; Brazo Derecho; 20°01'22"N, 76°50'49"W; 594 m a.s.l.; 21. XI. 2010; PLDelC leg; leaves litter microhabitat; rainy season. • one nymph; Guasimilla; 20°07'18"N, 76°52'01"W; 178 m a.s.l.; 29. XI. 2010; PLDelC leg; leaves litter microhabitat; rainy season. • three nymphs; Las Cuevas; 20°06'33"N, 76°52'33"W; 187 m a.s.l.; 29. XI. 2010; PLDelC leg; leaves litter microhabitat; rainy season.

Diagnosis. Specimens of this species were identified according to the criteria of (Kluge, 1994a; Naranjo-López *et al.* 2019). The labrum has an anteromedian margin with denticles. All tibiae with strongly flattened outer margin. Claws with distal denticle slightly thicker than the remaining ones, apices of denticles forming nearly straight line. Also, the color pattern in the terga with four distinct marks (Figures 4A, 4B and 4C).

Traverina oriente (Kluge, 1994a)

Figures 5A and 5B.

Traverina oriente (Kluge, 1994a) pp. 269

Holotype information:

Hagenulus (Traverina) oriente (Kluge 1994a)

Male imago, Province Guantánamo, Río Naranjal (Baracoa), Kluge leg 15–III–1989.

Development stages know: Male and female imagos, nymph, egg.

Taxonomy references: (Kluge, 1994a; Naranjo-López & Peters, 2016).

Distribution. Male imago, Province Santiago de Cuba, Arroyo Paco (Río Palma Mocha), Kluge leg 22-II-1989.

Material examined. CUBA: Granma. • one nymph; Los Lirios; 20°06'11"N, 76°50'14; 266 m a.s.l.; 07. III. 2010; PLDelC leg; leave litter microhabitat; dry season. • five nymphs; Frio de Nagua; 20°06'45"N, 76°52'11"W; 168 m a.s.l.; 09. IV. 2010; PLDelC leg; leave litter microhabitat; dry season. • two nymphs; Sierrita de Nagua; 20°07'44"N, 76°55'13"W; 96 m a.s.l.; 11. IV. 2010; PLDelC leg; cobbles in pools microhabitat; dry season. • six nymphs; Sierrita de Nagua; 20°07'44"N, 76°55'13"W; 96 m a.s.l.; 11. IV. 2010; PLDelC leg; leave litter microhabitat; dry season. • one nymph; Providencia; 20°04'54"N, 76°55'57"W; 116 m a.s.l.; 07. IV. 2010; PLDelC leg; cobbles in pools microhabitat; dry season. • one nymph; Palma Criolla; 20°05'15"N, 76°55'33"W; 134 m a.s.l.; 07. IV. 2010; PLDelC leg; cobbles in pools microhabitat; dry season. • one nymph; Palma Criolla; 20°05'15"N, 76°55'33"W; 134 m a.s.l.; 07. IV. 2010; PLDelC; leg leave litter microhabitat; dry season. • one nymph; Rancho Claro; 20°05'48"N, 76°50'39"W; 259 m a.s.l.; 12. IV. 2010; PLDelC; leg cobbles in pools microhabitat; dry season. • one nymph; Providencia; 20°04'54"N, 76°55'57"W; 116 m a.s.l.; 25. XI. 2010; PLDelC leg; cobbles in pools microhabitat; rainy season.

Diagnosis. The identification of the nymphs of this species was made on the basis of the criteria of (Kluge, 1994a). This genus can be separated from other by the structure of nymphal gills, each lamella with proximal portion widened, two additional short terminal processes on each side of the median long terminal process. Also, legs with cuticle colorless on femur and tibia, cuticle of tarsus slightly more pigmented. Likewise, it is distinguished from *T. cubensis* by the relatively shorter, rounded lateral processes of the gills (Figures 5A and 5B).

