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Ephemeroptera (Insecta) in Cuba

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Abstract. Systematic, faunistic and ecological aspects of the six families and 34 species and subspecies in the order Ephemeroptera currently recorded from Cuba are reviewed based primarily on a reference collection located at the Universidad de Oriente (Santiago de Cuba), collections at the Institute of Ecology and Systematics (Havana) and historic literature. A key to nymphs is included with photographs of significant features of many species. An annotated list of species is presented with comments on type localities, species ecology and distribution. The morpho-ecological types of the nymphs are updated according to current taxonomic changes, and indicator species of organic contamination are analyzed according to the BMWP-Cub index. Based on present data, mayflies are best collected between January and June although many species are present throughout the year, and almost half of the species are widely distributed. Possible routes of penetration from the continents toward Cuba are from South America through the arc of islands formed by the Lesser Antilles, from Central and South America through the peninsula of Yucatan, and via an ancient landspan or island chain from northern South America (GAARlandia). With one exception, there is no evidence for dispersal of species from North America (through Florida) to Cuba (and then to the Antilles) or vice versa. The pattern of geographical distribution of Ephemeroptera inside Cuba is very similar to that of the orders Trichoptera and Odonata. The greatest number of species is found in the Eastern region and the fewest in the Central and Central-East regions. The high endemism (76.5%) is probably due to geographical isolation and processes that bring about this phenomenon together with the low vagility that characterizes the order.

Key words. Systematics; taxonomy; altitudinal distribution; seasonal distribution; zoogeography; endemism.

Resumen. Se revisaron aspectos sistemáticos y ecológicos de las seis familias y 34 especies y subespecies actualmente citadas para Cuba basados principalmente sobre una colección de referencias localizada en la Universidad de Oriente (Santiago de Cuba), las colecciones del Instituto de Ecología y Sistemática (Habana) y la literatura histórica publicada sobre el tema. Se incluye una clave de ninfas con fotografías de los caracteres morfológicos más relevantes y se presenta una lista con comentarios de las localidades tipos, de la ecología de las especies y mapas de distribución. Los tipos ecológicos de las ninfas están actualizados de acuerdo a los cambios taxonómicos recientes y se analizan las especies indicadoras de contaminación orgánica de acuerdo al índice BMWP-Cub. Basado en los datos actuales, la mejor época para recolectar las efímeras en Cuba se encuentra entre enero y junio, aunque muchas especies se recolectan a lo largo del año y casi la mitad de las especies se encuentran ampliamente distribuidas. Se proponen hipotéticas rutas de penetración de las especies desde los continentes hacia Cuba: 1- desde América del Sur a través del arco de islas formado por las Antillas; 2- desde América Central y América del Sur a través de la península de Yucatán, y 3- desde el norte de América del Sur, tomando como vía un puente terrestre (GAARlandia). Con una excepción, no existen evidencias de dispersión de las especies desde Norte América (a través de la Florida) hacia Cuba (y luego al resto de las Antillas) y viceversa. El patrón de distribución geográfica de Ephemeroptera dentro de Cuba es muy similar al de los órdenes Trichoptera y Odonata. El mayor número de especies es encontrado en la región Oriental y muy pocas en las regiones Central y Centro-Oriental. El alto endemismo (76.5%) probablemente se debe al aislamiento geográfico y la escasa vagilidad que caracteriza a las especies de este orden.

Palabras clave. Sistemática; taxonomía; distribución altitudinal; distribución estacional; zoogeografía; endemismo.

Introduction

The order Ephemeroptera is composed at present of more than 3000 described species worldwide and represents one of the earliest existing orders of winged insects (Barber-James et al. 2008). The inability to fold the wings over the abdomen, the presence of 10 abdominal segments, and a limited reduction of primary wing veins, are among characteristics considered ancestral which persist within the order (Elouard et al. 2003; Salles 2006).

Mayflies are abundant in freshwater ecosystems, especially in running waters. They are broadly distributed and may be encountered at high and low altitudes, in temperate and tropical zones, and are most diverse in the tropics (Stout and Vandermeer 1975). Only the nymphs have a direct relationship with the water and respire through gills generally located on the abdomen. Most feed on detritus or algae and diatoms and process an important quantity of organic material; a few are carnivores. Mayflies also serve as food for other aquatic life such as bugs, beetles, odonate nymphs and fish to form an important link in the trophic chain.

The nymphal stages occupy the major part of the life cycle of these insects and, because different species tolerate distinct grades of contamination, immatures have been used as biological indicators of water quality (Salles 2006; Merritt et al. 2008). The opposite is true for adults who live only a short time, generally one or two days, the short adult life being the basis for the name of the order. Typically, they form mating swarms several centimeters to several meters in the air, the male holding the female with his forceps. Copulation lasts a short time, in some cases only seconds (Domínguez et al. 2006); oviposition can take place almost immediately or after several days (in the case of ovoviviparous species). The female often flies upstream to deposit the eggs (Domínguez et al. 2006). During the periods of emergence, nuptial flight and oviposition, adults are easy prey for birds, bats and other insects, thus returning a significant amount of energy to the terrestrial environment.

The life cycles vary according to group and habitat, from one generation per year to alternating short summer and long winter generations, to non-seasonal generations in the tropics with adults flying throughout the year (Domínguez et al. 2006). In Cuba, the order is present in most clean to lightly contaminated rivers and is most abundant in the mountain streams of the four geographic regions established by Núñez (1989), especially in the Eastern Region where the two most important ranges in the country are found (González-Lazo et al. 2008). In spite of this order's broad distribution and its abundance and importance in lotic habitats, the group is not well known to entomologists in Cuba or other countries. Ecological and systematic data on Cuban species is dispersed in the literature (Peters 1971; Naranjo 1986; Soldán 1986; Kluge and Naranjo 1990, 1994; Kluge 1991, 1992a, 1992b, 1994; Naranjo and Teruel 2001). Only one publication in the history of Cuban entomology (Alayo 1977) addresses the study of Ephemeroptera as a comprehensive group and at that time (Alayo 1977), only ten species were known or reported.

Given the need that exists in Cuba for an update that includes all related work on the systematics, ecology and distribution of Cuban mayflies, the authors present this revision of the Ephemeroptera of Cuba in order to summarize this information in a single accessible publication.

Materials and Methods

Review of the literature. Here we have reviewed publications addressing the subject of Ephemeroptera in Cuba overall (Alayo 1977, Osoria 1994, Cañizares 1998, González-Lazo et al. 2005, 2008) and dissertations and BSc theses based on work in the following rivers: Táyaba (Prov. Sancti Spíritus, Central Region), Máximo (Prov. Camagüey, Central-East Region), Yáquimo and Sevilla (Prov. Las Tunas, Central-East Region), Cacoyogüín, Gibara and Mayarí (Prov. Holguín, Eastern Region), Guantánamo and Guaso (Prov. Guantánamo, Eastern Region), Bayamo, Yara, Cautillo, Jibacoa, and Sevilla (Prov. Granma, Eastern Region). We also looked at unpublished lists covering the Río Mula and Río San Juan (Prov. Santiago de Cuba, Eastern Region), Río Cuzco (Prov. Guantánamo, Eastern Region), and Río Piloto (provinces of Santiago de Cuba and Holguín, Eastern Region).

Review of collections. We examined the specimens in the Alayo collection at the Institute of Ecology and Systematics (IES) in Havana, including life stage, quantity, locality, date and collector. Similarly, we examined the collections in the Department of Biology at the Universidad de Oriente where specimens are cataloged by location, and material from this collection was used to create a reference collection deposited in the Charles Ramsden Museum of the Universidad de Oriente for ease of accessibility to specialists interested in the study of Ephemeroptera.

This collection was used for preparation of the list of species organized by families following Domínguez et al. (2006) but arranged in approximate phylogenetic order. The species of Baetidae were arranged according to the system of Kluge (1992b), the Leptophlebiidae according to Kluge (1994), and the Leptohyphidae following Kluge and Naranjo (1990), except that generic status follows Domínguez et al. (2006).

Using the above specimens, we created a reference collection organized into families, genera and species. We prepared photographs of nymphs of 24 species using a digital camera (Canon Power Shot A630) with a resolution of 8.0 megapixels. Some additional photographs were prepared using cameras at Florida A&M University.

Information was organized as follows: name of species with collector and collection data, ecology, geographic distribution, seasonal distribution, altitudinal distribution in meters above sea level (m), and geographic distribution following the regional classification of Núñez (1989) (Fig. 1).

Analysis of distribution. To analyze distribution patterns, we used the Sorensen Index of Biological Similarity (Feinsinger 2004). Numbers used for the calculation of the Index were taken from the present publication for Cuba, from Naranjo and Peters (2016) for the Greater Antilles, from Pescador and Richard (2004 with updates) for Florida, and from McCafferty and Jacobus (2013) for Central America.

Ephemeroptera of Cuba

A. Annotated List of Ephemeroptera of Cuba

Table 1.

Below we present an annotated list of species recorded from Cuba with figures and photographs of significant identification characters. We give ecological characteristics (when available), the status of Ephemeroptera as pollution indicator species, and a discussion of altitudinal, seasonal, and geographic distribution and endemism in Cuban Ephemeroptera.

Before 1976, Cuba was divided into six provinces instead of the present 16 provinces. In the discussion below and in the list of paratypes, names of the provinces are given in brackets if different from those given by earlier authors.

For each species, the locality of the holotype is given and distribution data including surveys conducted prior to 2008 by the Department of Biology, Universidad de Oriente, are given in the text; Appendix 1 itemizes these survey localities. Subsequent, significant new records are discussed in the text, and all records are combined on the distribution maps (Fig. 2–19). Details for paratype localities are included as Appendix 2.

Table 1. Ephemeroptera of Cuba: regional distribution and endemism (modified and updated from Naranjo and Peters 2016).

	Species	Regional Distribution				*Endemic*	Family
		Western	Central	Central-East	Eastern		
1	*Americabaetis naranjoi*		X	X	X	yes	Baetidae
2	*Callibaetis floridanus*	X	X	X	X		Baetidae
3	*Cloeodes superior*		X		X		Baetidae
4	*Cloeodes inferior*	X	X	X	X		Baetidae
5	*Caribaetis planifrons*	X	X	X	X		Baetidae
6	*Caribaetis alcarrazae*				X	yes	Baetidae
7	*Caribaetis grandis*				X	yes	Baetidae
8	*Fallceon longifolius*			X	X		Baetidae
9	*Fallceon poeyi*	X	X	X	X		Baetidae
10	*Fallceon sextus*				X	yes	Baetidae
11	*Fallceon testudineus*				X	yes	Baetidae
12	*Paracloeodes lilliputian*			X	X	yes	Baetidae
13	*Lachlania abnormis*						Oligoneuriidae
14	*Farrodes bimaculatus*	X	X	X	X	yes	Leptophlebiidae
15	*Hagenulus caligatus*	X				yes	Leptophlebiidae
16	*Hagenulus morrisonae*		X	X	X	yes	Leptophlebiidae
17	*Borinquena sexta*			X	X	yes	Leptophlebiidae
18	*Turquinophlebia grandis*				X	yes	Leptophlebiidae
19	*Poecilophlebia pacoi*				X	yes	Leptophlebiidae
20a	*Careospina hespera hespera*	X	X			yes	Leptophlebiidae
20b	*Careospina hespera sierramaestrae*			X	X	yes	Leptophlebiidae
21	*Careospina baconaoi*	X			X	yes	Leptophlebiidae
22	*Careospina evanescens*				X	yes	Leptophlebiidae
23	*Careospina minuta*		X			yes	Leptophlebiidae
24	*Traverina cubensis*	X				yes	Leptophlebiidae
25	*Traverina oriente*				X	yes	Leptophlebiidae
26	*Mesoplocia inaccessibile*				X		Euthyplociidae
27	*Tricorythodes sierramaestrae*				X	yes	Leptohyphidae
28	*Tricorythodes sacculobranchis*	X	X	X	X	yes	Leptohyphidae
29	*Tricorythodes cubensis*	X	X		X	yes	Leptohyphidae
30	*Tricorythodes montanus*				X	yes	Leptohyphidae
31	*Tricorythodes grallator*	X	X	X	X	yes	Leptohyphidae
32	*Insulibrachys needhami*	X				yes	Caenidae
33	*Caenis cubensis*	X	X	X	X	yes	Caenidae
	total	**14**	**14**	**14**	**28**	**26**	

Family Baetidae

There were 161 species of Baetidae described from the Neotropical region as of 2005 (Barber-James et al. 2008), and more species are described each year. Twelve species are presently recognized in Cuba.

A.1. *Americabaetis naranjoi* (Kluge, 1992)

Figures 2, 20.

Baetis (Americabaetis) naranjoi Kluge 1992a:19 (male and female imagos, nymph, egg).
Acerpenna naranjoi; Lugo-Ortiz and McCafferty 1994:71.
Americabaetis naranjoi; Lugo-Ortiz and McCafferty 1996b:167.

Holotype. Male imago, Province Guantánamo, Río Duaba (Baracoa), 15-III-1989, N. Kluge.

The type material of *Americabaetis naranjoi* was collected in the provinces of Guantánamo and Granma by Kluge (1992a). Nymphs are easily recognized by the banded caudal filaments and absence of gills on abdominal segment 1.

Ecology. According to Benítez (2007), nymphs of *A. naranjoi* are found swimming in stony-muddy rivers in areas with little current. They were collected at depths between 11 and 107 cm, and all were found at altitudes below 250 m. Results of Benítez (2007) correspond to results of Kluge (1992a) who suggested that species was an inhabitant of the potamal zone of rivers. Cañizares (1998) considers this a rare species in Cuban rivers.

Geographic distribution. The species is found in the Central Region (one nymph from Río Táyaba, Trinidad), Central-East Region (30 nymphs from Río Máximo) and Eastern Region of Cuba (Kluge 1992a, Naranjo and González-Lazo 2005b) (Fig. 2).

A.2. *Callibaetis floridanus* Banks, 1900

Figures 2, 21.

Callibaetis floridanus Banks 1900:249; Lugo-Ortíz and McCafferty 1996a:3 (= *C. completa*).
Callibaetis completa Banks 1930:87 (female imago); Kluge 1991:128 (nymph, egg, male imago).

Holotype of *Callibaetis floridanus*. Female imago, Florida, Biscayne Bay, A. T. Slosson.
Holotype of *Callibaetis completa*. Female imago, Province Cienfuegos, Río Soledad, 2-VI, R. Salt.

Banks (1930) described *Callibaetis completa* from female imagos collected in Soledad, Cienfuegos Province (Central Region). Later Kluge (1991) redescribed the female and described for the first time the nymph and male imago from specimens collected in Río El Codillo and Río El Tártaro (Guamá, Santiago de Cuba Prov.). *Callibaetis completa* is now considered to be a synonym of *C. floridanus* (Lugo-Ortíz and McCafferty 1996a).

Nymphs of this species are easily recognized because the first and second pair of abdominal gills are triple-folded (3 apparent lamellae) and the 3rd to 6th pairs of gills are doubled. Tarsal claws of all legs have a double row of denticles, but these denticles are much longer on the first pair of legs. In *Callibaetis* adults the body is covered by reddish brown spots (pigmentation more intense in the female). In forewings there are two marginal intercalary veins in each space.

Ecology. Kluge (1991) and Lugo-Ortiz and McCafferty (1996a) report that nymphs of *C. floridanus* swim in small pools of still water that form in lowland streams and rivers. In the Alayo collection at IES are several specimens collected in the Zapata Swamp (Western Region). Nymphs swim through vegetation and appear to prefer warmer waters; the presence of double and triple gill lamellae is presumably an adaptation to low oxygen concentrations characteristic of stagnant waters. According to Naranjo (1986) and Cañizares (1998), the species has a narrow altitudinal range (5–110 m). Kluge (1991) also reported this species from the lowlands of Sierra Maestra. Other specimens have been collected from marshes, temporary ponds, and brackish waters in the cays north of Camagüey Province. In Florida, specimens have been collected from a wide variety of habitats including brackish waters and highly acidic waters (Berner and Pescador 1988). This is the only ovoviviparous species known from Cuba. Berner (1941)

reported the phenomenon of ovoviviparity for *C. floridanus*, *C. pretiosus* Banks, and other species of *Callibaetis* from Michigan and suggested that all or nearly all species of the genus are ovoviviparous.

According to Trost and Berner (1963), the life cycle is relatively short and both nymphs and adults have been collected throughout the year. These authors suggest that developmental time varies by season. The shortest time recorded from oviposition to emergence of the subimago was 27 days (19 August to 14 September) and the longest from 60 to 75 days. The nymphs pass through 9 to 11 nymphal instars (possibly more) before emerging to subimagos. The molt from subimago to imago occurs 7–9 hours later, and most mating takes place in the morning. The male imago dies within two days, but the female may survive up to two weeks. The longevity of the females is related to the ovoviviparity of the species (Berner and Pescador 1988).

Nymphs reported here were collected in the period between January and July, and Kluge (1991) reports collections in October, November and December.

Geographic distribution. In Cuba, *C. floridanus* is reported throughout the island (Banks 1930, Kluge 1991, Lugo-Ortiz and McCafferty 1996a). In our collections are specimens from the Central, Central-East, and Eastern Regions but no records from the far west of the island. However, in the collection of P. Alayo are records from Arroyo del Pinar (Pinar del Río Prov.), Playa Larga (Ciénaga de Zapata, Matanzas Prov.), Guanimar (Alquizar, Havana Prov.), Río Quitacalzón (Casiguas, Havana Prov.) and Casimbas (Yateras, Guantánamo Prov). Outside of Cuba it is reported from the northeast, southeast and southwest of the United States, from Mexico (North America) to Belize, Costa Rica, Honduras, El Salvador and Guatemala (Central America) to Puerto Rico (Greater Antilles) and Guadeloupe (Lesser Antilles) (Traver 1938, Berner and Pescador 1988, McCafferty and Waltz 1990, Kluge 1991, McCafferty and Davis 1992, Lugo-Ortiz and McCafferty 1996a, Hofmann et al. 1999, McCafferty and Jacobus 2013) (Fig. 2).

A.3. *Cloeodes superior* Kluge, 1991

Figures 3, 22.

Cloeodes superior Kluge 1991:130 (male and female imagos, nymph).

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

The species was described from specimens collected in La Alcarraza, Arroyo Paco and La Idalia (Guamá), Santiago de Cuba. Nymphs of *Cloeodes* have no denticles on the claws, the gills are simple and tapered with smooth margins, and rows of fine hyaline setae are found on the basal outer margins of tibiae and tarsi. The first abdominal sternum is smooth and the second to sixth sterna have transverse rows of small setae. Nymphs of *C. superior* can be distinguished from *C. inferior* by shorter gills and generally dark abdominal terga which usually lack the darker anteromedian markings on each tergum characteristic of *C. inferior*. In adult males of *C. inferior*, there is no keel between the basal segments of the forceps.

Ecology. Nymphs are encountered in submerged vegetation in cool, clear waters at a depth between 30 and 50 cm. Kluge (1991) named this species *C. superior* because he found it only at higher altitudes; it has now been collected over a wide range of altitudes but usually above 500 m (Cañizares 1998, López et al. 2004).

Geographic distribution. The distribution of this species in Cuba (Fig. 3) is restricted to the mountain ranges of Sierra Maestra and Nipe-Sagua-Baracoa in the Eastern Region and the Guamuhaya Mountains of the Central Region (Cañizares 1998, López et al. 2006). It is also recorded from the Dominican Republic (Naranjo and Peters 2016).

A.4. *Cloeodes inferior* Kluge, 1991

Figures 3, 23.

Cloeodes inferior Kluge 1991:133 (male and female imagos, nymph).

Holotype. Male imago, Province Guantánamo, Río Duaba (Baracoa), 15-III-1989, N. Kluge.

The species was described from specimens collected in Río Duaba (Baracoa, Guantánamo Prov.) and Río Baconao (Santiago de Cuba Prov.) in the Eastern Region and from Sierra de Trinidad, Sancti Spíritus, in the Central Region (Kluge 1991). The abdominal terga are generally pale in color with a dark, contrasting median macula on the anterior margins, and the gills are more elongated than those of *C. superior*. In male imagos, there is a pronounced median keel between the basal segments of the forceps.

Ecology. Nymphs of *C. inferior* are found in submerged vegetation in areas of low flow in rivers with clean, well-oxygenated water (Kluge 1991, Cañizares 1998). Previously the species was reported at lower elevations of the Sierra Maestra (Naranjo 1986, Kluge 1991). More recently it has been collected at elevations up to 1750 m, although more frequently encountered below 500 m (Cañizares 1998, Aldana and Fonseca 2001).

Geographic distribution. This species has been collected in all four geographic regions of the country (Kluge 1991, Cañizares 1998, Aldana and Fonseca 2001) (Fig. 3) and the Dominican Republic (Naranjo and Peters 2016).

A.5. *Caribaetis planifrons* (Kluge, 1992)

Figures 4, 24c, 25b, 30, 31.

Baetis (*Caribaetis*) *planifrons* Kluge 1992a:15 (male and female imagos, nymph, egg,).
Fallceon planifrons; Lugo-Ortiz, McCafferty and Waltz 1994:487.
Caribaetis planifrons; Kluge and Novikova 2014:232.

Holotype. Male imago, [Province Artemisa], Soroa, 1-IV-1989, N. Kluge.