DISCUSSION

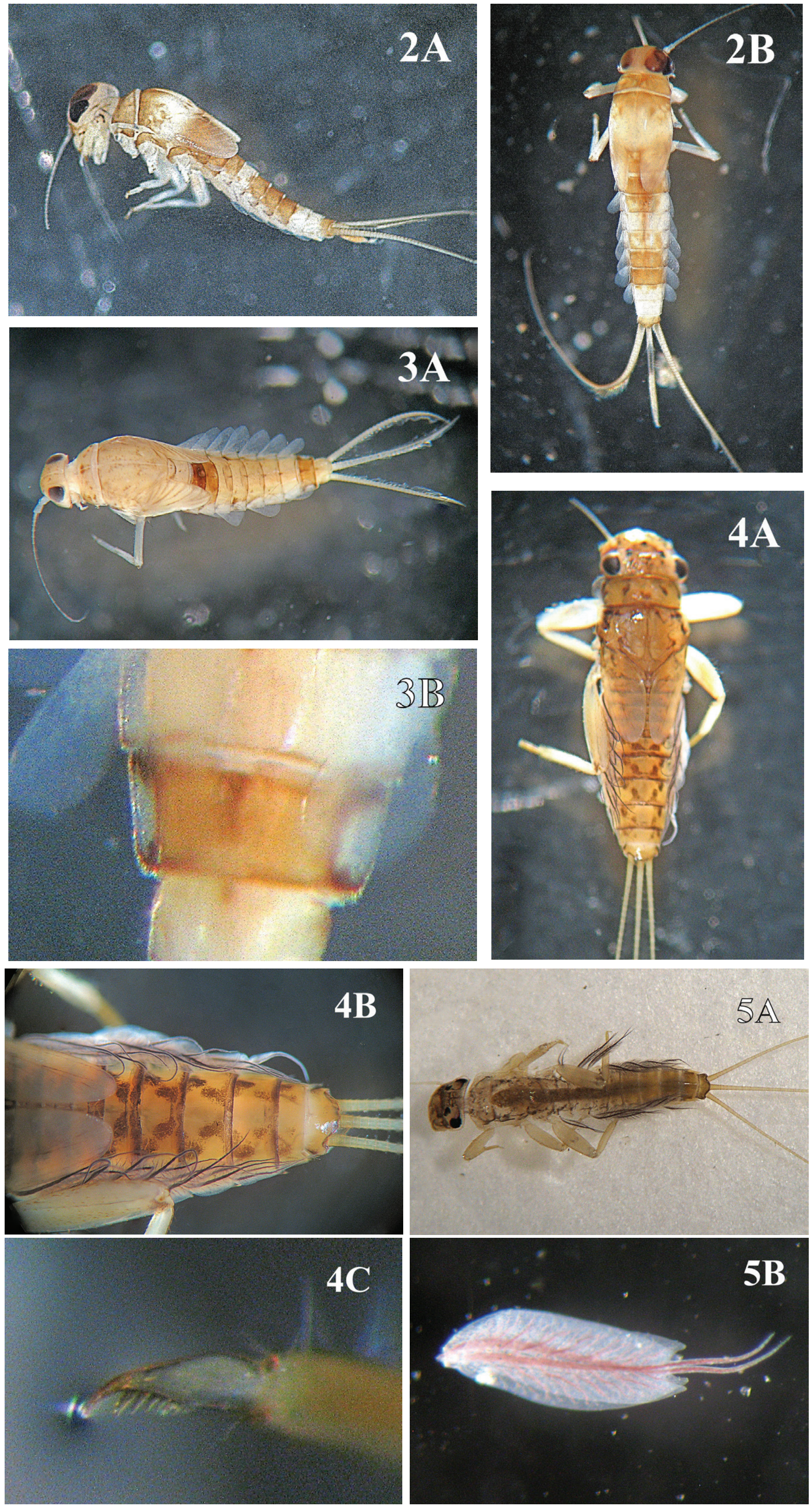
In Cuba the family Baetidae family currently have 12 species in six genera, with *Fallceon* being the most diverse with four species. The Leptophlebiidae have 13 species grouped in seven genera, with *Careospina* most diverse with four species. Overall, there are 25 species in the two families, but four of them are not founded in the eastern region of the archipelago. The findings of this study show a 75% of the species listed of Baetidae in eastern area of the archipelago, together with 46% of Leptophlebiidae. Additionally, this survey reports the 71.43% of the species listed to the eastern area of Cuba and 58.82% of whole Cuba.