Kluge (1992a) established the subgenus *Caribaetis* within the genus *Baetis* Leach for two species described from Cuba which differed from *Fallceon* by the presence of an apical seta on the claw and the absence of a keel between antennal bases. The species were easily distinguished by color pattern. Later, Lugo-Ortiz et al. (1994) synonymized the subgenus *Caribaetis* with *Fallceon* and transferred two Cuban species (*Caribaetis planifrons* and *C. alcarrazae*) to *Fallceon*; in 2014, Kluge and Novikova recognized the generic status of *Caribaetis*.

Ecology. Cañizares (1998) considers this a very abundant species frequently collected in Cuban rivers. Like nymphs of many Baetidae, it is most common in backwaters of stony and stony-sandy rivers with crystal clear waters at a depth between 20 and 40 cm (Kluge 1992a, Cañizares 1998, Benítez 2007). Previously, Naranjo (1986) remarked upon the reduced abundance of *C. planifrons* at higher altitudes. In the literature, there are records from low and high altitudes, but it is most often collected below 500 m. Mature nymphs have been collected throughout the year indicating that the life cycle is non-seasonal.

Geographic distribution. *Caribaetis planifrons* is found throughout all regions of Cuba (Lugo-Ortiz et al. 1994, Cañizares 1998, Naranjo and Cañizares 1999, Benítez 2007) (Fig. 4), Jamaica (Naranjo and Peters 2016) and Nicaragua (Meyer et al. 2008.)

A.6. *Caribaetis alcarrazae* (Kluge, 1992)

Figures 4, 32.

Baetis (*Caribaetis*) *alcarrazae* Kluge 1992a:18 (male and female imagos, nymph, egg).
Fallceon alcarrazae; Lugo-Ortiz, McCafferty and Waltz 1994:461.
Caribaetis alcarrazae; Kluge and Novikova 2014:232.

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

Caribaetis alcarazzae was described by Kluge (1992a) from La Alcarraza in the Sierra Maestra. It is distinguished by its highly contrasting color pattern with abdominal terga 2 and 6–7 very dark on a pale background, as compared with *C. planifrons* where markings occur on a yellowish background.

Ecology. Another 18 nymphs have been reported by Rodríguez and Pérez (1998) from the Río Jibacoa,

but comparison of a nymph from the type locality with these specimens would indicate that the Río Jibacoa material may belong to *Caribaetis planifrons* and not to *C. alcarrazae* (González-Lazo personal communication). Considering this and the report of Cañizares (1998), the species is considered rare in Cuba.

Nymphs have been collected in the months of November through January. Kluge (1992a) reported the species in February.

Geographic distribution. Formerly limited to La Alcarraza in the Sierra Maestra in the Eastern Region, we recently determined a nymph from the Río Mayarí with the label "03-II-01 cols. Andana y Fonseca" which expands the distribution to the Nipe-Sagua-Baracoa Massif, also in the Eastern Region (Fig. 4).

A.7. *Caribaetis grandis* (González-Lazo and Salles, 2007)

Figure 4.

Fallceon grandis González-Lazo and Salles 2007:52 (nymph).
Caribaetis grandis; Kluge and Novikova 2014:232.

Holotype. Mature nymph, Province Granma, Río Yara, 6-VI-99, P. López.

The species was described from the Río Yara, Granma Prov., by Gonzalez-Lazo and Salles (2007). It is similar to *C. planifrons* in coloration but distinguished from it by its larger size (> 7.5 mm).

Ecology. Little is known about the ecology of this species. It was collected on stones in rapids at an altitude between 300 and 400 m (López 2001).

Geographic distribution. Distribution of this species is limited to the type locality in the Eastern Region (Fig. 4).

A.8. *Fallceon longifolius* (Kluge, 1992)

Figures 5, 27f–g, 28.

Baetis (*Fallceon*) *longifolius* Kluge 1992b:44 (male and female imagos, nymph, egg).
Fallceon longifolius; Lugo-Ortiz, McCafferty and Waltz 1994:465; González-Lazo and Salles 2007:52.

Holotype. Male imago, Province Santiago de Cuba, La Alcarraza (Guamá), 7-II-1989, N. Kluge.

Fallceon longifolius was originally described by Kluge (1992b) from La Alcarraza and is easily distinguished from other species of *Fallceon* by its long, narrow gills.

Ecology. According to Kluge (1992b), Cañizares (1998) and Benítez (2007), *F. longifolius* inhabits the low zones of rivers in backwaters that form along the banks, mainly in mud-bottom areas, and tolerates some degree of pollution. It has a limited altitudinal range, having never been collected above 250 m (Kluge 1992b, Cañizares 1998). Kluge (1992b) recorded the species for the months of February, March, May, June, July and October; to this we add January and suggest that adults may emerge at any time of the year.

Geographic distribution. *Fallceon longifolius* has been recorded from the Eastern and Central-East Regions of Cuba (Kluge 1992b; Benítez 2007) (Fig. 5) and Jamaica (Naranjo and Peters 2016). Here we add two nymphs from Río Mayarí (Holguín Province) collected on 28-I-2001 by Aldana and Fonseca. González-Lazo and Salles (2007) indicated that a possible record from Mexico (Lugo-Ortiz et al. 1994) was not this species.

A.9. *Fallceon poeyi* (Eaton, 1885)

Figures 5, 24a–b, 25a, 27a–d, 29.

Centroptilum poëyi Eaton 1885:179 (male imago); Gundlach 1886:211.
Baetis poeyi; Traver 1938:28; Edmunds 1974:289.
Baetis (Fallceon) poeyi; Kluge 1992b:40 (lectotype; male and female imagos, nymph, egg).

Fallceon poeyi; McCafferty and Waltz 1990:778, McCafferty and Lugo-Ortiz 1994:162; Kluge and Novikova 2014:209.
Fallceon nikitai McCafferty and Lugo-Ortiz, 1994:162 (=*Baetis (Fallceon) poeyi* sensu Kluge).

Lectotype of *Centroptilum poeyi*. Male imago, "Cuba," Poëy 1864.

Eaton (1885) described *Centroptilum poeyi* from Cuba based on males. He stated that it was from the "Rangel Mountains, Cuba (Poëy & Ch. Wright) [Hag. Mus.]." Gundlach (1886) does not give this locality for *C. poeyi*. Traver (1938) suggested that *C. poeyi* was a species of *Baetis* (as defined in 1938) and Edmunds (1974) examined the type material and confirmed this placement. McCafferty and Waltz (1990) then included the species in *Fallceon*, a genus established by Waltz and McCafferty (1987). Kluge (1992b) reexamined the type material and designated a lectotype; in the same paper he limited the paralectotypes to three specimens and redescribed the species based on the lectotype and fresh material of the male, female, and nymph from the Western, Central, and Eastern regions of Cuba. Later, McCafferty and Lugo-Ortiz (1994) concluded that the material treated by Kluge as *Baetis (Fallceon) poeyi* represented a new species which they named *Fallceon nikitai*. They explained that the syntypes of *Baetis poeyi* which they examined did not have a hook-shaped costal projection on the hind wing but that the material described by Kluge did have such a projection. According to Kluge and Novikova (2014) who synonymized the two species, the hook is present on both. *Fallceon nikitai* is a common species with broad, well-tracheated gills.

Ecology. Benítez (2007) found this species in both rapids and pools in the Yáquimo and Sevilla Rivers in Las Tunas Province where it appears to prefer faster waters. Cañizares (1998) stated that nymphs are active swimmers in backwater areas but are often found avoiding the fastest current between rocks on the bottom of rivers. The species is abundant in all altitudinal zones but collected most frequently between 250 and 750 m.

Geographic distribution. The species is found throughout the Cuban archipelago and has been collected in all four geographic regions (Kluge 1992b, McCafferty and Lugo-Ortiz 1994, Cañizares 1998, Naranjo and Cañizares 1999) (Fig. 5). The actual locality for the lectotype is unknown. It has also been found in the Dominican Republic and Jamaica (Naranjo and Peters 2016).

A.10. *Fallceon sextus* (Kluge, 1992)

Figures 5, 26b, 27e.

Baetis (*Fallceon*) *sextus* Kluge 1992b:45 (male imago, nymph, egg).
Fallceon sextus; Lugo-Ortiz, McCafferty and Waltz 1994:473.

Holotype. Male imago, Province Santiago de Cuba, Río Las Yaguas (Baconao), 12-II-1989, N. Kluge.

Fallceon sextus was described from specimens collected in the Las Yaguas tributary of Baconao, Santiago de Cuba (Kluge 1992b). In the original figure (reproduced here, Fig. 27e), the gill tracheae are unpigmented which potentially may be a character to help identify the species. It has not been reported by researchers on aquatic fauna of the Universidad de Oriente. However, in material examined for this publication we found one nymph from the Río La Isabelica (Gran Piedra), 14-II-2000, col. A. Trapero.

Ecology. Little is known concerning the ecology of this species. It has been collected at altitudes of 200–1200 m.

Geographic distribution. Distribution is limited to the Eastern Region of Cuba (Kluge 1992b) (Fig. 5).

A.11. *Fallceon testudineus* (Kluge, 1992)

Figures 5, 26a.

Baetis (*Fallceon*) *testudineus* Kluge 1992b:45 (nymph, female subimago, egg).
Fallceon testudineus; Lugo-Ortiz, McCafferty and Waltz 1994:473.

Holotype. Mature nymph, Province Santiago de Cuba, Arroyo Paco (Río Palma Mocha), 4-II-1989, N. Kluge.

The type specimens of *F. testudineus* were collected in the localities of Palma Mocha, La Emajagua and Río Carpintero in the Sierra Maestra, during the months of December to February (Kluge 1992b). According to Kluge (1992b), the species is recognized by the apically narrow paraglossae and the broad distal segment of the labial palpi.

Ecology. *Fallceon testudineus* has not been found in collections made by the group working on aquatic fauna at the Universidad de Oriente (Appendix 1). The species is very rare and possibly an endemic.

Geographic distribution. This species appears to be restricted to the Eastern Region of Cuba (Kluge 1992b) (Fig. 5).

A.12. *Paracloeodes lilliputian* Kluge, 1991

Figures 6, 33.

Paracloeodes lilliputian Kluge 1991:134 (female imago and nymph).

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

Kluge (1991) described the nymph and female imago of this species from the Río Duaba. In the nymphs, the tarsal claws have two rows of tiny denticles basally and the apical setae of the paraglossae are arranged in a row. 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. The head has a longitudinal keel between the antennae. Imagos of both sexes of *Paracloeodes* lack hind wings; males have large, well developed eyes and apparently three-segmented forceps. Unfortunately, the male imagos of *P. lilliputian* are unknown.

Ecology. In general, nymphs of the genus *Paracloeodes* live in deep rocky areas of large rivers and then migrate toward the shore as they reach maturity; they also prefer sandy areas and strong current (Edmunds et al. 1976). Kluge (1991) described the species from the Río Duaba in Baracoa, Guantánamo Province, but it was not collected again until Benítez (2007) found nymphs in the Rió Yáquimo, Amancio, in Las Tunas. In the Yáquimo, nymphs were collected in both rapids and pools, although most were collected in rapids. However, recent observations have found that it is also common in leaf packs**.**

Geographic distribution. The species has been recorded from the Central-East and Eastern regions of Cuba (Kluge 1991; Benítez 2007) (Fig. 6). In this work, we also found two nymphs from the Río Mayarí (3-II-2001, col. Aldana and Fonseca), Eastern Region.

Family Oligoneuriidae

Only one species of Oligoneuriidae has been reported from Cuba.

A.13. *Lachlania abnormis* Hagen, 1868

Figure 35.

Lachlania abnormis Hagen 1868:372 (female).

Syntypes. Female imagos. "Cuba," Wright.

Lachlania abnormis was described by Hagen from specimens collected by Ch. Wright in Cuba based on specimen data in Hagen (1868). The report that they were collected in Rangel (Gundlach 1886) cannot be confirmed. In spite of intensive collection efforts, we have been unable to discover any specimens of Oligoneuriidae in Cuba. However, the genus *Lachlania* is widely distributed in Central America (Mexico, Guatemala, Panama, Honduras, Nicaragua) and *L. abnormis* has been reported from El Salvador (McCafferty 1985). Possibly the record from Cuba is a case of a local extinction, but it seems equally possible that the type series (Fig. 35) came from mislabeled specimens.

In the absence of any specimens from Cuba, figures (Fig. 34a–b) of a nymph of *Lachlania* sp. from Panama were provided by Dan Pickard, Center for Water and Environment, California State University, Chico.

Ecology. Not currently known from Cuba. In general nymphs inhabit fast current and wedge their bodies between rocks or snags, sometimes clinging to the underside of rocks. Some species mate in mid-morning and others near sunset (Domínguez et al. 2006).

Geographic distribution. No locality in Cuba is known for the species.

Family Leptophlebiidae

Leptophlebiidae are represented by two lineages in Cuba: one lineage is represented by *Farrodes* (one species) and another lineage is represented by eleven species belonging to the *Hagenulus*-group of genera (tribe Hagenulini of Kluge 1994). The Cuban species in this group were assigned to the following subgenera by Kluge (1994): *Hagenulus* sensu strictu (two species), *Borinquena* (one), *Turquinophlebia* (one), *Poecilophlebia* (one), *Careospina* (four, one with two subspecies) and *Traverina* (two), but all are treated as genera here (Peters et al. 2005; Domínguez et al. 2006). This generic complex is well represented in Miocene amber from Hispaniola where five species have been described (Staniczek 2003; Staniczek et al. 2017).

A.14. *Farrodes bimaculatus* Peters and Alayo, 1971

Figures 7, 40.

Farrodes bimaculatus Peters and Alayo in Peters 1971:8 (male and female imagos); Kluge 1994:252 (nymph, egg).

Holotype. Male imago, [Province Mayabeque], Río Güines, March 1966, P. Alayo.

Farrodes bimaculatus was originally described from an adult from Mayabeque Province (Peters and Alayo in Peters 1971). The nymph was described by Kluge (1994) from localities in the provinces of Pinar del Río, Sancti Spíritus, Guantánamo, and Santiago de Cuba. It is most easily recognized by the large subapical denticle on the claws.

Ecology. According to the literature, nymphs of this species prefer rocky-bottomed or muddy-rocky rivers and actively seek refuge under stones. The species is abundant at all altitudes but mostly between 100 and 750 m and especially above 500 m. In the collections are 353 specimens collected from diverse habitats from backwaters to rapids, with a preference for rapids. Nymphs have been collected throughout the year, indicating a non-seasonal life cycle.

Geographic distribution. Based on data of Peters (1971), Kluge (1994), and the review of the collections used for this work, the species is widespread throughout the Cuban Archipelago and has been collected from all four regions of Cuba (Fig. 7).

A.15. *Hagenulus caligatus* Eaton, 1882

Figures 8, 43.

Hagenulus caligatus Eaton 1882:207 (male subimago), 1884:113; Morrison 1919:144 (nymph); Peters 1971:20; Kluge 1994:259 (egg).

Holotype. Male subimago, "Rangel Mountains, Cuba (Poëy, Chas Wright and Gundlach).

Hagenulus caligatus was described by Eaton (1882) from a male subimago, and the nymph was later illustrated by Morrison (1919). *Hagenulus* nymphs are recognized by their filter-feeding maxillae and forelegs. The nymphs of *Hagenulus caligatus* can be separated from those of *H. morrisonae* by a very broad labrum which exceeds the width of the head.

Ecology. Nymphs of this species are abundant (Alayo 1977). They live in clean rivers and fast flowing rocky streams where they are found attached to the surface of the rocks, sometimes in large numbers (Alayo in Peters 1971; Alayo 1977). Alayo (in Peters 1971) found imagos and subimagos in the early morning resting on branches near the water about 2–3 m above the ground. Subimagos molted to imagos in approximately 24 hours.

Geographic distribution. Peters (1971) and Kluge (1994) report that this species is found only in the Western region (Fig. 8). Aldana and Fonseca (2001) also reported the species from the Nipe-Sagua-Baracoa Massif, but after reexamination by the senior author the record must be considered a misidentification.

A.16. *Hagenulus morrisonae* Peters and Alayo, 1971

Figures 8, 44.

Hagenulus morrisonae Peters and Alayo in Peters 1971:21 (male and female imagos, nymph); Kluge 1994:260.

Holotype. Male imago, [Province Santiago de Cuba], Río Boniatico (San Luis), November 1964, P. Alayo.

This species was described by Peters and Alayo (in Peters 1971) from Santiago de Cuba Province and other localities in the Eastern and Central region. It is easily distinguished from *H. caligatus* by the width of the labrum which, although broad, is narrower than the width of the head.

Ecology. Nymphs prefer stony rivers and streams with little current and clean water and are usually found at a depth of 15–30 cm (Peters 1971). Alayo (in Peters 1971) found the subimagos throughout the day and found imagos in the evening (1700 to 1800 h) flying near the surface of the water in stony areas, the number of individuals increasing as it became darker.

Nymphs of *H. morrisonae* show a clear preference for a riffle microhabitat (in one survey, 2035 individuals in riffles and 58 individuals in a lentic habitats). Aldana and Fonseca (2001) confirmed that the species prefers clear, cold, running waters at altitudes between 250 and 650 m; there, nymphs were found under stones at depths of 30–90 cm. Nymphs in collections are very abundant from lowland areas, with most (527) found in the Río Cautillo basin below 200 m (Rodríguez and Pérez 1998); numbers of individuals decrease as the altitude increases. Naranjo (1986) studied six rivers in the Sierra Maestra and found the species below 600 m; in other collection records, the species has been found up to 1750 m, but the majority of specimens are recorded below 500 m. Based on the presence of mature nymphs in the collections and their respective dates, there is no seasonal trend as they were collected in every month of the year.

Geographic distribution. The species is very abundant (Fig. 8) and has been cited from the Central, Central-East and Eastern Regions in the Cuban archipelago (Peters 1971, Kluge 1994, Naranjo and Cañizares 1999). One population from Nipe-Sagua-Baracoa Massif has been confused with *H. caligatus* because of its broader labrum (Fig. 44c).

A.17. *Borinquena sexta (*Kluge, 1994)

Figures 9, 47, 48.

Hagenulus (*Borinquena*) *sextus* Kluge 1994:261 (male and female imagos, nymph, egg).

Holotype. Male imago, Province Santiago de Cuba, Arroyo Paco (Río Palma Mocha), 24-II-1989, N. Kluge.

Described by Kluge (1994), nymphs have very narrow gills and are recognized by the third segment of the labial palp which is about half the length of the second segment. Abdominal coloration is generally pale with a narrow dark posterior border and small lateral markings on abdominal terga.

Ecology. This species is found in cold water rivers at altitudes between 300 and 1750 m. It is especially abundant at these higher altitudes in Paco Creek, a tributary of the Río Palma with its source on Turquino Peak. We have also found many nymphs from headwater streams of Bayamesa National Park (López et al. 2004).

Geographic distribution. Specimens have been collected in the Eastern and Central-East regions of Cuba (Fig. 9). From the headwater of two streams in Bayamesa National Park, we collected 31 nymphs in two microhabitats (running water and pools) in the rainy season (López et al. 2004). From collections examined for this work, misidentified material was discovered as follows: 2 nymphs, Province Holguín, Río Mayarí, 28-I-2001 and 3-XII-1998, col. Aldana and Fonseca; 1 nymph, Province Camagüey, Río Máximo, 12-II-2003, col. O. Bello (Bello 2004).

A.18. *Turquinophlebia grandis* (Kluge, 1994)

Figures 9, 42.

Hagenulus (*Turquinophlebia*) *grandis* Kluge 1994:265 (male and female imagos, nymph, egg).

Holotype. Male imago, Province Santiago de Cuba, Arroyo Paco (Río Palma Mocha), 24-II-1989, N. Kluge.

Like *Borinquena sexta*, the species was described from specimens collected in Arroyo Paco, a tributary of the Río Palma Mocha. Kluge (1994) states this is the largest leptophlebiid in Cuba. The gills are broadened basally, the lateral margins of the mandible are strongly curved, and the labrum is broad, triangular, and cleft distally (without denticles).

Ecology. Aldana and Fonseca (2001) reported these nymphs to be scattered and rare as only 11 specimens were found in two localities in Holguín Province. They were found by lifting rocks in the rapids of relatively cold water streams with a depth of approximately 100 cm and scanty vegetation cover. The bottom was bedrock.

Geographic distribution. Distribution is limited to the Eastern Region of Cuba (Fig. 9), specifically the provinces of Santiago de Cuba (type locality) and two locations in Holguín Province: 3 nymphs, Moa, 6/24-VI-2000; 8 nymphs, upper basin of the Río Mayarí.

A.19. *Poecilophlebia pacoi* (Kluge, 1994)

Figures 9, 38, 41.

Hagenulus (*Poecilophlebia*) *pacoi* Kluge 1994:269 (male and female imagos, nymph, egg).

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

Like *Borinquena sexta* and *Turquinophlebia grandis*, the species was described from specimens collected in Arroyo Paco. It resembles *T. grandis* with basally broadened gills, but in *Poecilophlebia* the labrum has an anteromedian margin with denticles. The tibiae of the hind legs are flat and ventrally concave.

Ecology. This species is found in cold water habitats at elevations between 680 and 1200 m. Recent research indicates a preference for leaf packs

Geographic distribution. *Poecilophlebia pacoi* is currently known only from the Turquino Massif in the provinces of Santiago de Cuba and Granma, Eastern Region (Fig. 9).

A.20a. *Careospina hespera hespera* Peters and Alayo, 1971

Figures 10, 47, 51.

Careospina hespera Peters and Alayo in Peters 1971:13 (male imago, nymph).
Hagenulus (Careospina) hespera hespera; Kluge 1994:274 (female imago, egg).

Holotype. Male imago, [Province Artemisa], Río Cuzco, March 1965, P. Alayo.

The species was defined based on specimens collected in the Río Cuzco around Soroa and other localities in the Western Region (Peters 1971); it was also reported from the Río Soroa by Kluge (1994) who established the subspecies. All species of *Careospina* have a short third segment of the labial palpi.

Ecology. Nymphs are found under stones in several microhabitats (Álvarez 2007) at depths of 1 cm or greater, mostly in rapids and backwaters but preferring rocky bottoms (Kluge 1994). Specimens in the collections representing theses (of diploma) were found exclusively at altitudes less than 250 m, indicating a preference for low altitudes. Nymphs were collected in January, May and June, and Kluge (1994) also reported nymphs in the months of March, April, October, November and December, indicating an apparently non-seasonal life cycle. The adults may emerge in any month of the year.

Geographic distribution. This subspecies is very abundant in the Western Region, especially in the streams of the Sierra de los Órganos, and is also found in the Central Region (Fig. 10).

A.20b. *Careospina hespera sierramaestrae* (Kluge, 1994)
Figures 10, 46, 52.

Hagenulus (*Careospina*) *hespera sierramaestrae* Kluge 1994:274 (male and female imagos, nymph).

Holotype. Male imago, Province Santiago de Cuba, Arroyo Paco (Río Palma Mocha), 25-II-1989, N. Kluge.

This subspecies was described from the Sierra Maestra based on morphological variations. Kluge (1994) separated *C. hespera sierramaestrae* from *C. hespera hespera* because the male eyes of *C. hespera sierramaestrae* are contiguous and those of *C. hespera hespera* are slightly separated. The tarsi of the nymphal legs of *C. hespera sierramaestrae* are darker than the tibiae and the hind tibiae are strongly flattened; these characters are the opposite of *C. hespera hespera* where the tarsi are paler than the tibiae and the hind tibiae are slightly flattened. The undescribed species of *Careospina* mentioned by Peters (1971) from various localities in Oriente is this subspecies.

Ecology. In collections made by researchers on aquatic fauna at the Universidad de Oriente, this was one of the most abundant species at high and low elevations. About 75% of the specimens were collected from rapids and 25% from backwaters, showing a preference for lotic streams with sandy bottoms. It has been collected up to 1750 m, although it is encountered most frequently at altitudes below 500 m. The nymphs were collected throughout the year, so it is supposed that the adults can emerge at any time of the year.

Geographic distribution. These subspecies can also be distinguished by their separate geographic ranges (Fig. 10). *Careospina hespera sierramaestrae* is reported only from the Eastern Region where it is abundant and the Central-East Region (Benítez 2007), while *C. hespera hespera* is recorded in the Western and Central Regions, especially in Sierra de los Órganos (abundant) and the mountain massif of Topes de Collantes (Kluge 1994, Naranjo and González-Lazo 2005c). According to Naranjo (1986), *C. hespera sierramaestrae* is homogenously distributed in the rivers of the Sierra Maestra at a low density. It has been recorded from 21 localities in the Eastern Region.

A.21. *Careospina baconaoi* (Kluge, 1994)
Figures 11, 45, 50.

Hagenulus (*Careospina*) *baconaoi* Kluge 1994:276 (male and female imagos, nymph, egg).

Holotype. Male imago, Province Santiago de Cuba, Río Baconao, Las Yaguas, 12-II-1989, N. Kluge.

This species was described by Kluge (1994) from specimens collected in La Yaguas (Río Baconao) and Toa (Eastern Region) and Soroa (Western Region). The color pattern resembles that of *Careospina hespera sierramaestrae* but the color is darker and more extensive on posterior terga, and the labrum is broad with a deep, broad anteromedian margin.

Ecology. The distribution of this species has been considered as rare and patchy (Aldana and Fonseca 2001, Hernández and Cala 2003). Individuals were captured along stream banks in areas of rapid waters at an altitude of 54 m. All specimens in the collection resulting from thesis projects were found below 600 m, with most collected at altitudes between 0 and 250 m. Nymphs were captured throughout the year, suggesting that adults may emerge at any time of the year.

Geographic distribution. The species is recorded from Soroa in the Western Region and in the Eastern provinces of Guantánamo and Santiago de Cuba. There are also 82 specimens in the collections from the provinces of Granma and Holguín, but no records from the Central or Central-East regions. This finding is interesting because the populations appear to be geographically isolated (Fig. 11). However, it is possible that this species has been overlooked in other regions because of its sparse distribution.

A.22. *Careospina evanescens* (Kluge, 1994)
Figures 11, 49.

Hagenulus (*Careospina*) *evanescens* Kluge 1994:276 (male and female imagos, nymph, egg).

Holotype. Male imago, Province Santiago de Cuba, Arroyo Paco (Río Palma Mocha), 15-V-1985, C. Naranjo.

The species was described from specimens collected in the Paco stream, Río Palma Mocha, in the Turquino Massif (Kluge 1994). It is easily recognized by its solid dark tergal coloration.

Ecology. The species has been found at an altitude of 300 m and water temperature of 28 °C (median temperature of the Río Mayarí) up to 1750 m in streams with temperatures of 17 °C to 20 °C (La Bayamesa). Most nymphs were collected at higher altitudes between 850 and 1750 m where 39 nymphs were found in June (López et al. 2004).

Geographic distribution. Originally described from Santiago de Cuba Province, the species was encountered a second time in the Eastern Region by Aldana and Fonseca (2001): one nymph, Holguín Province, Río Mayarí, June 1999. A review of the material from these authors discovered another 23 specimens from the Río Mayarí itself: 14 nymphs on 28-I-2001, 2 nymphs on 30-I-2001, 7 nymphs on 6-VI-2009. Another nymph was found in the collection dated 20-VI-2003 from the Río Mula, thus expanding the geographic distribution of the species. López et al. (2004, 2005) also report the species from Bayamesa (Fig. 11). In summary, the species is endemic to the eastern Region and found in the two most important mountain massifs: Sierra Maestra and Nipe-Sagua-Baracoa.

A.23. *Careospina minuta* Peters and Alayo, 1971

Figure 10.

Careospina minuta Peters and Alayo in Peters 1971:13 (male imago).
Hagenulus (Careospina) minuta; Kluge 1994:273.

Holotype. Male imago, Sancti Spíritus Province, Mina Carlota (Montañas de Trinidad), 22-III-1925.

The species was described from two males from Mina Carolota in Trinidad, Sancti Spíritus Province, collected in March 1925 (not 1935, an error in Peters 1971). Five other specimens from Cuba (C. Wright) were included among the paratypes. The Trinidad mountain locality has been revisited but the species was not found (Cañizares 1998) and the nymph is unknown. Kluge (1994) also did not find the species in collections from the Central region and considers that it is a rare, localized endemic or possibly a variation or third subspecies of *C. hespera.*

Ecology. No ecological data.

Geographic distribution. Currently considered endemic to a localized area in the center of the island (Fig. 10).

A.24. *Traverina cubensis* Peters and Alayo, 1971

Figures 12, 37, 39b.

Traverina cubensis Peters and Alayo in Peters 1971:10 (male and female imagos, nymph).
Hagenulus (Traverina) cubensis; Kluge 1994:282 (egg).

Holotype. Male imago, [Artemisa Province], Río Cuzco, March 1965, P. Alayo.

Species of *Traverina* are recognized by expanded gills with three processes, the median process much longer than the laterals. Originally described from the Río Cuzco, *T. cubensis* can be recognized by gills with acute lateral processes.

Ecology. There is no ecological data for this species. Specimens were collected in the months of March and June (Peters 1971) and in April of 1989 (Kluge 1994).

Geographic distribution. *Traverina cubensis* is found only in the Western Region, especially in the Province of Artemisa (formerly Pinar del Río) (Fig. 12). Since the original description, it has only been collected once (in 1989) near the type locality (Kluge 1994). Nymphs mentioned by Peters (1971) from Rio de San Antonio, Charco Azul, Trinidad Mountains, 23,29-III-1939, J. G. Needham, have gills similar

to *T. cubensis* but a very different color pattern. In the absence of adults or fresh material, it has never been described.

A.25. *Traverina oriente* (Kluge, 1994)

Figures 12, 36, 39a.

Hagenulus (*Traverina*) *oriente* Kluge 1994:282 (male and female imagos, nymph, egg).

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

Traverina oriente was described from the Río Naranjal in the Eastern Region (Kluge 1994). It is distinguished from *T. cubensis* by the relatively shorter, rounded lateral processes of the gills.

Ecology. Aldana and Fonseca (2001) collected nymphs in rapids but more commonly in pools with sandy bottoms; Hernández and Bauta (2003) found them more frequently in rapids. Our experience is that they are more common in rapids than backwaters, but the form of the abdominal gills aids them to survive in lentic waters. Although present in a broad altitudinal range (sea level to 900 m), they are most frequent below 250 m. Mature nymphs have been found throughout the year, indicating that emergence of adults is non-seasonal.

Geographic distribution. The species is uniquely found in the Eastern Region of the country (Kluge 1994; Naranjo and Cañizares 1999). Deposited in the collections are 127 specimens: 24 nymphs from the Río Mayarí, 9 from Río Cuzco in Guantánamo, 54 from the Río La Mula (Turquino), 2 from the Río Gibara, 30 from the Río San Juan, 4 from the Río Sevilla, 2 from the Río Guantánamo, and 2 from the Río Guamá. This demonstrates the broad distribution of the species across the Eastern Region of Cuba (Fig. 12).

Family Euthyplociidae

This small family is represented by one species in Cuba. *Mesoplocia* was synonymized with *Euthyplocia* by Kluge and Naranjo (1994) but the synonymy was not recognized by Domínguez et al. (2006).

A.26. *Mesoplocia inaccessibile* (Kluge and Naranjo, 1994)

Figures 13, 53.

Euthyplocia inaccessibile Kluge and Naranjo 1994:778 (male, nymph).

Holotype. Male, Province Santiago de Cuba, Arroyo Paco (Palma Mocha), 16-V-1985, C. Naranjo.

The large nymphs are easily recognized by the long mandibular tusks. The female is unknown; however, from examination of mature nymphs it is evident that the wing venation of the female resembles that of the male, and the median caudal filament is also reduced. In 1965, the species was collected a second time: 2 male imagos, Río Cayo Guam, Prov. Holguín, 10-VIII-1995, col. R. Teruel (Naranjo and Teruel 2001). Later, two nymphs were collected from Arroyo 26, La Bayamesa (Sierra Maestra), Prov. Santiago de Cuba, March 2004, col. P. López (López et al. 2004, 2005).

Ecology. Nymphs were originally collected from a pool in the Arroyo Paco at a depth between 10 and 15 cm partially burrowing in mud between rocks on the river bottom (Naranjo 1986). Later, nymphs were found in a different microhabitat in the Bayamesa Massif under rocks in headwaters of "Arroyo el 26" near Bayamesa Peak (López et al. 2004). This species has a broad altitudinal distribution but seems more common in crystal clear, cold, and well oxygenated streams. From collection data (mature nymphs in February and March, adults in May and August), *M. inaccessibile* appears to have a univoltine life cycle.

Geographic distribution. The species is an endemic in the Eastern Region with a disjunct distribution between a few adjacent localities in the Sierra Maestra and a similarly isolated population in the Nipe-Sagua-Baracoa Massif (Fig. 13). It is also reported from the Dominican Republic (Naranjo and Peters 2016).

Family Leptohyphidae

Five Cuban species are recognized in the family Leptohyphidae. All are included in the genus *Tricorythodes* following Kluge and Naranjo (1990) and Domínguez et al. (2006). Although members of the sacculobranchis species group were treated as *Asioplax* by Wiersema and McCafferty (2000), that genus was not recognized in later analyses of Neotropical *Tricorythodes* (Molineri 2002, 2006; Dias et al. 2019). The five Cuban species were divided into three distinct species groups by Kluge and Naranjo (1990) based on body form, pilosity, and structure of the operculate gills.

sacculobranchis species group

A.27. *Tricorythodes sierramaestrae* Kluge and Naranjo, 1990
Figures 14, 56.

Tricorythodes sierramaestrae Kluge and Naranjo 1990:570 (male and female imagos, nymph).
Asioplax sierramaestrae; Wiersema and McCafferty 2000:348.

Holotype. Male imago, Province Santiago de Cuba, La Alcarraza (Guamá), 7-II-1989, N. Kluge.

The two species in the sacculobranchis species group are recognized by a transverse row of setae positioned on the basal third of forefemora. The species *T. sierramaestrae* is easily recognized by pale operculate gill covers with only a narrow dark line proximally.

Ecology. The nymphs are found crawling on or between rocks in areas of rapids with little current. They are most abundant in lower zones of streams, although some were found up to an altitude of 900 m. Nymphs were present in the months of February, March, April, June, October, and December which would indicate that adults may emerge at any time of the year.

Geographic distribution. The species is found only on the southern slopes of the Sierra Maestra and Gran Piedra mountain ranges (Kluge and Naranjo 1990) in the Eastern Region (Fig. 14).

A.28. *Tricorythodes sacculobranchis* Kluge and Naranjo, 1990
Figures 15, 55a, 57.

Tricorythodes sacculobranchis Kluge and Naranjo 1990:370 (male and female subimagos, nymph).
Asioplax sacculobranchis; Wiersema and McCafferty 2000:348.

Holotype. Female imago, Province Santiago de Cuba, Río Las Yaguas (Baconao), 02-II-1989, N. Kluge.

Tricorythodes sacculobranchis was originally described from Baconao by Kluge and Naranjo (1990) and is distinguished from *T. sierramaestrae* by heavy markings on the operculate gills covers.

Ecology. Nymphs are found on, under or between rocks in areas of rapids with slower current. They move quickly. This species is the most common member of the family and one of the most common Ephemeroptera in Cuba. It has a broad altitudinal distribution but is found most frequently below 500 m. Nymphs are collected in almost every month of the year indicating that adults should emerge throughout the year.

Geographic distribution. *Tricorythodes sacculobranchis* is widely distributed on the island (Fig. 15) and is present in all four geographic regions including the Isla de la Juventud.

cubensis species group

A.29. *Tricorythodes cubensis* Kluge and Naranjo, 1990
Figures 16, 55b, 58.

Tricorythodes cubensis Kluge and Naranjo 1990:571 (male and female imagos, nymph).

Holotype. Male imago, Province Cienfuegos, Altura de Trinidad, 15-V-1989, N. Kluge.

In the cubensis species group, there is transverse row of strong setae near the middle of the forefemora and operculate gills are broadest in their basal half. Originally described from several regions in Cuba by Kluge and Naranjo (1990), the species *T. cubensis* has distinct posterior bands on the femora.

Ecology. Nymphal ecology is similar to that of *T. sacculobranchis*. The species is found over a broad range of altitudes and has been collected in every month except September and October, indicating that emergence may occur throughout the year.

Geographic distribution. *Tricorythodes cubensis* has been collected from all the major mountain regions of Cuba (Kluge and Naranjo 1990), but it has not been found in the Central-East Region which is composed of plains at low altitudes (Fig. 16).

A.30. *Tricorythodes montanus* Kluge and Naranjo, 1990

Figures 17, 59.

Tricorythodes montanus Kluge and Naranjo 1990:574 (male and female imagos, nymph).

Holotype. Female imago, Province Santiago de Cuba, Arroyo Paco (Río Palma Mocha), 21-II-1989, N. Kluge.

This species was described from Arroyo Paco in the Eastern Region by Kluge and Naranjo (1990). It is easily distinguished from the other member of the cubensis species group by markings of the femora which are not banded but which do have longitudinal grayish streaks.

Ecology. This species is found from almost sea level to 1750 m, although most frequently in the range between 250 and 750 m. Nymphs have been collected throughout the year which would indicate a non-seasonal life cycle. It may be locally abundant, and here we include a report of 150 specimens from the Río La Mula, Turquino Massif.

Geographic distribution. The species is reported from the Sierra Maestra and the Gran Piedra, Eastern Region, by Kluge and Naranjo (1990). In addition to the Río La Mula, Turquino Massif, we include other records for the northeastern subsector of Guantánamo Province (Massif Nipe-Sagua-Baracoa): 1 nymph de Río Toa and 1 from Río Mayarí (Fig. 17).

grallator species group

A.31. *Tricorythodes grallator* Kluge and Naranjo, 1990

Figures 18, 54.

Tricorythodes grallator Kluge and Naranjo 1990:575 (male and female imagos, nymph).

Holotype. Male imago, Province Santiago de Cuba, La Alcarraza (Guamá), 18-II-1989, N. Kluge.

This unique species of *Tricorythodes* is most easily recognized by its thin forefemora without any transverse bands. It was described by Kluge and Naranjo (1990) from collections throughout Cuba.

Ecology. Most species of Cuban Leptohyphidae are found between rocks or in submerged vegetation at the bottom of mountain streams. *Tricorythodes grallator* is the exception because it inhabits muddy or sandy bottomed streams and is usually camouflaged with a thin layer of mud. It has a wide altitudinal distribution (up to 1750 m), but it is found most frequently above 500 m where the stream water quality is usually good; however, it has also been found repeatedly in highly contaminated areas (mainly at low elevations) so we infer that it tolerates some pollution. Nymphs have been found from September to July indicating a non-seasonal life cycle. In terms of relative abundance, it is the second most common species in the family Leptohyphidae.

Geographic distribution. The nymphs are widely distributed and are found in all four geographic regions of the island (Fig. 18).

Family Caenidae

There are only two genera of Caenidae in Cuba: *Caenis* and *Insulibrachys*. The first was reported by Alayo (1977) as *Caenis* sp. and is very common and abundant. The second genus is represented by a single species whose present status is unknown. The two genera belong to two different subfamilies.

Subfamily Brachycercinae

A.32. *Insulibrachys needhami* Soldán, 1986

Figures 19, 60.

Insulibrachys needhami Soldán 1986:334 (nymph and female imago); Sun and McCafferty 2008:48.

Holotype. Female nymph, Province Pinar del Río, Santa Cruz de los Baños, March 1939, col. J. G. Needham. The only paratype is also from Pinar del Río Province.

The one nymph and the one female from a different locality were described by Soldán (1986). The two specimens were not associated and males are unknown. It has never been seen again and is considered extremely rare and possibly extinct, but can be easily recognized by setaceous tubercles on the ocelli.

Ecology. According to Soldán (1986), the presence in the nymph of ocellar tubercles, thoracic protuberances, posterolateral spines on the abdominal segments and heavy setation on the legs are adaptations to a burrowing habitat.

Geographic distribution. Endemic to the Western Region (Fig. 19).

Subfamily Caeninae

A.33. *Caenis cubensis* Malzacher, Naranjo, González-Lazo and Kluge, 2007

Figures 19, 61.

Caenis cubensis Malzacher, Naranjo, González-Lazo and Kluge 2007:226 (male and female imagos, nymph, egg).

Holotype. Male imago, Province Santiago de Cuba, Río Guamá (Sierra Maestra), 4-IV-1989, N. Kluge.

Originally described by Malzacher et al. (2007) from multiple localities in all regions of Cuba, this is the only species of *Caenis* on the island.

Ecology. *Caenis cubensis* is found in a wide range of altitudes up to 900 m, but it has been collected most frequently below 500 m and less frequently between 750 and 900 m, especially in Bayamesa National Park of the Sierra Maestra. Specimens have been collected in contaminated rivers, lakes and even a swimming pool (Malzacher et al. 2007). Nymphs with black wing pads have been collected throughout the year.

Geographic distribution. Present in all four geographic regions of Cuba. Malzacher et al. (2007) stated that this mayfly is the most widespread of any species in the country and is possibly the most common species (Fig. 19). Paratypes (Appendix 2) are listed from nine provinces and the Isla de la Juventud.

B. Key to Mature Nymphs of Cuban Ephemeroptera

The following key is presented for the convenience of students of Cuban Ephemeroptera and is not applicable to genera or species outside of Cuba. Keys are based on the work of González-Lazo and Naranjo (2007), González-Lazo and Salles (2007), and original works in the Literature Cited.

1. Head with long mandibular tusks, these much longer than head (Fig. 53); a large species (> 15 mm) **Euthyplociidae**, one species . . . ***Mesoplocia inaccessibile* (Kluge and Naranjo)**
— Head without tusk on mandibles, size variable **2**

2(1). Gills exposed and visible on abdominal segments 1–7 or 2–7 (as in Fig. 20d, 21b, 22c, 33b, 36a, 40c) **3**

— Gills on abdominal segment 2 forming an operculate cover over other gills (as in Fig. 54a, 57–58, 60) **26**

3(2). First pair of gills ventral and gills 2–7 dorsal; median caudal filament absent (Fig. 34b) **Oligoneuriidae**, one species (rare, absent or extinct in Cuba) . . . . . ***Lachlania abnormis* Hagen**

— First pair of gills dorsal, lateral, or absent (never ventral); three caudal filaments (although median caudal filament may be short) **4**

4(3). Gills rounded or oval, usually single (as in Fig. 20d–e, 22c–e, 27), but in one case oval and folded (Fig. 21c); caudal filaments shorter than body (Fig. 20a, 23c, 31–32, 33b) . . . . **Baetidae (5)**

— Gills long, apically tapered with lamellae appearing doubled (Fig. 36–38, 43, 48a, 49); caudal filaments longer than body (Fig. 36a, 40a, 41b, 52d) . . . . . **Leptophlebiidae (16)**

Baetidae.