The Sierra Maestra massif has an east-west orientation with rugged topography. In some areas the dividing line is crossed by some short mountain chains like the Turquino massif. Because the streams of the south are short, they have numerous cascades (Viña Bayés, 2001). A combination of several factors including well-preserved forests provides suitable conditions for various species of mayflies, including several leptophlebiids in Arroyo Paco (Kluge, 1994a), and baetids in the Alcarraza stream (Kluge, 1991). Conversely, the rivers in the northern hills are longer and wider, and face greater anthropic pressure.

In this study, we provide new records for four species: *Caribaetis alcarrazae*, *Paracloeodes lilliputian*, *Poecilophlebia pacoi*, and *Traverina oriente*. A few studies have been conducted in streams of the northern slope of the Sierra Maestra massif so far, resulting in lists of mayfly species, however their distribution patterns are not analyzed for these species (López Del Castillo *et al.*, 2004, 2005; Deler-Hernández *et al.*, 2007).

Caribaetis alcarrazae was limited to the type locality in La Alcarraza located in the southern hills of the Sierra Maestra (Kluge, 1992a). The second record of this species was documented at the Mayarí River in the Holguín province, located in the northern and eastern part of the archipelago (Aldana & Fonseca, 2001). This is the third record to the specie that is classified as rare by (Naranjo & Cañizares, 1999). Between these two watersheds lie the highest peaks of the archipelago, located in the "Sierra de los libertadores" within Pico Bayamesa National Park, and the Turquino massif range, in the Turquino National Park. In this study, this species showed a strong seasonal influence on their abundance, with 87% of specimens collected in the dry season (Figure 6). During this period, nymphs were mostly found in the cobble in riffles microhabitats. The remaining 13% were collected in the rainy season, among cobble in riffles and sand in pools microhabitats (Figure 7).

The species *Paracloeodes lilliputian* was reported twice, the first time in the type locality of Duaba River, located in the Nipe-Sagua-Baracoa massif in the eastern and northen part of the Cuban archipelago, by Kluge (1991). The Yáquimo River in Las Tunas province provides the second record (Benítez, 2007). This research provides the third record for the species and the first one for the entire Sierra Maestra massif. This species showed a marked seasonal variation, with a marked use for microhabitats in the pool subsystem, mainly in sand and leaf litter microhabitats (Figure 7).



Figures 2-5. **2.** *Caribaetis alcarrazae* (2A) later view. (2B) habitus dorsal view. 3. *Paracloeodes lilliputian* (3A) habitus dorsal view. (3B) Detail of marking on lateral abdominal segment. 4. *Poecilophlebia pacoi* (4A) habitus. (4B) Abdominal color pattern. (4C) Claw. 5 *Traverina oriente* (5A) habitus dorsal view. (5B) Abdominal gill.

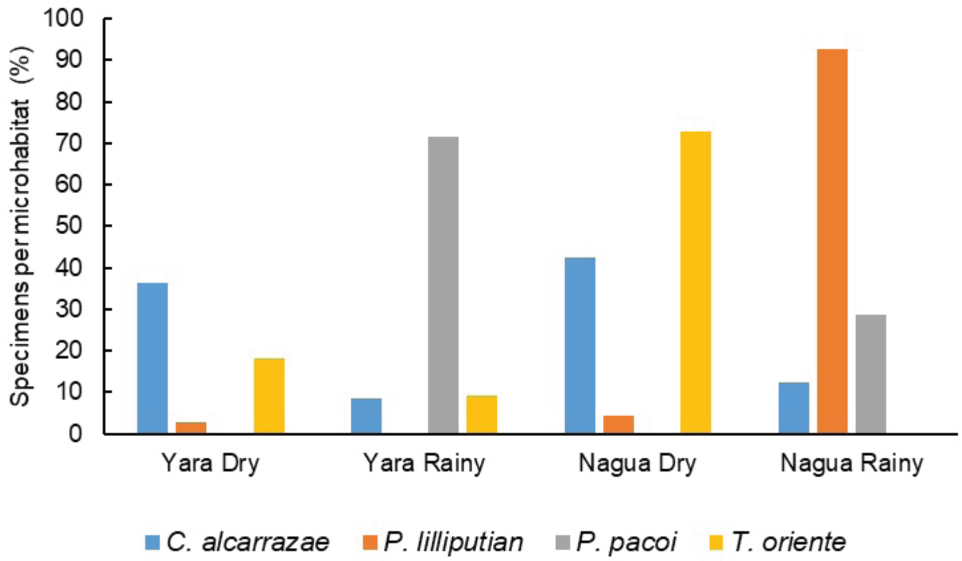


Figure 6. Average percentage of individuals collected per river and hydrological period for the new records.

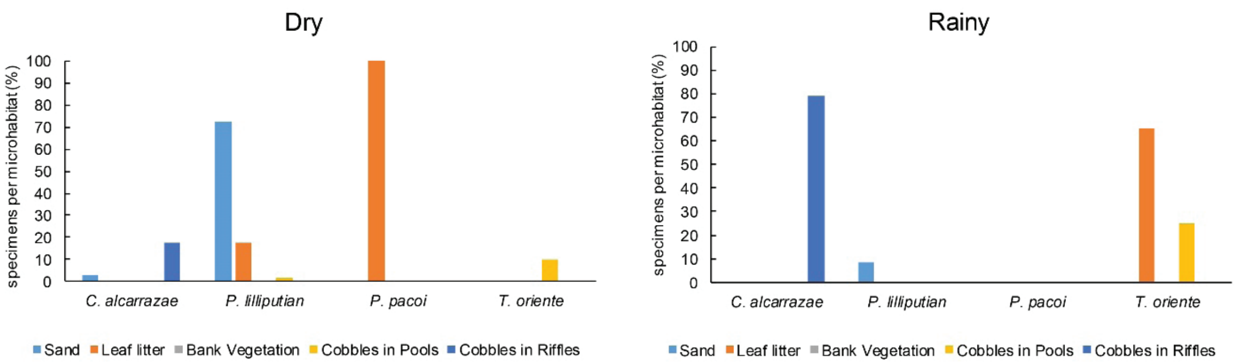


Figure 7. Average percentage of new record species collected in both rivers per hydrological period by microhabitats.

Although *Poecilophlebia pacoi* has been recorded several times, the knowledge about its natural history, biological traits, use of microhabitats, and response of the populations to flow fluctuation influence is limited. Due to its scarcity, previous studies have approached this species from a conservationist perspective (Deler-Hernández *et al.,* 2007; Salazar-Salina & Torres-Cambas, 2021). In this study individuals of *P. pacoi* were collected from a sampling site located in the headwaters of the Yara River inside Turquino National Park (Brazo derecho). All individuals were collected during the rainy season, using the leaf litter microhabitat. This behavior is important for identify stress factors and assess vulnerability, such as prolonged periods of low flow limiting availability of this microhabitat (Figure 7). Despite *Traverina oriente* having a wide distribution in the eastern area of the archipelago, most of the specimens were collected from the Nipe-Sagua-Baracoa massif range near the type locality (Naranjo-López *et al.*, 2019). In the Sierra Maestra massif range, this species was collected from streams on the south slope in Rio La Mula. This locality was sampled for over 10 years for the undergraduate students of Biology of the Universidad de Oriente. Another sampling locality was Sevilla River, in the western area of the Sierra Maestra Massif range. According to the present study, the distribution is strongly influenced by seasonality. During the dry season, 19 individuals were collected whereas only one nymph was found during the rainy season (Figure 7, Table 2). The species mainly utilized the microhabitat of leaf litter in pools. It was widely distributed in the Nagua watershed but only was found in the two lowest sampling points within the Yara watershed.

Therefore, future conservation plans would be focused on protecting the local riparian forest on small to medium scale. It is essential to know the natural structure of the forest and the main characteristics of the surrounding areas in order to mitigate the external source of stress. Understanding the patterns of species abundance and microhabitat use during different hydroclimatic periods can enhance the quality of the results in the calibration of the BMWP/cub index. Also, biomonitoring and biodiversity assessment programs.

ACKNOWLEDGEMENTS

The first author would like to thank the family of Dr. Carlos Naranjo for opening her home for a long period of time to identify mayflies. Also, many thanks to Idea Wild for providing the equipment and laptop needed for this study. Alicante University funded the research stays of PLDelC in the Ecology department through the “Proyecto Habana”. The authors are grateful to two anonymous reviewers and Professor Luis Manuel Guevara-Chumacero for their constructive comments on the manuscript.