5(4). Abdominal gills very broad with ventral recurved flaps (Fig. 21c); foreclaw with double row of long denticles (Fig. 21a) . . . . . ***Callibaetis floridanus* Banks**

— Abdominal gills oval or elongate-oval without ventral portion or flap (Fig. 20d–e, 22c–e, 27); denticles on foreclaw absent (Fig. 22a) or present and short (Fig. 25, 33a) **6**

6(5). Abdominal segment 1 without gills, gills present on 2–7 only (Fig. 20d); caudal filaments with two distinct color bands (Fig. 20e–f) . . . . . ***Americabaetis naranjoi* (Kluge)**

— Abdominal segments 1–7 with gills; caudal filaments without distinct bands **7**

7(6). Claws apparently without denticles (Fig. 22a), although minute denticles may be present basally (Fig. 33a) **8**

— Claws with visible denticles (Fig. 25) . . . . . **(10)**

8(7). Body length of mature nymphs < 3 mm; abdominal tergum 9 with lateral white marking and with darker dorsal coloration (Fig. 33b–c); claws with row of minute denticles basally (Fig. 33a); outer basal margins of tibiae and tarsi without rows of setae . . . . . ***Paracloeodes lilliputian* Kluge**

— Body length of mature nymphs > 3 mm; abdominal tergum 9 variable but without white lateral marking; claws without denticles (Fig. 22a); basal margins of tibae and tarsi with rows of setae (Fig. 22b) . . . . . ***Cloeodes* (9)**

9(8). Color pattern somewhat variable, but middle abdominal terga (5–6) without contrasting dark marks in anteromedian margin (Fig. 22c–f) . . . . . ***Cloeodes superior* Kluge**

— Color pattern variable (Fig. 23a–b,d), but middle abdominal terga (5–6) usually with anteromedian, contrasting dark marks (Fig. 23a–b) . . . . . ***Cloeodes inferior* Kluge**

10(7). Frontal margin (frons) of head flat, without keel between antennal bases (Fig. 24c); foreclaw with one long subapical seta (Fig. 25b) . . . . . ***Caribaetis* (11)**

— Frontal margin (frons) of head with keel between antennal bases (Fig. 24a–b); foreclaw without apical seta (Fig. 25a) . . . . . ***Fallceon* (13)**

11(10). Abdominal terga 2, 6–7 uniformly dark brown; terga 4 and 9 pale, other terga variable but usually with some submedian markings (Fig. 32a–b) . . . ***Caribaetis alcarrazae* (Kluge)**

— Abdominal terga 2, 6–7 with weakly indicated markings on beige or brown background, terga 4 and 8–10 with similar markings on beige background (Fig. 30–31) **12**

12(11). Mature nymphs relatively large (7.5 to 8 mm body length); dorsal margin of femora with many setae; rare . . . . . ***C. grandis* (González-Lazo and Salles)**

— Mature nymphs small (3 to 5 mm body length); dorsal margin of femora with few setae . . . . . ***C. planifrons* (Kluge)**

13(10). Abdominal gills 2–6 relatively long and narrow, at least as long as two abdominal segments (Fig. 27f–g, 28) . . . . . ***Fallceon longifolius*** **(Kluge)**

— Abdominal gills 3–6 more oval (Fig. 27a–e), not more than 1.5 times length of an abdominal segments **14**

14(13). Distal segment of labial palp apically broad (Fig. 26a); paraglossae narrow and pointed apically (Fig. 26a); rare . . . . . ***F. testudineus*** **(Kluge)**

— Distal segment of labial palpi about same width as preceding segment (Fig. 26b); paraglossae broad and rounded (Fig. 26b) **15**

15(14). Abdominal gills widest medially (Fig. 27a–d); common . . . . . ***F. poeyi*** **(Eaton)**

— Abdominal gills widest distally (Fig. 27e); rare . . . . . ***F. sextus*** **(Kluge)**

Leptophlebiidae.

16(4). Gills with long median process and two lateral processes (Fig. 36b, 37) . . . . . ***Traverina*** **(17)**

— Gills gradually tapered apically, without lateral processes (Fig. 38, 40c, 41c–d, 48a, 49) . . . **18**

17(16). Apical denticle of foreclaw larger than other denticles (Fig. 39a); lateral gill processes rounded apically (Fig. 36b); Eastern Region . . . . . ***Traverina oriente*** **(Kluge)**

— Denticles on foreclaw progressively larger apically (Fig. 39b); lateral gill processes acute apically (Fig. 37); Western Region . . . . . ***T. cubensis*** **Peters and Alayo**

18(16). Apex of sternum 9 convex (Fig. 40b); apical denticle of claw much larger than other denticles (Fig. 40e); posterolateral projections present on abdominal segments 8–9 only (Fig. 40b) . . . . . ***Farrodes bimaculatus*** **Peters and Alayo**

— Apex of sternum 9 incised; denticles of claw either progressively larger or equal sized (as in Fig. 39, 52c); posterolateral projections present on abdominal segments 3–9 to 6–9 (Fig. 41a, 48a, 49, 51) **19**

19(18). Basal portion of abdominal gills 3–5 broad with many tracheal branches (Fig. 38, 41c–d); rare (at elevations > 600 m in Eastern Region) **20**

— Basal portion of abdominal gills 3–5 narrow with few or no tracheal branches (Fig. 43, 48a, 49, 52a–b); generally distributed **21**

20(19). Width of labrum subequal to a little broader than clypeus, anteromedian margin of labrum with denticles (Fig. 41e); color pattern on terga with four distinct marks (Fig. 41b–c) . . . . . ***Poecilophlebia pacoi*** **(Kluge)**

— Labrum triangular, broader than clypeus, anteromedian margin of labrum cleft, without denticles (Fig. 42b); color pattern of terga as in Fig. 42a ***Turquinophlebia grandis*** **(Kluge)**

21(19). Head with large, maxillary palps visible in dorsal view (Fig. 43–44); labrum much broader than clypeus; tibiae of forelegs with long rows of filtering setae (Fig. 43, 44a–b) . . . . . ***Hagenulus*** **(22)**

— Head without projecting maxillary palps (Fig. 45–46); labrum a little broader to subequal in width to clypeus; setae on forelegs short, not arranged in long rows **23**

22(21). Labrum broader than width of head (Fig. 43); Western Region . . . . . ***Hagenulus caligatus*** **Eaton**

— Width of labrum less than width of head (Fig. 44); Central, Central-East and Eastern Regions . . . . . ***H. morrisonae*** **Peters and Alayo**

23(21). Length of third segment of labial palp approximately half length of second segment (Fig. 47) . . . . . ***Borinquena sexta*** **(Kluge)**

— Length of third segment of labial palp 1/3 or less than 1/3 length of second segment (Fig. 47) . . . . . ***Careospina (24)***

24(23). Dorsal color of abdominal terga a solid dark brownish black, except on posterior tergum (Fig. 49) . . . . . ***Careospina evanescens*** **(Kluge)**

— Dorsal abdominal color pattern faded posteriorly on at least terga 5–9 (Fig. 50–52a) **25**

25 (24). Labrum broad with deep, divergent anteromedian emargination (Fig. 45); abdominal color pattern faded on anterior and posterior portions of each tergum (Fig. 50) . . ***C. baconaoi* (Kluge)**

— Labrum with shallow anteromedian emargination (Fig. 46); abdominal terga with dark blackish brown markings surrounding paler markings (Fig. 51–52a) . . . . . ***C. hespera* Peters and Alayo**

26(2). Operculate gills subrectangular with "Y" ridges, gills overlapping dorsally (Fig. 60–61) . . . . . **Caenidae (27)**

— Operculate gills triangular or oval, lateral in position and not overlapping (Fig. 54a, 56–59) . . . . . **Leptohyphidae (28)**

Caenidae.

27(26). Head with prominent ocellar tubercles, tubercles with dense setae (Fig. 60); rare . . . . . ***Insulibrachys insularis* Soldán**

— Head rounded without tubercles (Fig. 61); common . . . . . ***Caenis cubensis* Malzacher, Naranjo, González-Lazo and Kluge**

Leptohyphidae.

28(26). Femora of legs cylindrical, not expanded, with numerous long, thin setae (Fig. 54b); nymphs in muddy conditions and body covered with small sediment particles adhering to long setae (Fig. 54a) . . . . . ***Tricorythodes grallator* Kluge and Naranjo**

— Femora of legs broad, flattened, with short, thick spatulate setae; forefemora with transverse band of setae (Fig. 55a–b); habitat variable but not in muddy conditions **29**

29(28). Operculate gills oval, with maximum width near middle or distal to middle of gill (Fig. 56–57a); transverse row of setae on forefemora in proximal third (Fig. 55a) (sacculobranchis group) **30**

— Operculate gills suboval to subtriangular with maximum width proximal to middle of gill (Fig. 58b, 59b); transverse row of setae near middle of forefemora (Fig. 55b) (cubensis group) **31**

30(29). Operculate gills with inner margin blackened proximally (Fig. 56); abdominal terga 7–9 with lateral marks much darker than submedial marks; claws with three (sometimes four) thin denticles . . . . . ***T. sierramaestrae* Kluge and Naranjo**

— Operculate gills dark with light markings, distinct pale oval mark near inner base of each operculum (Fig. 57); abdominal terga 7–9 with dark lateral markings similar in intensity to medial markings (Fig. 57b–c); claws with only one (occasionally two) small apical denticles . . . . . ***T. sacculobranchis* Kluge and Naranjo**

31(29). Color pattern of operculate gills variable but with lateral curved or triangular pale area (Fig. 58); operculum without ventral lobe; femora with blackish-brown transverse marks . . . . . ***T. cubensis* Kluge and Naranjo**

— Operculate gills dark gray except at margins (Fig. 59a); operculum with a well-developed ventral lobe; femora without color bands or transverse marks but with grayish longitudinal lines (Fig. 59a,c) . . . . . ***T. montanus* Kluge and Naranjo**

C. Ecological Types of Cuban Mayflies

Nymphs of Cuban Ephemeroptera were classified by Alayo (1977) into three types, depending on the habitat. After further study of the morphology and habitat, Naranjo (1988) classified the nymphs into five eco-morphological types. In this present work, the classification of Naranjo is updated with the addition of more genera and important morphological characteristics.

1) Nymphs with broad gills inhabiting aquatic vegetation: species of *Callibaetis* and *Cloeodes* (Fig. 21–23).

2) Nymphs with small, narrow or oval gills, active swimmers: species of *Americabaetis, Caribaetis, Fallceon* and *Paracloeodes* (Fig. 20, 24–33).
3) Nymphs with operculate gills (oval, suboval, triangular, or subquadrate) covering the gills; inhabitants of stream bottoms: represented by the genera *Caenis* and *Tricorythodes* (Fig. 54–61).
4) Nymphs with compressed body living under stones in rapid flowing water: includes all Cuban species of the family Leptophlebiidae (Fig. 36–52).
5) Nymphs partially burrowing in mud-sandy bottoms of cold, well oxygenated streams: a single species of the genus *Mesoplocia* (Fig. 53).

D. Indicator Species of Contamination

Naranjo et al. (2005) developed a method to quickly and easily evaluate the water quality of lotic waters in Cuba which took into consideration the tolerance for organic pollution by aquatic invertebrates. This index was adapted for Cuba from the BMWP (Biological Monitoring Working Party) index of Hellawell (1978) and is known as the BMWP-Cub. It considers the tolerances for five of the six families recognized for Cuba (excluding Oligoneuriidae for lack of data). The following index was established, with families listed from the least to the most pollution-tolerant:

9 points – Leptophlebiidae
9 points – Euthyplociidae
7 points – Baetidae
6 points – Leptohyphidae
4 points – Caenidae.

Based on data summarized here, the first two families are representative of localities with little or no pollution. For Baetidae, the score decreases (down to 7) because of the species *Callibaetis floridanus*, which is found even in the Zapata swamp (lentic water) and in waters with high organic contamination. Species in the last two families are typical of backwaters in river systems with slight to heavy contamination.

E. Analysis of Altitudinal Distribution

From collection records for 34 Cuban taxa (Kluge and Naranjo 1990, 1994; Kluge 1991, 1992a, 1992b, 1994; Naranjo and Cañizares 1999; González-Lazo et al. 2008), it is possible to distinguish five altitudinal groupings, of which the last two (groups IV and V) have the broadest altitudinal range. The remaining three groups have a more limited altitudinal distribution. (There is no information for *Lachlania abnormis*.)

Group I, range 0–250 m. At these low altitudes are found five taxa: *Americabaetis naranjoi*, *Fallceon longifolius*, *Careospina hespera hespera*, *C. minuta*, and *Insulibrachys needhami*. Two of the species (*Careospina minuta*, *Insulibrachys needhami*) appear to be restricted to narrow, very specific habitats and, although the type localities have been revisited, no further specimens have been collected.

Group II, range 0–600 m. The group comprises seven species: *Callibaetis floridanus*, *Caribaetis alcarrazae*, *C. grandis*, *Paracloeodes lilliputian*, *Hagenulus caligatus, Traverina cubensis, Careospina baconaoi.* The distribution of these species is limited to the lower zones, presumably because of stronger water currents at higher elevations**.**

Group III, range 600–1000 m. This small group is formed by two species, *Turquinophlebia grandis* and *Poecilophlebia pacoi*, which are encountered almost exclusively between 600 and 1000 m. These species appear to have very narrow ecological requirements which limit their distribution; they prefer cold, uncontaminated waters typical of this zone.

Group IV, range 0–1000 m. This group consists of six species: *Fallceon sextus*, *F. testudineus, Tricorythodes cubensis*, *T. sierramaestrae*, *Traverina oriente,* and *Caenis cubensis* which have been collected from sea level up to 800–1000 m. *Caenis cubensis* is usually found below 500 m and the others are more often found between 250 and 750 m, although data for *Fallceon testudineus* is limited.

Group V. The following groups have all been found at a broad range of altitudes (from near sea level to 1750 m). They are subdivided into a range of altitudes where most frequently encountered.

Subgroup Va). This group of five taxa has a broad altitudinal distribution but is most often encountered between sea level and 500 m: *Cloeodes inferior*, *Caribaetis planifrons*, *Tricorythodes sacculobranchis*, *Hagenulus morrisonae* and *Careospina hespera sierramaestrae*. The distribution of this group is generally similar to that of Group II, but specimens are occasionally found at higher elevations in the Eastern Region.

Subgroup Vb). These three species have a broad altitudinal range but are collected more frequently between 250 and 750 m: *Fallceon poeyi, Tricorythodes montanus*, and *T. grallator*. Only *Tricorythodes grallator* has been encountered in polluted zones.

Subgroup Vc). These species have a broad altitudinal distribution but are collected most frequently between 500 and 1750 m, including the following five species: *Cloeodes superior*, *Borinquena sexta*, *Careospina evanescens*, *Farrodes bimaculatus,* and *Mesoplocia inaccessibile*. The first four species are adapted to the strong currents typical of higher elevations and prefer clear, cold, well oxygenated waters. M*esoplocia inaccessibile* occupies a similar habitat but is often found in backwaters in this same region.

Overall, we observe that species richness declines with altitude. Thirty-one taxa are found at elevations between sea level and 600 m (94%), but only 13 taxa (39%) are found above 1200 m. This trend may be the result of strong currents prevalent on the steep slopes of mountain streams above 1000 m, especially in the Sierra Maestra.

In summary, 19 species showed a broad altitudinal distribution, two were restricted to a narrow altitudinal range between 600 and 1000 m, and 12 have only been found below 600 m. Of these, five have only been collected below 250 m. Overall, the altitudinal distribution of Cuban mayflies seems well balanced. This result is mainly due to the presence of only a few high-altitude localities in Cuba and thus few areas with ecological characteristics suitable for high altitude species.

F. Seasonal Distribution

In general, species in the order Ephemeroptera show seasonality in their life cycle in regions where water temperatures vary with the season of the year. In tropical zones where water temperatures vary little, these insects emerge throughout the whole year (Hynes 1970). As a tropical country, Cuba has only two seasons which are closely allied with rainfall. Therefore, seasonality must take into consideration the wet and dry seasons (Trapero and Naranjo 2003).

In analyzing seasonality from monthly records, we find that 98 records correspond to the rainy season (months of May to October) and 121 to the dry season (November to April), representing 45% and 55% respectively. Twelve species were recorded in most months of the year (10–12), and with the exception of *Hagenulus caligatus* which is considered relatively rare, all have large populations and broad altitudinal and geographic distributions. This obviously has influenced their frequency and the greater number of collection records, but there is no strong seasonality in their life cycle.

In contrast, nine species have been reported in only one or two months. The few records of these species are a result of a narrow altitudinal and geographic distribution range which, combined with smaller populations, make them difficult to find and their presence is "occasional." Only *Fallceon testudineus* and *Mesoplocia inaccessibile* were found in both the dry and rainy seasons; the others were encountered in the dry season.

Records for the remaining 13 species range from three months (*Caribaetis alcarrazae*, *Fallceon sextus*, and *Careospina evanescens*) to nine months (*Cloeodes superior* and *C. inferior*) and range over the wet and dry seasons so there is no apparent seasonal life cycle. Based on collection records, we can conclude that the optimum time to collect mayflies in Cuba is between the months of January and June (with 133 records representing 61% of total), although we note that most species can be found throughout the year.

G. Zoogeographic Relationships of Cuban Ephemeroptera

The zoogeographic relationships of other Cuban aquatic insects are known to be complex (Botosaneanu 1979, Trapero and Naranjo 2003), and the relationships of Cuban mayflies with other regions have not been studied in depth (González-Lazo et al. 2008). The geology of the Caribbean is also complex and

beyond the scope of this work, but summaries can be found in Pindell and Kennan (2009), Iturralde-Vinent and MacPhee (1999), and earlier works (e.g. Donnelly 1988).

G.1. Relationships with Continental America

Although the Ephemeroptera fauna of Cuba and the Antilles is generally considered to be Neotropical in origin, the affinities with North, Central and South America have not been worked out in detail (Peters 1988). To establish the volume and direction of flow of a species across a zoogeographic region is useful in theory (Trapero and Naranjo 2003), but the high level of endemism of the Cuban Ephemeroptera make this impractical. Here, we discuss these relationships at the generic level only.

The Cuban mayflies are grouped in 18 genera. Following González-Lazo et al. (2008) and previous studies (Lugo-Ortiz and McCafferty 1996b, McCafferty 1998), the genera *Americabaetis, Cloeodes, Fallceon, Caribaetis*, *Paracloeodes*, *Tricorythodes, Mesoplocia, Lachlania, Farrodes* and *Hagenulus*, have a Neotropical origin (McCafferty 1998). Other taxa such as *Borinquena*, *Careospina*, *Traverina*, *Turquinophlebia*, *Poecilophlebia* and *Insulibrachys* may be endemic to the Antilles (the last five only to Cuba) and all except *Insulibrachys* appear to be related to Neotropical genera; for *Insulibrachys* the relationships are unclear although there are other members of the subfamily in North, Central, and South America (Sun and McCafferty 2008). The genera *Callibaetis* and *Caenis* are broadly distributed throughout the Western Hemisphere (*Caenis* through most of the world) but the one Cuban species of *Caenis* is probably related to Neotropical species (Malzacher et al. 2007).

At the generic level, the Index of Biological Similarity with Florida is low (6%) compared to the similarity with genera from Central America. The low affinity between Florida and Cuba, and the Antilles in general, may be the result of ecological conditions, as the mountainous conditions of the Antilles are not found in Florida, and most species of Ephemeroptera in Florida have Nearctic origins (Peters 1988). The dispersal from Florida to Cuba and the islands of the West Indies seems unlikely (although the possibility cannot be rejected) and is corroborated by the low Index of Similarity at the species level (2%). Berner (1940, 1950) pointed out that although many insect species are able to move between Florida and the West Indies, this is not true for mayflies because of environmental conditions in South Florida. Only *Callibaetis floridanus* inhabits both Florida and the Antilles. This tolerant species can be found living in ponds, pools, and marshes, so its presence in both regions is not unexpected (Berner and Pescador 1988, Lugo-Ortiz and McCafferty 1996a).

There are two apparent routes of dispersal from continental regions to Cuba: 1, penetration into Cuba via the arc of islands formed by the Greater and Lesser Antilles; and 2, movement from Central America and across the Yucatán Peninsula. The first pattern would account for the distribution of *Tricorythodes*, *Farrodes, Caenis,* and Baetidae. The second pattern would include the same groups and *Lachlania* (assuming that the 1868 record is accurate). Neither pattern will account for the distribution of the euthyplociid genus *Mesoplocia* or other Leptophlebiidae representing the grouping *Hagenulus* (sensu lato of Kluge 1994) which include *Hagenulus, Borinquena, Neohagenulus, Careospina, Traverina, Poecilophlebia, Turquinophlebia* and the extinct genus *Hagenulites*. The only currently known localities for representatives of *Mesoplocia* and *Hagenulus* outside the Caribbean are in Ecuador.

The question of whether major distribution patterns in the Caribbean have resulted from vicariance or dispersal events is a matter of debate (Slater 1988). Although the pattern of dispersal between Central America, South America, and the Antilles by wind, storm, ocean currents, and island hopping provides a plausible explanation for most groups, it is difficult to imagine this scenario for a connection between Ecuador and the Greater Antilles.

Iturralde-Vinent and MacPhee (1999) reported that for a short period in geologic time an extensive emerging crest of land existed between northern South America and the island blocks that would become the Greater Antilles (GA). This occurred at the time of the Eocene–Oligocene transition and is represented now by the submerged Aves Ridge (AR). Commonly called GAARlandia (for Greater Antilles—Aves Ridge, MacPhee and Iturralde-Vinent 2005), such a landspan or island chain might account for the apparent distribution of *Mesoplocia* and *Hagenulus* genera. Unfortunately, we know little about these genera in Ecuador and questions remain concerning GAARlandia (Ali 2012). Although most distributions can be explained by the dispersal patterns above, GAARlandia is one hypothesis that may account for this exceptional distribution.

G.2. Relationships between Cuba and the Antilles

For the Greater Antilles, the Index of Similarity can be computed at the generic level based on previous work and recent findings in Naranjo and Peters (2016). The Index between Cuba and Puerto Rico is 56 % and between Cuba and Hispaniola 44%. At the species level, this Index is higher for Hispaniola (12%) than for Puerto Rico (3%). The similarity values between Cuba and Hispaniola are expected to be higher because both islands are very close, especially the Eastern Region of Cuba and Haiti which existed as part of single island block until sometime between 12 million (Rojas-Agramonte et al. 2006) and 19 million years ago (Pindell and Kennan 2009). Unfortunately, the mayfly fauna of Hispaniola is poorly studied. The same is true for Jamaica.

The proximity between eastern Cuba and Hispaniola facilitates the passage of Antillean and South American species from one island to the other. It seems that the greater flow is established from northern South America to the Greater Antilles through the island arc formed by the Lesser Antilles. Storms, sometimes with hurricane winds characteristic of the Antilles, are presumed to be important in the dispersal of many insects (Iturralde-Vinent and MacPhee 1999).

G.3. Relationships within the Cuban Territory

Of taxa of Ephemeroptera reported from Cuba with approximate locality data, 28 (88%) of the total) are known from the Eastern Region; 14 (44%) from the Central; 14 (44%) from the Central-East; and 14 (44%) from the Western Region (Table 1).

There are eight taxa (24%) widely distributed in the four regions of Cuba (Table 1). Three taxa are found in only three regions: *Americabaetis naranjoi* and *Hagenulus morrisonae* (both from Central, Central-East, and Eastern), and *Tricorythodes cubens*is (Western, Central East and Eastern). Seven taxa are characteristic of two regions: *Careospina hespera hespera* (Western and Central), *Cloeodes superior* (Central and Eastern), *Paracloeodes lilliputian, Fallceon longifolius, Borinquena sexta*, and *Careospina hespera sierramaestrae* (all Central-East and Eastern) and *Careospina baconaoi* (Western and Eastern). Fifteen taxa are found in only one region: some of these are clearly endemics restricted to specialized microhabitats, but this number also includes at least three species which have never been seen following their original descriptions and represent either extinction, or unique and unexplored habitats.

Finally, many species are located in the Eastern Region. There are three possible reasons. First, the Eastern Region is the main route of entry of mayflies to the Cuban territory through the arc of islands formed by the Greater and Lesser Antilles. Also, this region contains the two most extensive mountain ecosystems on the island, and it has been the location of the most intensive collection activity over the past half century.

The zoogeographic distribution given here corrects a few records from Naranjo and Peters (2016) and differs from that of González-Lazo et al. (2008) in the following points: 1, here are included new locality records for *Paracloeodes lilliputian, Fallceon longifolius,* and *Borinquena sexta* from the Central-East; 2, *Careospina hespera hespera* is only found in the Western and Central Regions (a possible report from the Central-East could not be confirmed); 3, *Traverina cubensis* and *Hagenulus caligatus* are only found in the Western Region and not in the East as indicated in González-Lazo et al. (2008). The previous reports were based on erroneous determinations. In summary, the distribution patterns for Ephemeroptera are very similar to those already presented for the orders Trichoptera and Odonata in Cuba (Trapero and Naranjo 2003, Naranjo and González-Lazo 2005a). For all three orders, the greatest number of species and greatest percentage representation is found in the Eastern Region and the lowest in the other regions (Naranjo and González-Lazo 2005a).

G.4. Analysis of Endemism of Ephemeroptera in Cuba

The order is characterized in Cuba by a high level of endemism (76%). Only eight species are shared with other countries. *Callibaetis floridanus* has been reported for other geographic regions: Puerto Rico and Jamaica (Greater Antilles), northwestern, southeastern and southwestern United States (North America), to Belize, Costa Rica, Honduras, El Salvador and Guatemala in Central America. *Lachlania abnormis* and *Caribaetis planifrons* are also known from Central America. The five remaining species

(*Cloeodes superior, C. inferior*, *Fallceon longifolius, F. poeyi, Mesoplocia inaccessibile*) are well distributed between the islands of Jamaica and Hispaniola. Although *Fallceon longifolius* was reported by Lugo-Ortiz et al. (1994) from Mexico, the description differs from that of *F. longifolius* in Cuba (Kluge 1992b, González-Lazo and Salles 2007); González-Lazo and Salles (2007) consider the Mexican record to represent a new species.

There are 21 endemic species in eastern Cuba (Table 1). Over half of the species are restricted to the Eastern Region presumably due to the poor dispersal ability of mayfly adults (Domínguez et al. 2006). The high percentage of endemics in Cuba is due to geographic isolation which has favored speciation.

The post-Cretaceous history of the Antilles covers several periods but the permanent status of the islands probably dates from about 35 million years ago following their separation from Central America and the subsidence of GAARlandia (Iturralde-Vinent 2004). Established biota diversified or became extinct, but the rate of extinction has increased over the last three million years following climate change, and especially over the last 500 years following the arrival of Europeans. Iturralde-Vinent (2004) attributes most recent extinctions to the introduction of exotic species and the loss of natural biodiversity from agricultural practices and urban development.

Based on surveys summarized in this study, we suspect that the genera *Lachlania* and *Insulibrachys* may already be extinct in Cuba, although we hope to eventually find remnant populations. Several other species mentioned here have been rarely collected and might be considered as threatened or endangered species. This is especially true for endemic species with limited distributions. For example, *Caribaetis grandis, Fallceon sextus, Traverina cubensis* and *Careospina minuta* have been collected from only a few localities. Four other species are known only from a single mountain massif (*Fallceon testudineus, Hagenulus caligatus*, *Poecilophlebia pacoi* and *Tricorythodes sierramaestrae*) and two more species (*Caribaetis alcarrazae* and *Turquinophlebia grandis*) have only been found in two massifs of the Eastern Region. In summary, the status of another 12 of the 33 species recorded for Cuba may be considered as "threatened" due to their geographic isolation.

H. Conservation of Biodiversity

The Republic of Cuba is concerned with the protection of biodiversity and has several laws pertaining to the conservation of river ecosystems. Law No. 81 is the most important for environmental protection, and covers the national system of protected areas, environmental impact assessment, environmental licenses, environmental education, scientific research and technological innovation, protection and sustainable use of water and aquatic ecosystems, terrestrial waters and watersheds.

In the upper and middle reaches of mountainous habitats, macroinvertebrates are protected naturally due to their inaccessibility. However, there are areas where runoff from coffee cultivation and resulting pulp residues contaminate streams and the environment (Naranjo and González-Lazo 2005a). A remarkable percentage of the areas occupied by healthy populations of freshwater macroinvertebrates are included in areas with some level of environmental protection or management. For example, of the 34 taxa of Ephemeroptera in Cuba, 24 are in the Sierra Maestra mountain range which is home to three national parks (Almenares 1985).

The lowland zones of Cuban rivers have little protection. Major impacts on macroinvertebrates are caused by deforestation of the river banks; agricultural land use near rivers which generate contamination by pesticides, chemical fertilizers and organic matter leading to an increase in suspended solids; dumping of raw sewage from industrial and domestic sources; an increased number of dams which fragment and reduce habitat for macroinvertebrates; and extraction of sand and stone. In addition, the introduction of exotic species such as tilapia (*Oreochromis aureus* [Steindachner]) and claria (*Clarias gariepinus* Burchell) and climate change as reflected in prolonged droughts and torrential rains have affected the quality and quantity of water in the rivers and streams.

Despite identifiable impacts, little work has been done to evaluate the extent and importance of aquatic ecosystems and wildlife. For this reason, there are no consistent management plans for the river basins of Cuba. However, in recent years there have been numerous activities to protect and improve the river banks in the Río Cauto Basin, resulting in improved water quality of the river basin. Such activities might well be applied to other river systems in Cuba (López et al. 2004).

Summary and Recommendations

A. Summary

The annotated checklist of the Cuban mayflies was updated to include unpublished distribution records for the 34 taxa reported from the island. Photographs of significant characters have been added to prepare a key to nymphs to aid future students in studying aquatic ecosystems.

The altitudinal distribution of the Cuban mayflies is quite balanced and most of the species are well distributed throughout a vertical gradient.

For most species of Cuban mayflies, the life cycle is not dependent on the season, a situation that is common for tropical ecosystems.

Zoogeographically, the Cuban fauna shows a close relationship to other islands of the West Indies and Central America. The possibility of an earlier distribution through the GAARlandia landspan may account for an unusual distribution pattern between the Greater Antilles and Ecuador.

Because of the restricted habitats and the high degree of endemism on Cuba, the existence of many species of Ephemeroptera may be considered as threatened, and habitat conservation is critical.

B. Recommendations

It is necessary to intensify environmental education on aquatic insects, other groups of freshwater animals, and aquatic systems in general. This is important in order to impress upon citizens the importance of care for our river basins and streams, and includes conservation of streamside vegetation and prevention of bank erosion. The public should also be aware of the disastrous consequences of the water contamination and avoid runoff or direct actions polluting streambeds.

Although plans for protecting some river basins in Cuba do exist, it is essential to perfect them and apply them to all river basins of the country. Reforestation of the river banks should occupy a primary position and the extraction of sand should be controlled. Dumping of toxic industrial waste, residues from the pulp of the coffee production in the mountains of the Eastern Region, and residues from the sugar industry in the whole country have to be strictly controlled and sanctioned in the cases of violations. It is indispensable to enforce and rigorously apply the laws protecting Cuban rivers so that the uniqueness of the fauna is conserved and the future of its citizens is protected.

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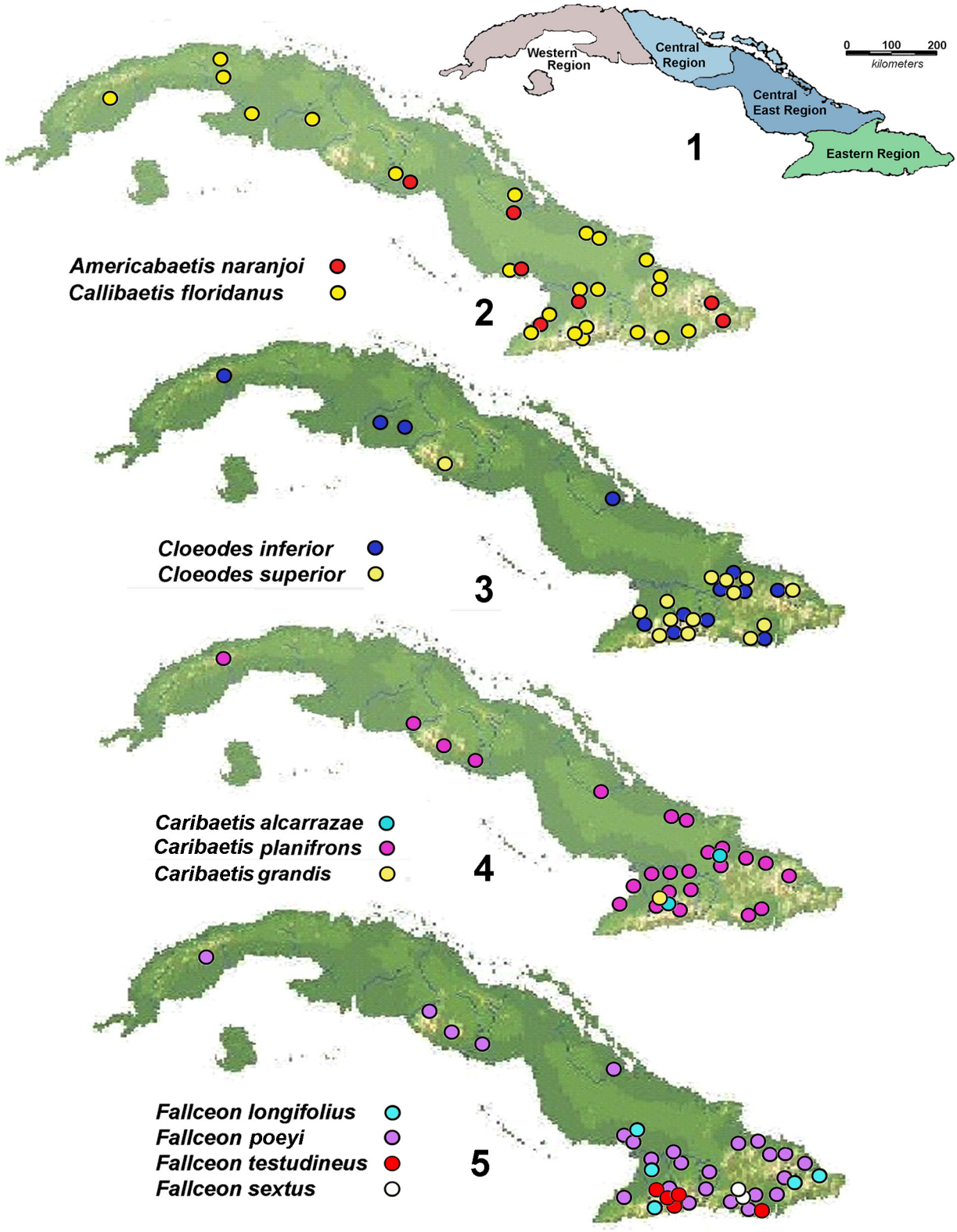
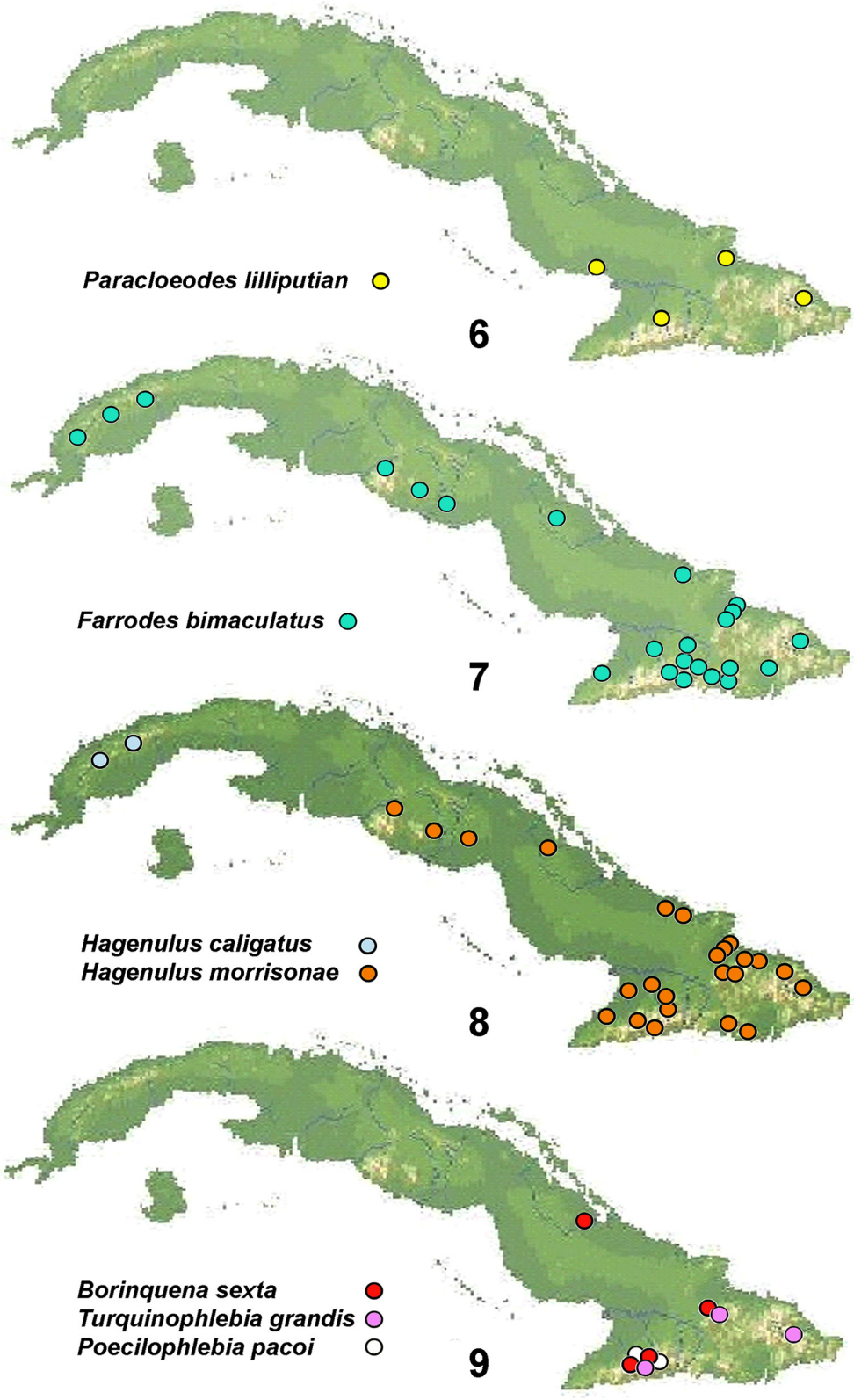
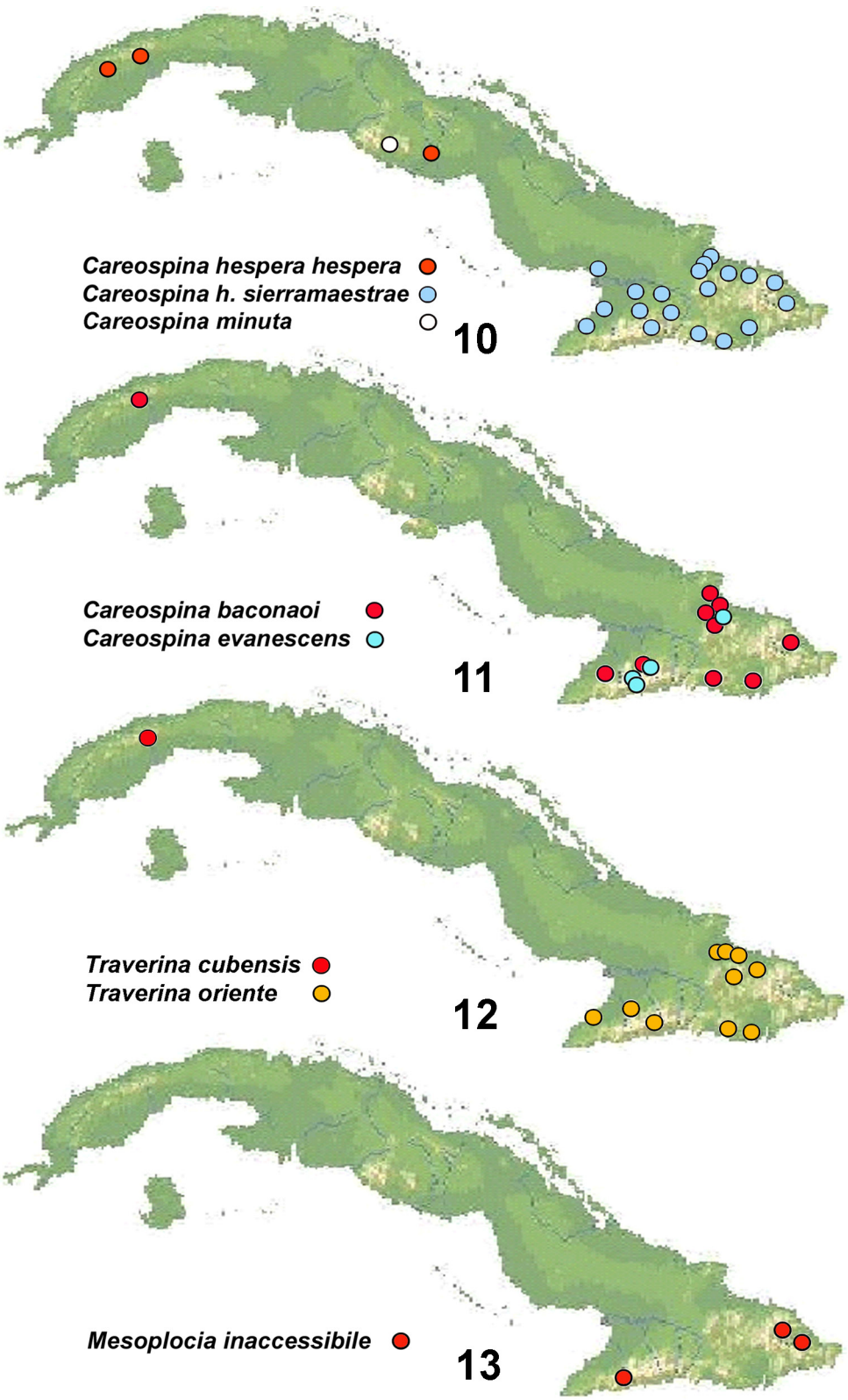