AUTHORS’ CONTRIBUTIONS

PLDelC designed the research, collected and identification of the specimens, and drafted the article. GMLI and LMGL contributed to the research design, wrote and critically reviewed the draft. JGP critically reviewed the draft.

REFERENCES

Aldana, M. & L. Fonseca. 2001. Caracterización ecológica de la macrofauna del río Mayarí. Tesis de Grado. Facultad Ciencias Naturales y Exactas, Universidad de Oriente, Cuba. 76 p.

Allen, R. K. 1973. New species of *Leptohyphes* Eaton (Ephemeroptera: Tricorythidae). *The Pan-Pacific Entomologist* 49:363-372.

Benítez, Y. 2007. Revisión del orden Ephemeroptera en los ríos Yáquimo y Sevilla, Amancio, Las Tunas. Tesis de Grado. Facultad Ciencias Naturales y Exactas, Universidad de Oriente, Cuba. 56 p.

Campos de Oliveira, R. 2022. Hagenulina Kluge (1994): diversity, phylogeny, and biogeography (Ephemeroptera: Leptophlebiidae). Tesis de doctorado, Facultad de Filosofia, Ciencias y Letras de Ribeirao Preto, Universidad de Sao Paulo, Brazil. 151 p. DOI:10.11606/t.59.2022.tde-03052022-082823

Cummins, R. W. 1962. An evaluation of some techniques for the collection and analysis of benthic samples with special emphasis on lotic waters. *American Midland Naturalist* 67:477-504. DOI:10.2307/2422722

Deler-Hernández, A., Y. S. Megna, D. D. González-Lazo & C. N. Carcasés-Torres. 2007. Insectos acuáticos y áreas prioritarias para la conservación en la cuenca alta del río Cauto (Santiago de Cuba, Cuba). *Boletín Sociedad Entomológica Aragonesa* 40:451-461. DOI:10.23818/limn.23.19

Dudgeon, D. 1982. Aspects of the microdistribution of insect macrobenthos in a forest stream in Hong Kong. *Archives of Hydrobiology* 64:221-239.

INRH (Instituto Nacional de Recursos Hidráulicos). 2011. Delegación Provincial de Recursos Hidráulicos. Ciudad de Bayamo. Granma. Cuba. Reporte del año 2010.

Kluge, N. J. 1991. Efímeras cubanas de la familia Baetidae (Ephemeroptera) I: Géneros *Callibaetis*, *Cloeodes* y *Paracloeodes*. *Zoologicheskii Zhurnal* 12:128-135.

Kluge, N. J. 1992a. Efímeras cubanas de la familia Baetidae (Ephemeroptera) II: subgéneros *Caribaetis* y *Americabaetis* del género *Baetis*. *Zoologicheskii Zhurnal* 71:13-20.

Kluge, N. J. 1992b. Efímeras cubanas de la familia Baetidae (Ephemeroptera) III: subgénero *Fallceon* y del género *Baetis*. *Zoologicheskii Zhurnal* 71:38-48.

Kluge, N. J. 1994a. A revision of Leptophlebiidae of Cuba (Ephemeroptera). *Zoosystematica Rossica* 2: 247-285.

Kluge, N. J. 1994b. Habrophlebiinae subfam. n. with description of a new species of *Habroleptoides* from Caucasus (Ephemeroptera: Leptophlebiidae). *Zoosystematica Rossica* 3:35-43.

Kluge, N. J. & A. Novikova. 2014. Systematics of Indobaetis Müller-Liebeau & Morihara 1982, andrelated implications for some other Baetidae genera (Ephemeroptera). *Zootaxa* 3835(2):209-236. DOI:10.11646/zootaxa.3835.2.3

Kluge, N. J. & C. Naranjo-López. 1990. Efímeras de la familia Leptohyphidae (Ephemeroptera) de Cuba. *Entomologicheskoe Obozrenie* 69:564-577.