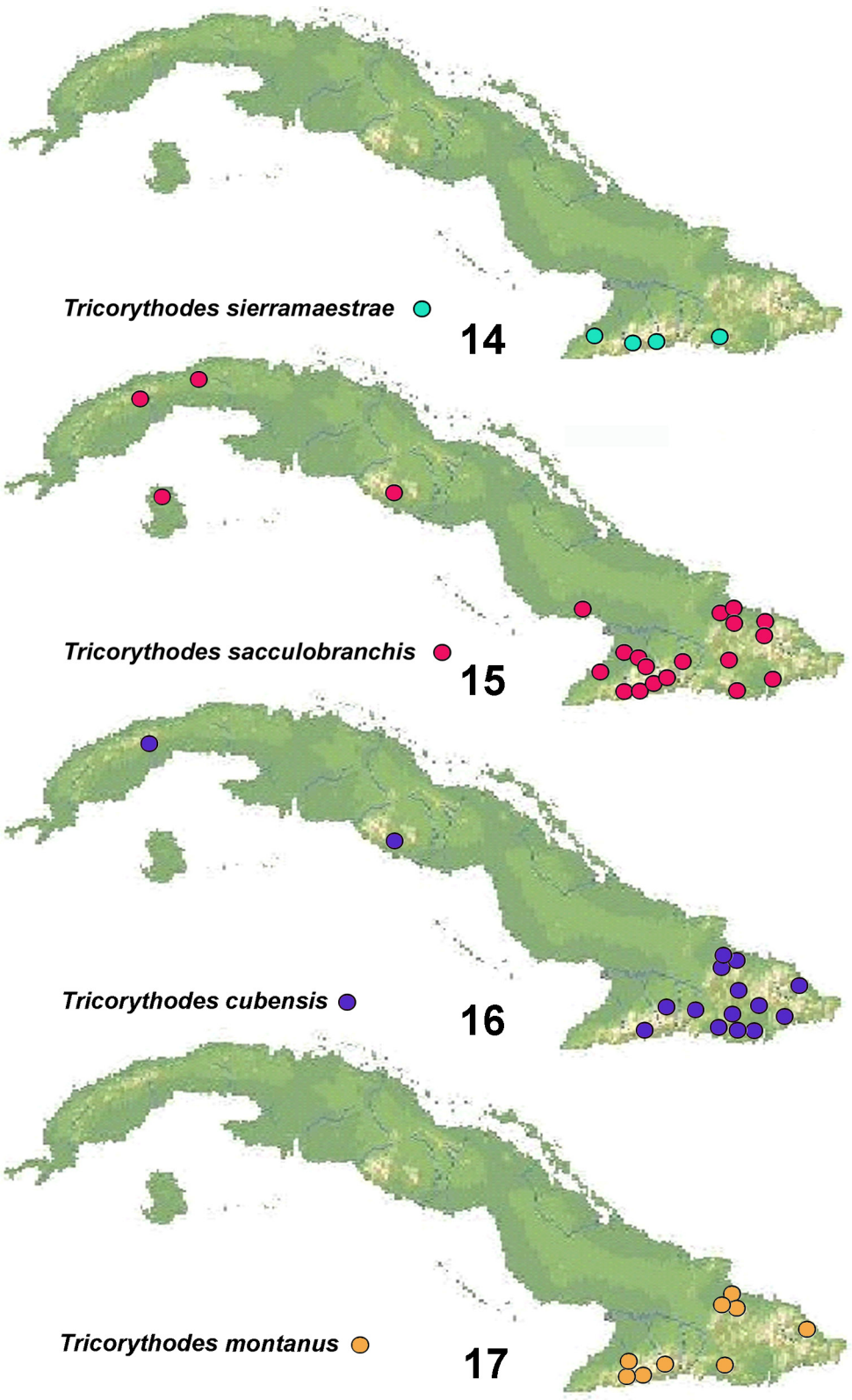
Figures 1–5. Distribution records for Ephemeroptera in Cuba. **1)** Major geographic regions of Cuba (Núñez 1989). **2)** *Americabaetis naranjoi*, *Callibaetis floridanus*. **3)** *Cloeodes inferior*, *C. superior*. **4)** *Caribaetis alcarrazae*, *C. planifrons*, *C. grandis*. **5)** *Fallceon longifolius*, *F. poeyi*, *F. testudineus*, *F. sextus*.



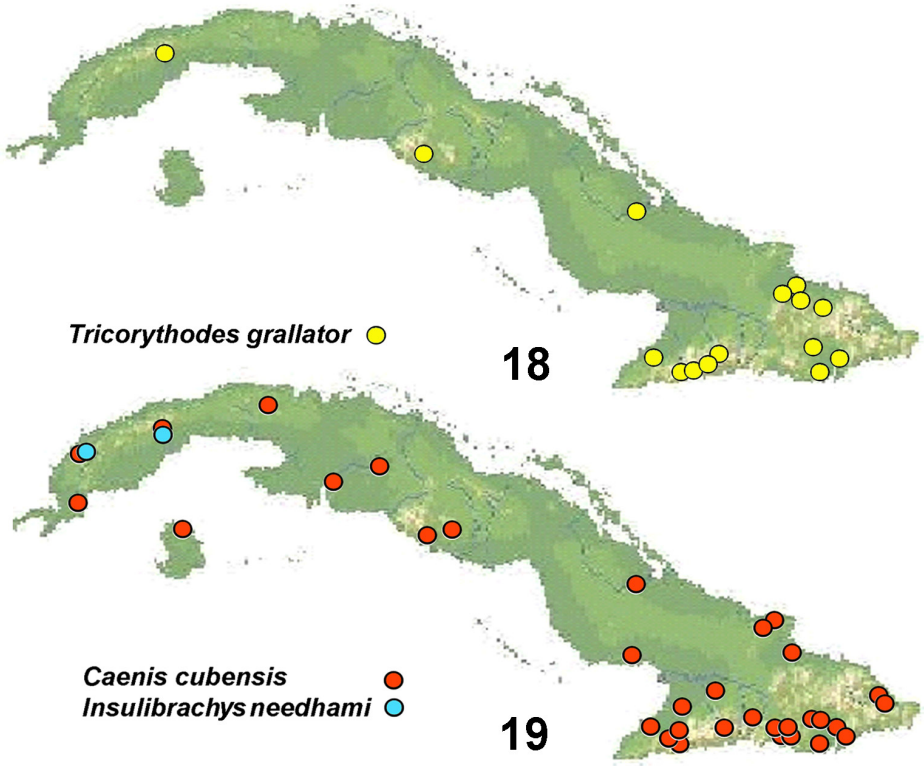
Figures 6–9. Distribution records for Ephemeroptera in Cuba. **6)** *Paracloeodes lilliputian*. **7)** *Farrodes bimaculatus*. **8)** *Hagenulus caligatus, H. morrisonae*. **9)** *Borinquena sexta, Turquinophlebia grandis, Poecilophlebia pacoi*.



Figures 10–13. Distribution records for Ephemeroptera in Cuba. **10)** *Careospina hespera hespera, C. h. sierramaestrae, C. minuta*. **11)** *Careospina baconaoi, C. evanescens*. **12)** *Traverina cubensis*, *T. oriente*. **13)** *Mesoplocia inaccessibile*.

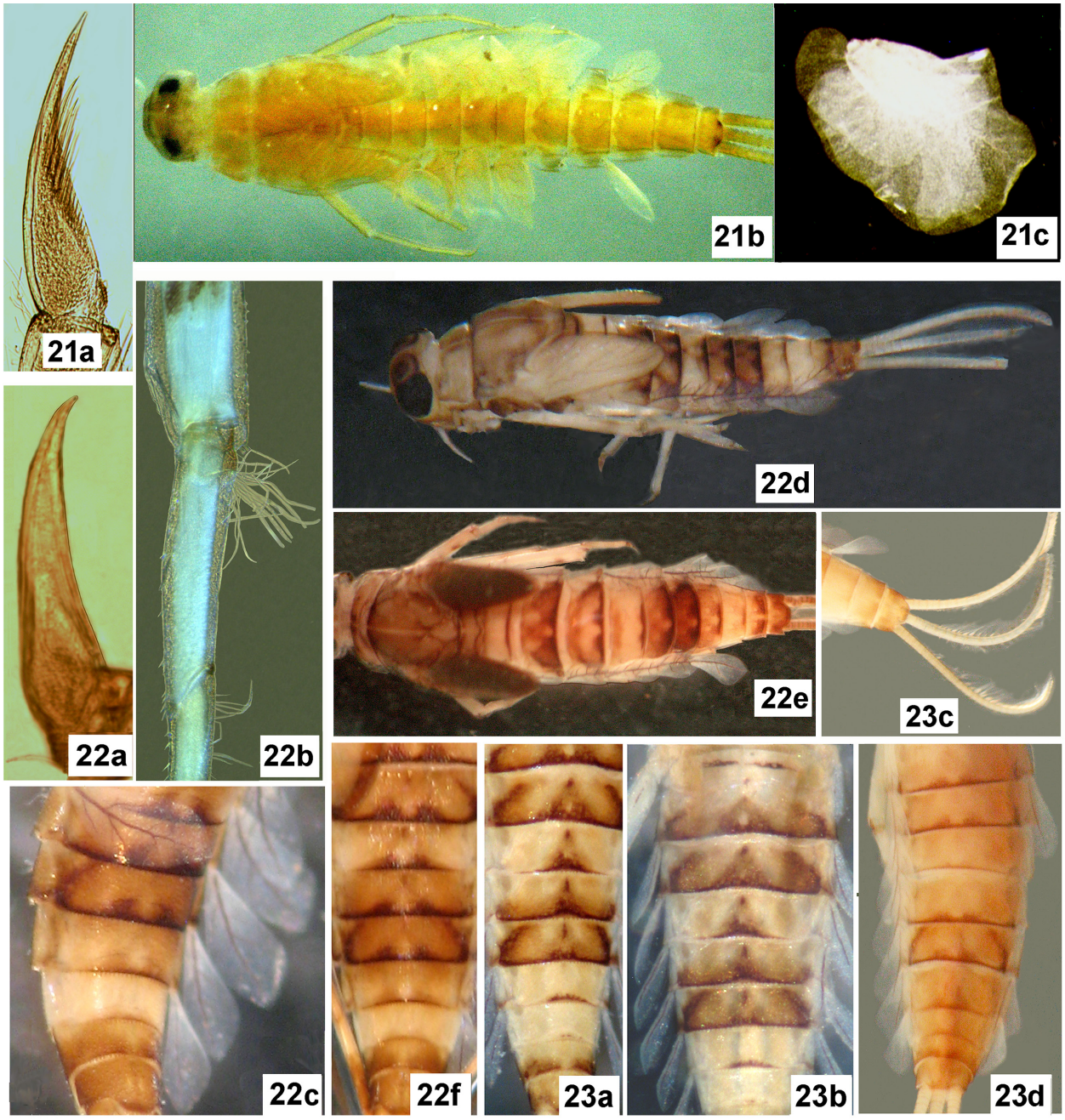


Figures 14–17. Distribution records for Ephemeroptera in Cuba. **14.** *Tricorythodes sierramaestrae*. **15)** *Tricorythodes sacculobranchis*. **16)** *Tricorythodes cubensis*. **17)** *Tricorythodes montanus*.

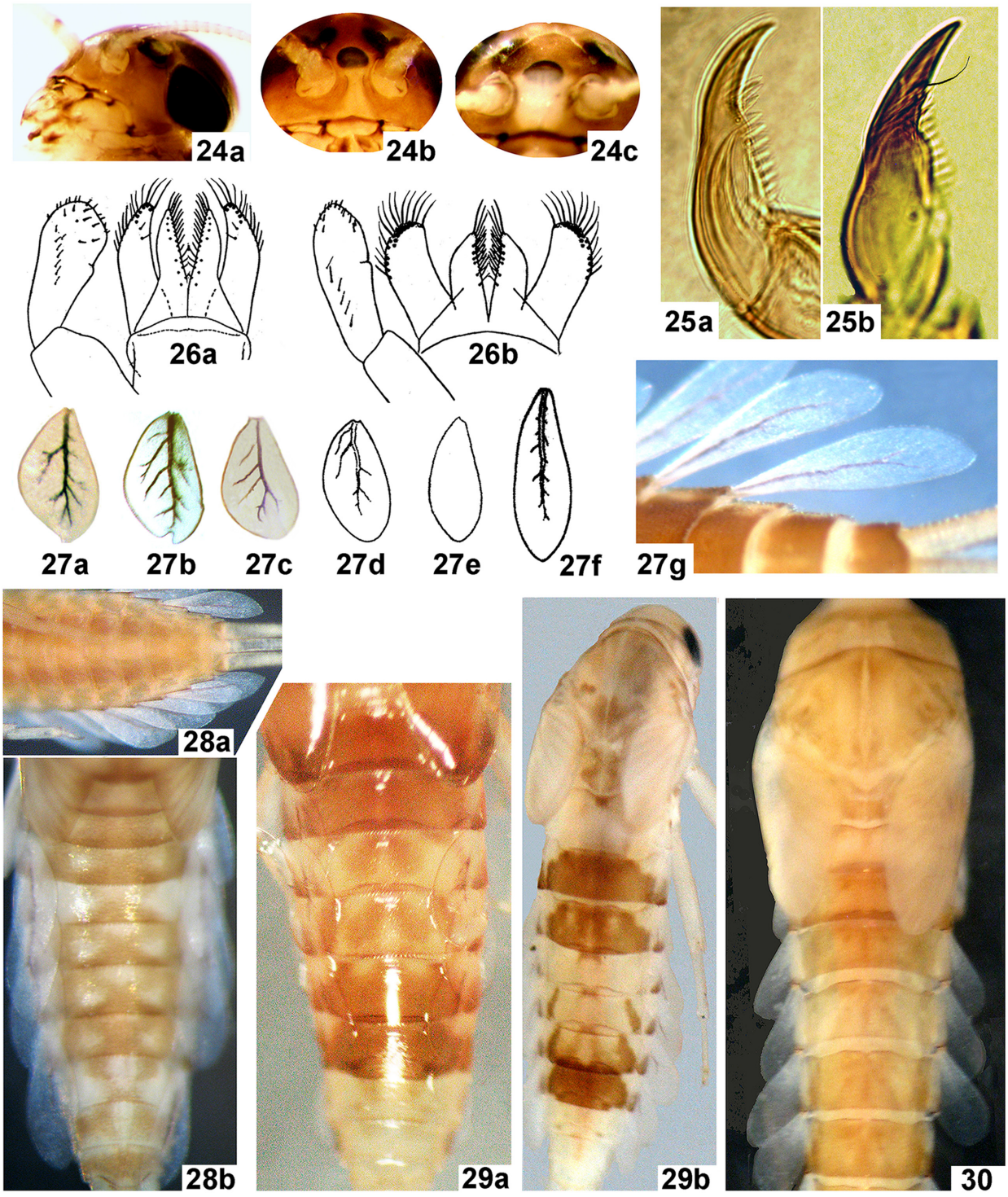


Figures 18–19. Distribution records for Ephemeroptera in Cuba. **18).** *Tricorythodes grallator*. **19)** *Caenis cubensis, Insulibrachys needhami*.

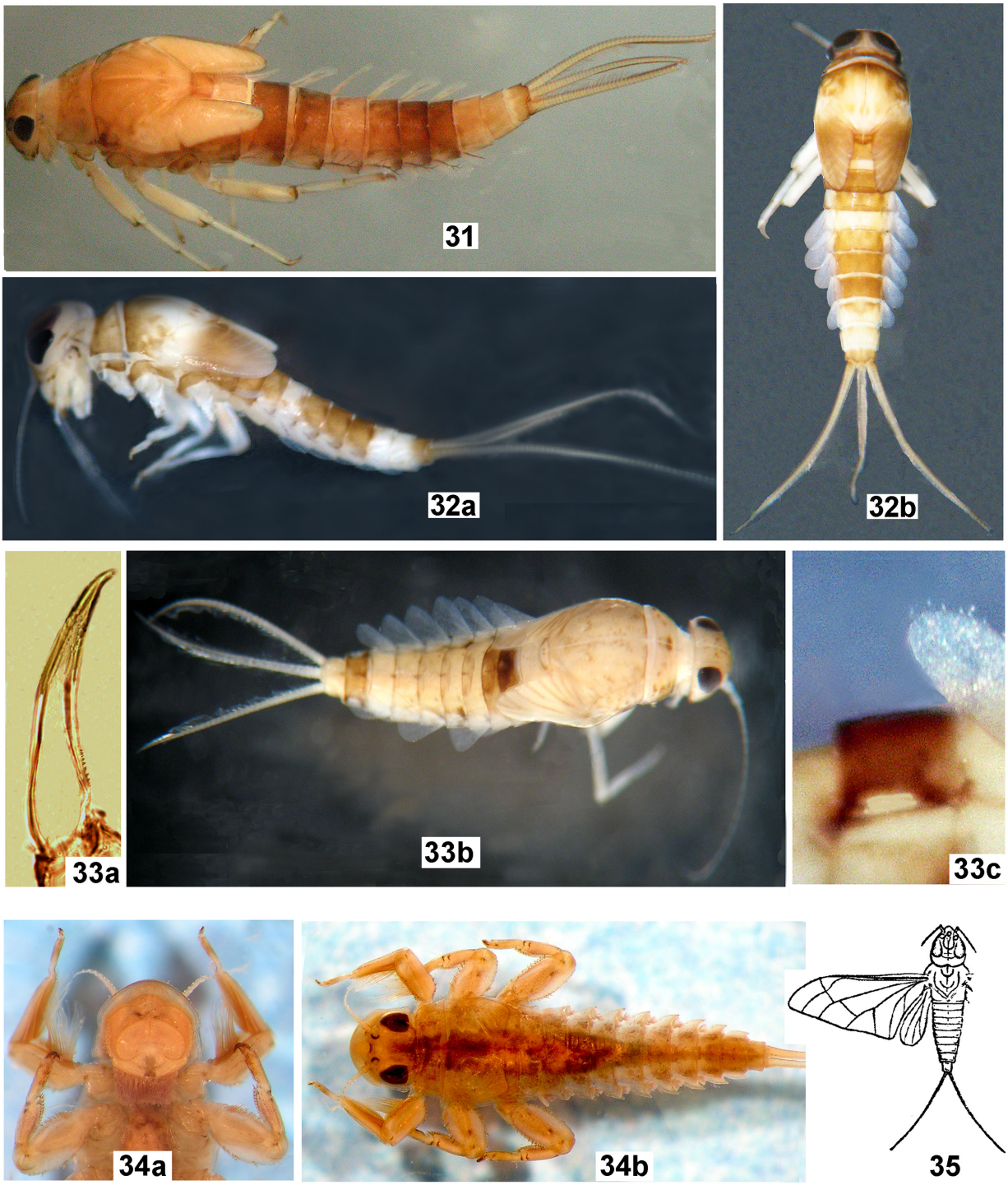
Figure 20. Baetidae. *Americabaetis naranjoi*. **a)** Habitus. **b)** Head and thorax, dorsal. **c)** Head, lateral. **d)** Abdomen, dorsal. **e)** Gill. **f)** Caudal filaments.



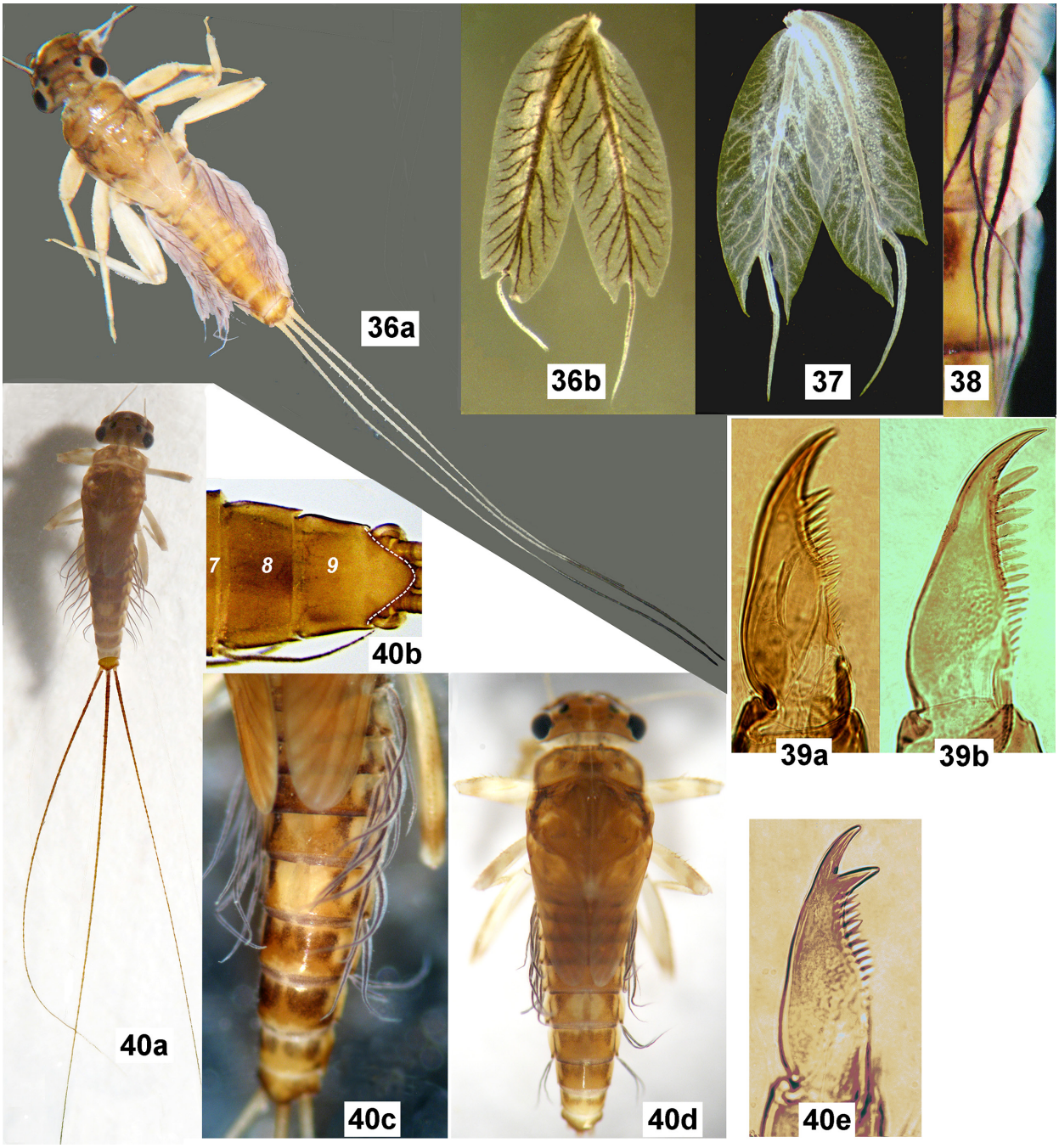
Figures 21–23. Baetidae**. 21)** *Callibaetis floridanus*. **21a)** Foreclaw. **21b)** Habitus. **21c)** Gill 2. **22)** *Cloeodes superior*. **22a)** Foreclaw. **22b)** Rows of setae on basal margin of tibia and tarsus. **22c)** Abdomen with gills 3–7. **22d)** Habitus. **22e)** Habitus (pre-emergent). **22f)** Terga 3–10. **23)** *Cloeodes inferior*. **23a)** Terga 3–10. **23b)** Terga 2–8. **23c)** Caudal filaments. **23d)** Terga 2–10, variation.



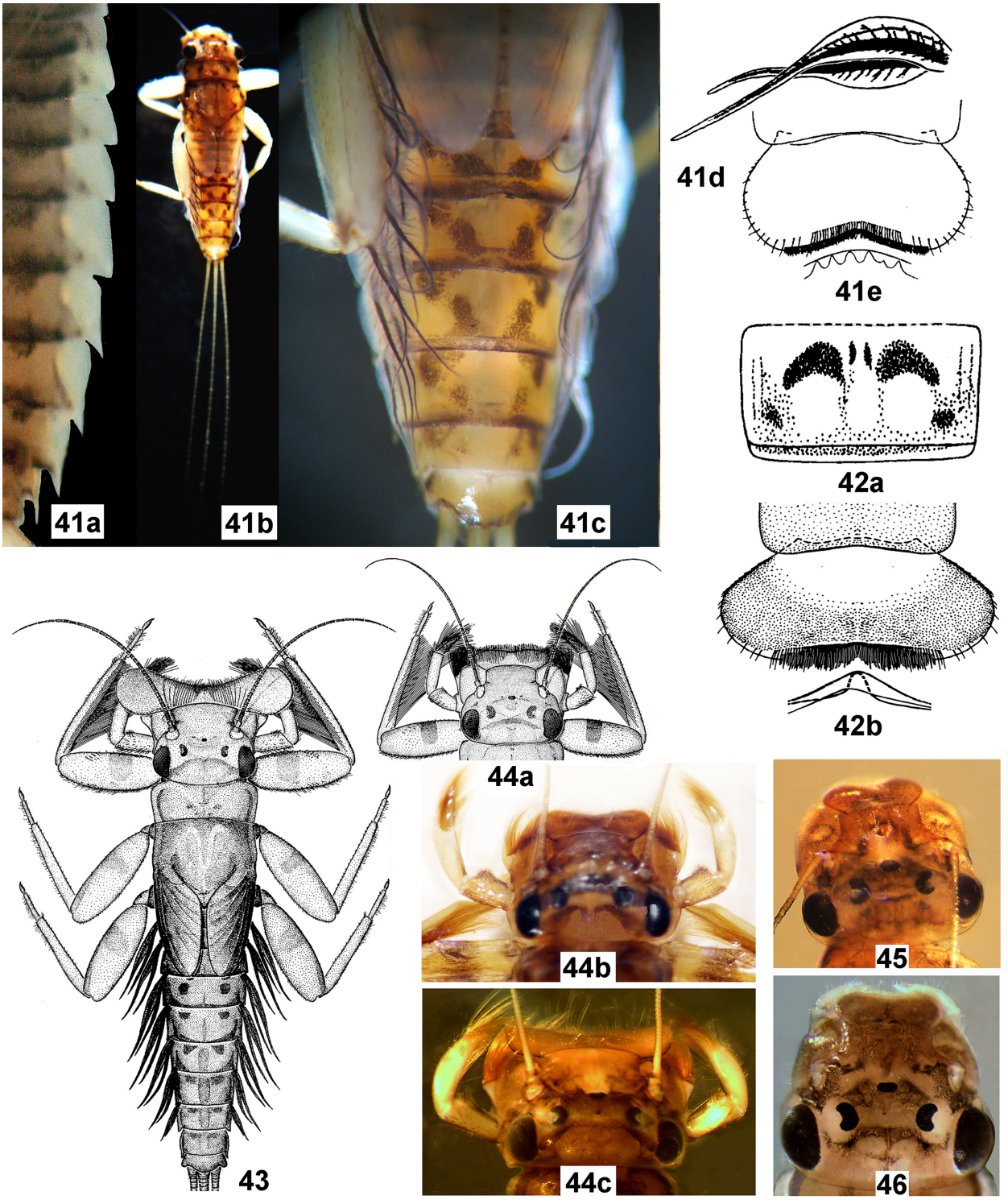
Figures 24–30. Baetidae. **24)** Front of head. **24a–b)** *Fallceon poeyi* with keel. **24c)** *Caribaetis planifrons*. **25)** Foreclaw. **25a)** *Fallceon poeyi*. **25b)** *Caribaetis planifrons* (seta retouched). **26.** Labium. **26a)** *Fallceon testudineus*. **26b)** *F. sextus*. **27)** Abdominal gills. **27a–d)** *Fallceon poeyi*. **27e)** *F. sextus*. **27f–g)** *F. longifolius*. **28.** *Fallceon longifolius*, abdomen. **28a)** Ventral. **28b)** Dorsal. **29)** *Fallceon poeyi*. **29a)** Terga 2–10. **29b)** Habitus. **30)** *Caribaetis planifrons*, dorsal. Figures 26, 27d–f after Kluge (1992b).



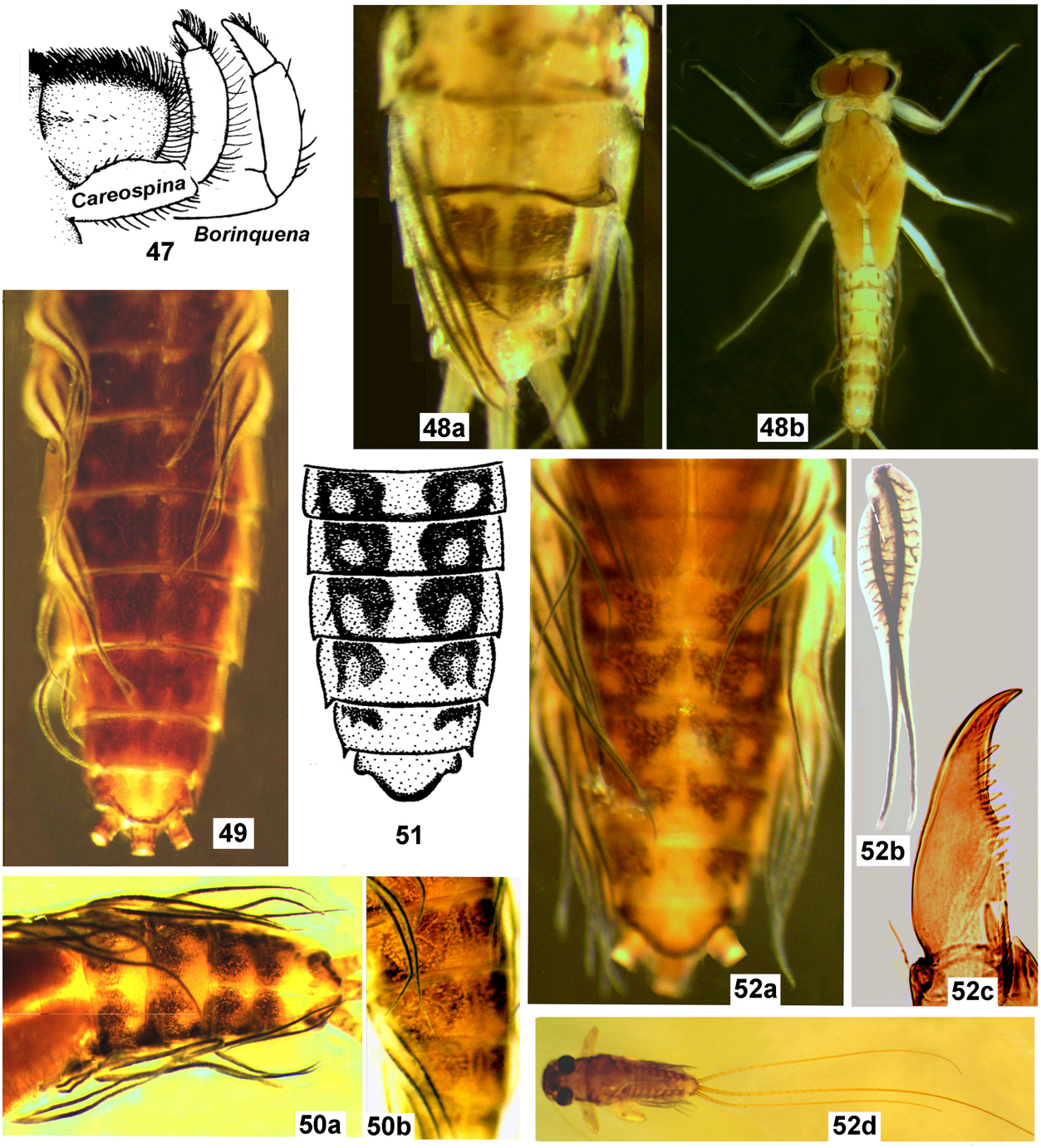
Figures 31–35. Baetidae and Oligoneuriidae. **31)** *Caribaetis planifrons*¸ habitus. **32)** *Caribaetis alcarrazae*, habitus. **32a)** Lateral. **32b)** Dorsal). **33.** *Paracloeodes lilliputian*. **33a)** Foreclaw. **33b)** Habitus. **33c)** Detail of marking on lateral abdominal segment 9. **34)** *Lachlania* sp. from Panama. **34a)** Ventral head capsule and anterior thorax. **34b)** Habitus. **35)** *Lachlania abnormis*, drawing from only Cuban record (Hagen 1868), one of 6 females collected by Ch. Wright.



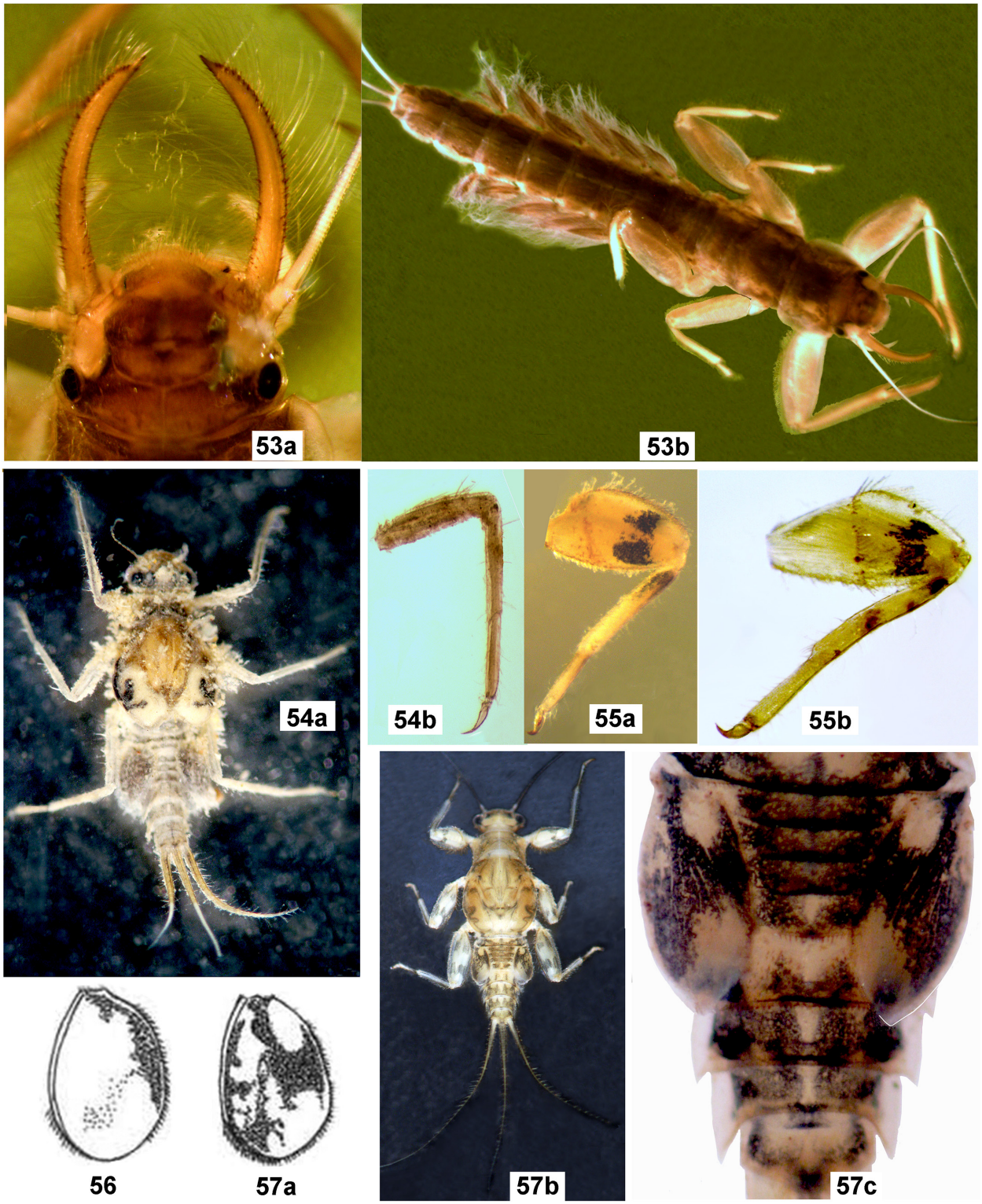
Figures 36–40. Leptophlebiidae. **36)** *Traverina oriente*. **36a)** Habitus. **36b)** Abdominal gill. **37)** *Traverina cubensis,* abdominal gill. **38)** *Poecilophlebia pacoi,* lateral abdominal gills 5–7. **39)** Claw of *Traverina*. **39a)** *T. oriente*. **39b)** *T. cubensis*. **40)** *Farrodes bimaculatus*. **40a)** Habitus. **40b)** Sterna 7–9. **40c)** Male abdominal color. **40d)** Female habitus. **40e)** Claw.



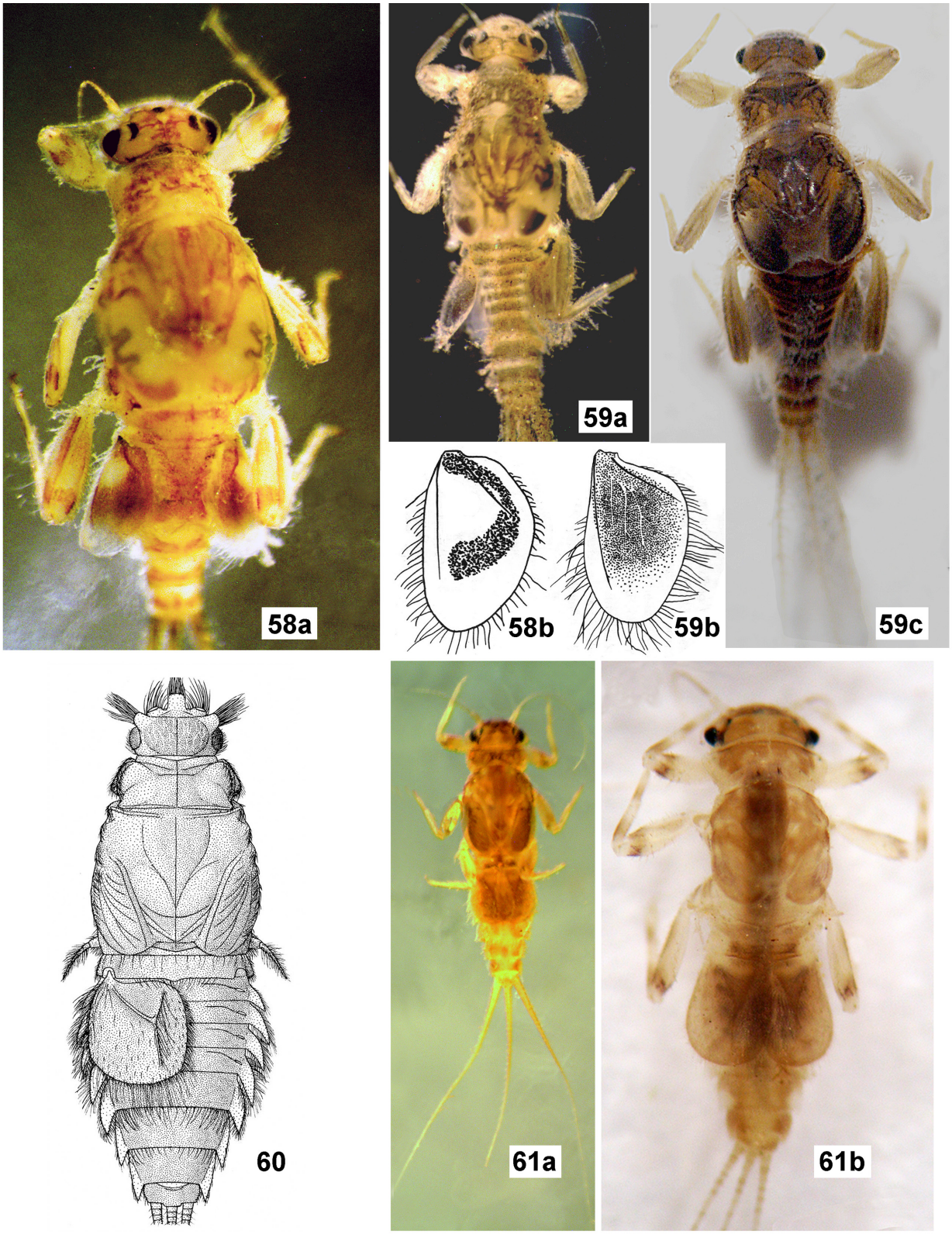
Figures 41–46. Leptophlebiidae. **41)** *Poecilophlebia pacoi*. **41a)** Lateral margins of abdominal terga. **41b)** Habitus. **41c)** Abdominal color pattern. **41d)** Gill. **41e)** Labrum with detail of anteromedian margin. **42)** *Turquinophlebia grandis*. **42a)** Color pattern of abdominal tergum 5. **42b)** Labrum with detail of anteromedian margin. **43)** *Hagenulus caligatus*. **44)** *Hagenulus morrisonae*. **44a)** Head. **44b)** Head. **44c)** Head (variation, Nipe-Sagua-Baracoa Massif). **45)** *Careospina baconaoi*, head. **46)** *Careospina hespera sierramaestrae*, head. Figures 41d–42 after Kluge 1994; 43–44a after Peters 1971.



Figures 47–52. Leptophlebiidae. **47)** Labial palpi comparing segmentation ratios of *Careospina hespera hespera* and *Borinquena sexta*. **48)** *Borinquena sexta*. **48a)** Terga 6–10. 48**b)** Habitus. **49)** *Careospina evanescens*, terga 3–10. **50)** *Careospina baconaoi*. **50a)** Male, terga 5–10. **50b)** Female, terga 6–9. **51)** *Careospina hespera hespera*, terga 5–10. **52)** *Careospina hespera sierramaestrae*. **52a)** Terga 3–10. **52b)** Gill. **52c)** Foreclaw. **52d)** Habitus. Figure 51 after Peters 1971.