López Del Castillo, P., C. Naranjo-López, J. L. Fernández, D. D. González-Lazo, A. Trapero & J. Pérez. 2004. Insectos acuáticos del Parque Nacional ‘La Bayamesa’, Cuba. *Boletín Sociedad Entomológica Aragonesa* 35:225-231.

López Del Castillo, P., C. Naranjo-López, J. L. Fernández, J. P. Osoria, D. González-Lazo, & A. Trapero. 2005. Freshwater insects. In: Maceira, D., A. Fong, W. S. Alverson & T. Wachter (eds.) *Cuba: Parque Nacional La Bayamesa. Rapid Biological Inventories Report 13*. The Field Museum. Chicago, IL. USA. pp. 134-136. DOI:10.5962/bhl.title.86395

Lugo-Ortiz, C. R., W. P. McCafferty & R. D. Waltz. 1994. Contribution to the taxonomy of the Panamerican genus *Fallceon* (Ephemeroptera: Baetidae). *Journal of the New York Entomological Society* 102(4):460-475. DOI:10.4289/07-080.1

Naranjo-López, C. & M. Cañizares. 1999. Situación actual del orden Ephemeroptera en Cuba. *Cocuyo* 8:17-19.

Naranjo-López, C. & J. G. Peters. 2016. New records of Ephemeroptera (Insecta) for Jamaica and the Dominican Republic. In: M. Yoshimura & Y. Takemon (eds.). *International Progress in Ephemeroptera and Plecoptera Research. Proc. 13 th Inter. Conf. on Ephemeroptera and Plecoptera Research.* Biology Inland Water Suppl. Tokyo, Japan, pp. 83-91. DOI:10.1007/978-1-4615-1257-8_38

Naranjo-López, C., J. G. Peters & P. López Del Castillo. 2019. Ephemeroptera (Insecta) in Cuba. *Insecta Mundi* 0736:1-52.

O’Donnell, B. C. & E. L. Jockusch. 2008. Phylogenetic relationships of leptophlebiid mayflies as inferred by histone H3 and 28S ribosomal DNA. *Systematic Entomology* 33:651-667. DOI:10.1111/ j.1365-3113.2008.00434.x

Peters, W. L. 1971. A revision of the Leptophlebiidae of the West Indies (Ephemeroptera). *Smithsonian Contributions to Zoology* 62:1-48. DOI:10.5479/si.00810282.62

Peters, W. L. 1980. Phylogeny of the Leptophlebiidae (Ephemeroptera): an introduction. In: Flannigan, J. F. & K. E. Marshall (eds). *Advances in Ephemeroptera Biology*. Plenum Press, New York, pp. 43-56. DOI:10.1007/978-1-4613-3066-0_3

Salazar-Salina, J. C. & Y. Torres-Cambas. 2021. A new record of the Cuban endemic mayfly *Poecilophlebia pacoi* (Kluge, 1994) (Ephemeroptera, Leptophlebiidae) from Gran Piedra massif, eastern Cuba. *Check List* 17(4):1103-1106. DOI: 10.15560/17.4.1103

Sartori, M. & J. E. Brittain. 2015. Order Ephemeroptera. In: Thorp, J. H. & A. P. Covich's (eds.). *Freshwater Invertebrates: Ecology and General Biology*. 4th ed. Academic Press, New York, USA, pp. 873-891. DOI: 10.1016/B978-0-12-385026-3.00034-6

Strahler, A. N. 1957. Quantitative analysis of watershed geomorphology. *Eos, Transactions American Geophysical Union* 38(6):913-920.

Traver, J. R. 1938. Mayflies of Puerto Rico. *Journal of Agriculture of the University of Puerto Rico* 22:5-42.

Vilenica, M, A. Brigić, M. Sartori & Z. Mihaljević. 2018. Microhabitat selection and distribution of functional feeding groups of mayfly larvae (Ephemeroptera) in lotic karst habitats. *Knowledge and Management of Aquatic Ecosystems* 419:1-17. http://dx.doi.org/10.1051/kmae/2018011

Viña Bayés, N. 2001. Caracterización geográfica. In: Fong, A., N. Viña & D. Maceira (eds.). *Diversidad Biológica de los macizos montañosos orientales.* Centro Oriental de Ecosistemas y Biodiversidad (BIOECO), Santiago de Cuba, Cuba, pp. 4-12.