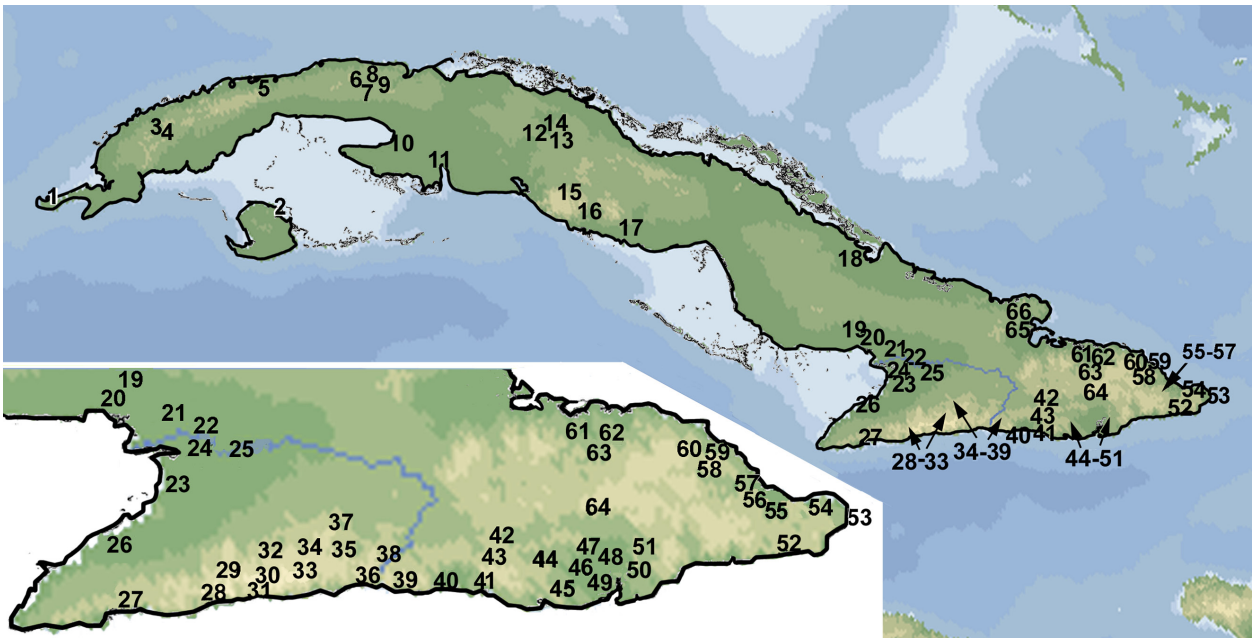
Figures 53–57. Euthyplociidae and Leptohyphidae. **53)** *Mesoplocia inaccessibile*. **53a)** Head. **53b)** Habitus. **54)** *Tricorythodes grallator*. **54a)** Habitus. **54b)** Foreleg. **55)** Foreleg. **55a)** *Tricorythodes sacculobranchis*. **55b)** *T. cubensis*. **56)** *Tricorythodes sierramaestrae*, operculate gill cover. **57)** *Tricorythodes sacculobranchis*. **57a)** Operculate gill cover. **57b)** Habitus. **57c)** Detail of abdominal terga 3–10 with operculate gills. Figure 56–57a after Kluge and Naranjo 1990.



Figures 58–61. Leptohyphidae and Caenidae. **58)** *Tricorythodes cubensis*. **58a)** Habitus. **58b)** Operculate gill. **59)** *Tricorythodes montanus*. **59a)** Habitus. **59b)** Operculate gill. **59c)** Habitus. **60)** *Insulibrachys needhami*. **61)** *Caenis cubensis*. **61a)** Mature nymph. **61b)** Younger nymph. Figure 58b, 59b after Kluge and Naranjo 1990; Fig. 60 after Sun and McCafferty 2008 (gills on right removed).

Appendix 1

Localities surveyed by researchers from the Department of Biology, Universidad de Oriente, through 2008. Detail of Eastern Region inset.



Western Region

1 – Pinar del Río Province: Sta. Cruz de los Pinos.
2 – Isla de la Juventud**:** Nueva Gerona.
3 – Pinar del Río Province: Hotel San Vicente (Viñales).
4 – Pinar del Río Province: San Diego de los Baños.
5 – Artemisa Province: Río Soroa.
6 – Habana Province: Melena del sur.
7 – Habana Province: Río Güines.
8 – Habana Province: Río Quitacalzón, Casiguas.
9 – Habana Province: Vento.
10 – Matanzas Province: Ciénaga de Zapata.
11 – Matanzas Province: Río Buena Ventura.

Central Region

12 – Villa Clara Province: Río Anaya,
13 – Villa Clara Province: Río Gíbacoa.
14 – Sancti Spíritus Province: Río Soledad.
15 – Sancti Spíritus Province: Altura de Trinidad.
16 – Sancti Spíritus Province: Río Táyaba.
17 – Sancti Spíritus Province: Río Banao.

Central-East Region

18 – Camagüey Province: Río Máximo.
19 – Las Tunas Province: Río Yáquimo.
20 – Las Tunas Province: Río Sevilla (Amancio).

Eastern Region

21 – Granma Province: Río Bayamo.
22 – Granma Province: Río La Bayamesa.
23 – Granma Province: Río Yara near Manzanillo.

24 – Granma Province: Cuenca baja Río Yara.
25 – Granma Province: Cuenca alta del Río Yara.
26 – Granma Province: Río Sevilla (Níquero).
27 – Santiago de Cuba Province: Río El Macío.
28 – Santiago de Cuba Province: Río Palma Mocha.
29 – Santiago de Cuba Province: Arroyo Emajagua.
30 – Santiago de Cuba Province: Río Turquino.
31 – Santiago de Cuba Province: Río La Mula.
32 – Granma Province: Río Nagua.
33 – Santiago de Cuba Province: Arroyo Paco.
34 – Santiago de Cuba Province: Río Peladero.
35 – Santiago de Cuba Province: La Alcarraza.
36 – Santiago de Cuba Province: Río El Codillo.
37 – Santiago de Cuba Province: Río Guamá.
38 – Santiago de Cuba Province: Río Mogote.
39 – Santiago de Cuba Province: Río San Lorenzo.
40 – Santiago de Cuba Province: Río El Zaino.
41 – Santiago de Cuba Province: Río La Purísima.
42 – Santiago de Cuba Province: Río San Rafael.
43 – Santiago de Cuba Province: Río Boniatico.
44 – Santiago de Cuba Province: Río San Juan.
45 – Santiago de Cuba Province: Río Carpintero.
46 – Santiago de Cuba Province: Gran Piedra.
47 – Santiago de Cuba Province: Río El Indio.
48 – Santiago de Cuba Province: Río Las Yaguas.
49 – Santiago de Cuba Province: Río Baconao.
50 – Guantánamo Province: Río Guantánamo.
51 – Guantánamo Province: Río Guaso.
52 – Guantánamo Province: Río Imías.
53 – Guantánamo Province: Río La Tinta.
54 – Guantánamo Province: Río Miel.
55 – Guantánamo Province: Río Duaba.
56 – Guantánamo Province: Río Naranjal.
57 – Guantánamo Province: Río Toa.
58 – Guantánamo Province: Río La Ceremonia.
59 – Holguín Province: Río Cayo Guam.
60 – Holguín Province: Río Sagua de Tánamo.
61 – Holguín Province: Cuenca baja Río Mayarí.
62 – Holguín Province: Cuenca media Río Mayarí.
63 – Holguín Province: Cuenca alta Río Mayarí.
64 – Guantánamo Province: Río Cuzco,
65 – Holguín Province: Río Gibara.
66 – Holguín Province: Río Cacoyuguín.

Appendix 2

Localities for paratypes and revisionary material. (When names or borders of provinces have changed, the current name is given in brackets.)

1. A*mericabaetis naranjoi* paratypes. **Province Granma:** Río Yara (Sto. Domingo), 7-VIII-1984, 19-IV-1985, 14-XII-1985, C. Naranjo. **Province Guantánamo:** Río Duaba (Baracoa), 15-III-1989, N. Kluge; Río Imías, 12-II-1985, C. Naranjo.
2. *Callibaetis floridanus* Cuban specimens treated as *Callibaetis completa* in Kluge (1991). **Province Santiago de Cuba:** Río El Codillo (Guamá), 5-II-1989, N. Kluge; Río Carpintero, 4-XII-1989, N.

Kluge; Río San Lorenzo (Guamá), 4-V-1985, C. Naranjo; Río El Tártaro (Guamá), 22-X-1983, 4-V-1985, C. Naranjo.

3. *Cloeodes inferior* paratypes. **Province Sancti Spíritus:** Sierra Trinidad, 18-IV-1989, N. Kluge. **Province Santiago de Cuba:** Río Las Yaguas (Baconao), 12-II-1989, N. Kluge; same locality, 25-XII-1983, C. Naranjo. **Province Guantánamo:** Río Duaba (Baracoa), 15-III-1989, N. Kluge.
4. *Cloeodes superior* paratypes. **Province Santiago de Cuba:** La Alcarraza (Guamá), 4-II-1989, N. Kluge; Arroyo Paco (Río Palma Mocha), 24-II-1989, N. Kluge; same locality, 04-XII-1983, C. Naranjo; Río La Idalia (Gran Piedra), 25-I-1986, C. Naranjo.
5. *Caribaetis alcarrazae* paratypes. **Province Santiago de Cuba:** La Alcarraza (Guamá), 4-II-1989, N. Kluge.
6. *Caribaetis grandis* paratypes. **Province Granma:** Río Yara, 06-VI-1999, P. López.
7. *Caribaetis planifrons* paratypes. [**Province Artemisa]:** Río Soroa, 1-IV-1989, N. Kluge. **Province Sancti Spíritus:** Sierra Trinidad, 18-IV-1989, N. Kluge.
8. *Fallceon longifolius* paratypes. **Province Granma:** Río Yara, 14-XII-1985, C. Naranjo. **Province Santiago de Cuba:** La Alcarraza (Guamá), 7-II-1989, N. Kluge; Río Baconao, 04-III-1989, N. Kluge; Río Las Yaguas (Baconao), 12-II-1989, N. Kluge; Río Mogote (Cruce de los Baños), 03-V-1985, C. Naranjo; Río El Tártaro (Guamá), 22-X-1983, 13-VI-1985, C. Naranjo. **Province Guantánamo:** Río Duaba (Baracoa), 5-III-1989, N. Kluge.
9. *Fallceon poeyi* paralectotypes. Cuba Ch. Wright, no other data. Voucher material. **Province Sancti Spíritus:** Sierra Trinidad, 12/18-IV-1989, N. Kluge. **Province Santiago de Cuba:** Río Baconao, 03-III-1989, N. Kluge.
10. *Fallceon sextus* paratypes. **Province Santiago de Cuba:** Río Las Yaguas (Baconao), 12-II-1989, N. Kluge.
11. *Fallceon testudineus* paratypes. **Province Santiago de Cuba:** Arroyo Paco (Río Palma Mocha), 4-II-1989, N. Kluge; Arroyo Emajagua (Subida al Turquino), 2-II-1985, C. Naranjo; Río Carpintero (Gran Piedra), 3-I-1989, N. Kluge; same locality, 5-XII-1984, C. Naranjo.
12. *Paracloeodes lilliputian* paratypes. **Province Guantánamo:** Río Duaba, 15-III-1989, N. Kluge.
13. *Lachlania abnormis* syntypes from "Cuba;" no other data.
14. *Farrodes bimaculatus* paratypes. **[Province Mayabeque]:** Güines, March 1966, P. Alayo. Voucher material. [**Province Artemisa]:** Soroa, 1/7-IV-1989, N. Kluge. **Province Sancti Spíritus:** Caballero River (north of Trinidad), 12/18-IV-1989, N. Kluge. **Province Santiago de Cuba:** Arroyo Paco (tributary of Palma Mocha River near Pico Turquino),18/24-II-1989, N. Kluge; Guáma River near La Alcarraza, El Codillo and Sandor, 1/9-II-1989, N. Kluge; Baconao River in Las Yaguas, 12-II-1989, N. Kluge; same locality, 23-I-1986, C. Naranjo; Limoncito (Gran Piedra), east of Santiago de Cuba, 24-V-1985, C. Naranjo; La Idalia (Gran Piedra), 23-V-1985, 25-I-1986, C. Naranjo; Carpintero River, 15-XII-1984, 25-I-1986, C, Naranjo; Sto Domingo, 7-VIII-1984, C. Naranjo; Cruce de los Baños, 3-V-1985, C. Naranjo. **Province Guantánamo:** Toa River near Paso de Toa and Naranjal, 13/15-III-1989, N. Kluge; Imias, 12-III-1985, C. Naranjo.
15. *Hagenulus caligatus* voucher material collected by P. Alayo. **Province Pinar del Río:** Arroyo Pinar de Viñales, October 1964. [**Province Artemisa]:** Río Cuzco (Soroa), March 1965. [**Province Mayabeque]:** Güines, March 1966; Melena del Sur, February 1965. Other voucher material. **Province Pinar del Río:** Sta. Cruz de los Pinos, 24/28-III-1939, J. G. Needham. [**Province Artemisa]:** Río Soroa, 1/7-IV-1989, N. Kluge; same locality, 29-X-1965, V. Landa. **Province La Habana:** Vento, 20-IV-1930, J. G. Needham.
16. *Hagenulus morrisonae* paratypes. [**Province Cienfuegos]:** Río Anaya (Ciego Montero), December 1965, P. Alayo. [**Province Granma]:** Río Yara (Manzanillo), May 1965, P. Alayo. [**Province Santiago de Cuba]:** Río Nagua, near Turquino, May 1965, P. Alayo; Río San Rafael (San Luís), 16-XI-1964, V. Landa; Río Boniatico (San Luis), November 1964, P. Alayo. [**Province Guantánamo]:** Río Guantánamo, December 1965. P. Alayo.
17. *Borinquena sexta* paratypes. **Province Santiago de Cuba:** Arroyo Paco (Río Palma Mocha), 8/24-II-1989, N. Kluge; same locality, 2-VI-1985, 16-V-1985, 21-VI-1985, 23-VI-1985, C. Naranjo.
18. *Turquinophlebia grandis* paratypes. **Province Santiago de Cuba:** Arroyo Paco (Río Palma Mocha), 18/24-II-1989, N. Kluge.

19. *Poecilophlebia pacoi* paratypes. **Province Santiago de Cuba:** Arroyo Paco (Río Palma Mocha), 22-II-1989, N. Kluge; same locality, 6-II-1989, C. Naranjo.
20a. *Careospina hespera hespera* paratypes. **Province Pinar del Río:** Arroyo Pinar de Viñales, P. Alayo; Viñales, October 1964, P. Alayo. [**Province Artemisa]:** Río Cuzco, March 1965, P. Alayo; Soroa, December 1964, P. Alayo.
20b. *Careospina hespera sierramaestrae* paratypes. **Province Santiago de Cuba:** Arroyo Paco (Río Palma Mocha), 25-II-1989, N. Kluge; same locality, 6-II-1986, 9-I-1984, 15-V-1985, C. Naranjo; Gran Piedra, 15-X-1983, 13-XI-1984, 2-II-1984, 24-V-1985, C. Naranjo; Cruce de los Baños, 11-VI-1985, C. Naranjo; El Tártaro, 11-VI-1985, C. Naranjo.
21. *Careospina baconaoi* paratypes. [**Province Artemisa]:** Río Soroa, 1/7-V-1989, N. Kluge. **Province Santiago de Cuba:** Río Baconao, Las Yaguas, 12-II-1989, N. Kluge; same locality, 23-I-1986, 22/23-I-1985, C. Naranjo; Río Baconao, 18-III-1985, N. Kluge; same locality, 4-III-1989, C. Naranjo. **Province Granma:** Río Yara, Santo Domingo, 22-VIII-1983, C. Naranjo. **Province Guantánamo:** Río Toa, 15-III-1989, N. Kluge.
22. *Careospina evanescens* paratypes. **Province Santiago de Cuba:** Arroyo Paco (Río Palma Mocha), 15/16-V-1985, 2-VI-1985, 23-VI-1985, C. Naranjo.
23. *Careospina minuta* paratypes. **Province Sancti Spíritus:** Mina Carlota (Montañas de Trinidad), 22-III-1925; other paratypes from "Cuba", collected by C. Wright.
24. *Traverina cubensis* paratypes. [**Province Artemisa]:** Río Cuzco, March 1965, P. Alayo; Río Soroa, June 1965, P. Alayo.
25. *Traverina oriente* paratypes. **Province Santiago de Cuba:** Río Las Yaguas, 24-V-1985, C. Naranjo. **Province Guantánamo:** Río Naranjal (Baracoa), 15-III-1989, N. Kluge.
26. *Mesoplocia inaccessibile* paratypes. **Province Santiago de Cuba:** Arroyo Paco (Palma Mocha), 16-V-1985, C. Naranjo; same locality, 7-II-1986, C. Naranjo.
27. *Tricorythodes sierramaestrae* paratypes. **Province Santiago de Cuba:** Río Palma Mocha basin, Arroyo Emajagua, 19-I-1985, 2-II-1985, C. Naranjo and others; Arroyo Paco, 28-VIII-1983, 4-XII-1983, 30-III-1984, C. Naranjo and others; same locality, 18/24-II-1989, N. Kluge; La Alcarraza (Guamá), 7-II-1989, N. Kluge.
28. *Tricorythodes sacculobranchis* paratypes. **Province Granma:** Río Yara and Santo Domingo, 22-VIII-1983, 18-VI-1985, C. Naranjo and others; Arroyo La Santana, trib. of Río Yara, 3-XII-1983, 20-VI-1985, C. Naranjo. **Province Santiago de Cuba:** Arroyo Paco, trib. Río Palma Mocha, 9-I-1985, C. Naranjo and P. Almenares; La Alcarraza (Guamá), 1/7-II-1989, N. Kluge; Río San Lorenzo (Contramaestre), 4-V-1985, 12-VI-1985, C. Naranjo and P. Almenares; Río El Indio and Ramon de Las Yaguas, 25-XII-1983, C. Naranjo and others.
29. *Tricorythodes cubensis* paratypes. [**Province Artemisa]:** Río Soroa, 1/7-IV-1989, N. Kluge. **Province Ciengfuegos:** Altura de Trinidad, 14/18-IV-1989, N. Kluge. **Province Santiago de Cuba:** La Alcarraza (Guamá),1/7-II-1989, N. Kluge; Río San Lorenzo (Contramaestre), 4-V-1985, C. Naranjo; Río Las Yaguas (Baconao), 22-V-1985, C. Naranjo; same locality, 12-II-1989, N. Kluge; Río Baconao, 3-III-1989, N. Kluge. **Province Guantánamo:** Río Imías, 12-III-1985, C. Naranjo; Río Toa (Baracoa), 11-III-1989, N. Kluge; Río La Tinta (Baracoa), 16-1-1984, C. Naranjo.
30. *Tricorythodes montanus* paratypes. **Province Santiago de Cuba:** Arroyo Paco (trib. Río Palma Mocha), 6-II-1986, C. Naranjo; same locality, 18/24-II-1989, N. Kluge; La Alcarraza (Guamá),1-7-II-1989, N. Kluge; Río La Idalia, Gran Piedra, 21-V-1981, 25-IX-1983, 13-XI-1983, C. Naranjo.1
31. *Tricorythodes grallator* paratypes. [**Province Artemisa]:** Río Soroa, 1/7-IV-1989, N. Kluge. **Province Cienfuegos:** Altura de Trinidad, 15/18-IV-1989, N. Kluge. **Province Villa Clara:** Río Gíbacoa, 15/18-IV-1989, N. Kluge. **Province Santiago de Cuba:** Arroyo La Santana and La Emajagua, Río Palma Mocha, 3-3-XII-1983 and18-I-1985, C. Naranjo and others; La Alcarraza (Guamá), 7-II-1989, N. Kluge.
32. *Insulibrachys needhami* paratype. [**Province Artemisa]:** Soroa, 12-X-1964, V. Landa.
33. *Caenis cubensis* paratypes. **Province Pinar del Río:** Hotel San Vicente (Viñales), October 1964, P. Alayo; San Diego de los Baños, 1965, P. Alayo. **Isla de la Juventud:** Nueva Gerona, 24-II-1965, P. Alayo. [**Province La Artemisa]:** Río Soroa, June 1965, P. Alayo; same locality, 1/7-IV-1989, N. Kluge. [**Province Mayabeque]:** Río Quitacalzón Casiguas, March 1966, P. Alayo. **Province**

Matanzas: Cienága de Zapata, October 1964, P. Alayo; Río Buena Ventura (Ciegána de Zapata), February 1965, P. Alayo. **Province Cienfuegos:** Caburni, 14/18-IV-1989, N. Kluge. **Province Villa Clara:** Río La Soledad, October 1964, P. Alayo. **Province Sancti Spíritus:** Río Banao. 6-II-2005, P. López; **Province Camagüey:** Río Máximo, 6-VIII-2003, O. Bello. **Province Granma:** Río Yara (Arroyo Santana), 3-XII-1983, 14-XII-1985, C. Naranjo; Río Sevilla (Niquero), 3-II-2003, D. Hernández and Y. Cala. **Province Holguín:** Río Cacoyugüín, Gibara, 30-I-2003, Y. Bauta and Y. Hernández. **Province Santiago de Cuba:** Río La Alcarraza (Sierra Maestra), 1/7-II-1989, N. Kluge; Arroyo Paco (Río Palma Mocha), 9-I-1985, 6-II-1989, C. Naranjo; same locality,18/24-II-1989, N. Kluge; Río Turquino (Guamá),17-VI-2006, D. Gonzáles and C. Naranjo; Río San Lorenzo,1984-1985, C. Naranjo; Río Baconao, Las Yaguas, 12-II-1989, N. Kluge; Río La Bayamesa (Sierra Maestra), 26-I-2003, P. López; Río La Purísima (El Cristo), 27-IX-2003, C. Carrisco; same locality, 9-IX-2002, Y. Cambas; Río Boniato (Boniato), 1-III-2002, A. Trapero Río El Zaino (Carretera del Cobre), 4-III-2001, A. Trapero; Río La Idalia (Gran Piedra), 9-IV-2005, D. Gonzáles and C. Naranjo. **Province Guantánamo:** Baracoa, Imías (Nipe-Sagua-Baracoa), 12-III-1985, C. Naranjo; Río Cuzco, 21-III-2003, S. Muñoz.