



Two new species of *Choroterpes* Eaton (Ephemeroptera: Leptophlebiidae) from Costa Rica

SOCORRO ÁVILA A.¹ & R. WILLS FLOWERS^{2*}

¹Instituto Nacional de Biodiversidad, Apdo. 22-3100, Santo Domingo de Heredia, Costa Rica, C.A.

E-mail: savila@inbio.ac.cr

²Center for Biological Control, Florida A&M University, Tallahassee, FL 32307 USA.

E-mail: rflowers7@earthlink.net

*Corresponding author

Abstract

Choroterpes gregoryi **new species** (type locality: Maquenco, Costa Rica) and *Choroterpes mairena* **new species** (type locality: Cuajiniquil, Costa Rica) (Ephemeroptera: Leptophlebiidae: Atalophlebiinae) are described from imagos and nymphs. Both species occur along the west coast of Costa Rica in streams on or near the Nicoya Complex. *Choroterpes mairena* is adapted to living in temporary streams with long dry seasons, while *Choroterpes gregoryi* is found in permanent streams. Both species occur in pools with extensive leaf packs.

Key words: *Choroterpes*, Ephemeroptera, Leptophlebiidae, Osa, Nicoya, Santa Elena, new species, temporary streams, biogeography

Resumen

Se describen de imagos y ninfas *Choroterpes gregoryi* **especie nueva** (localidad tipo: Maquenco, Costa Rica) y *Choroterpes mairena* **especie nueva** (localidad tipo: Cuajiniquil, Costa Rica) (Ephemeroptera: Leptophlebiidae: Atalophlebiinae). Ambas especies viven a lo largo de la costa oeste de Costa Rica, en quebradas cerca y encima del Complejo de Nicoya. *Choroterpes mairena* está adaptada para vivir en quebradas temporales con las épocas secas largas, mientras que *Choroterpes gregoryi* se encuentra en quebradas permanentes. Ambas especies se encuentran en charcos con empaques extensivas de hojas.

Introduction

In the Western Hemisphere, the cosmopolitan genus *Choroterpes* Eaton is known from

four species distributed between Canada and México (*C. albiannulata* McDunnough, *C. basalis* (Banks), *C. inornata* Eaton, *C. terratoma* Seemann) and one species from southern México (*C. unguis* Ortiz and McCafferty). South of México *Choroterpes* has been known only from a few unidentified nymphs from Costa Rica and Colombia (Peters 1988, Peters et al. 2005). In this paper we describe two species from the Pacific peninsulas (Santa Elena, Nicoya and Osa) and nearby areas of Costa Rica.

Material and methods

Nymphs were collected by manually washing leaf packs collected in the bottoms of pools. Rearings were done in the field using plastic cups with screened windows, as described in Edmunds *et al.* (1976). Adults were collected at blacklight. Geographic coordinates and elevations of collecting sites were determined in the field using a Garmin etrex Summit™ GPS unit, or by locating the site on Costa Rican topographic maps. Specimens are deposited in the following institutions: FAMU, Florida A&M University, Tallahassee, Florida, USA; IFML, Instituto–Fundación Miguel Lillo, Tucumán, Argentina; INBio, Instituto Nacional de Biodiversidad, Santo Domingo de Heredia, Costa Rica, MZUCR, Museo de Zoología, Universidad de Costa Rica, San José, Costa Rica.

Choroterpes gregoryi Ávila and Flowers, new species

(Figs. 1, 3–5, 9, 10, 13, 15, 16, 19, 20, 23, 25)

Description

Holotype. Male imago (in alcohol, genitalia and one set of wings on slides): Length: body 4.7mm, forewing 4.8mm. Head: brown, washed with black, antenna translucent yellowish brown, scape and pedicel washed with reddish brown. Upper portion of eyes olive brown, stalk very short, lower portion dark gray. Ocelli whitish, their bases dark brown. Thorax: pronotum yellowish brown washed with black laterally and on basal margin; meso- and metanota chestnut brown, margins and carinae darker. Pleura orange-brown washed with dark brown, a diagonal area above mesocoxae washed with black. Thoracic sterna orange brown. Forewing (Fig. 1): membrane hyaline, translucent yellowish brown at base; longitudinal veins translucent brown, cross veins hyaline. Hind wing (Fig. 1): membrane hyaline, veins C and Sc translucent yellow in basal half, remaining veins hyaline. Foreleg: yellowish brown, tarsus lighter; femur with a dark brown spot at mid-length; tarsal formula: 0.18:1.0 (0.56mm): 0.75:0.39:0.18. Hind legs translucent yellow, femora with dark brown spots at mid-length and apically, tibiae darker brown at the femoral joint. Abdomen (Fig. 3, 5): terga translucent yellowish brown, washed with dark brown, with pale median, submedian and lateral markings. Abdominal sterna translucent yellowish brown, sternum IX with brown basal and lateral margins.

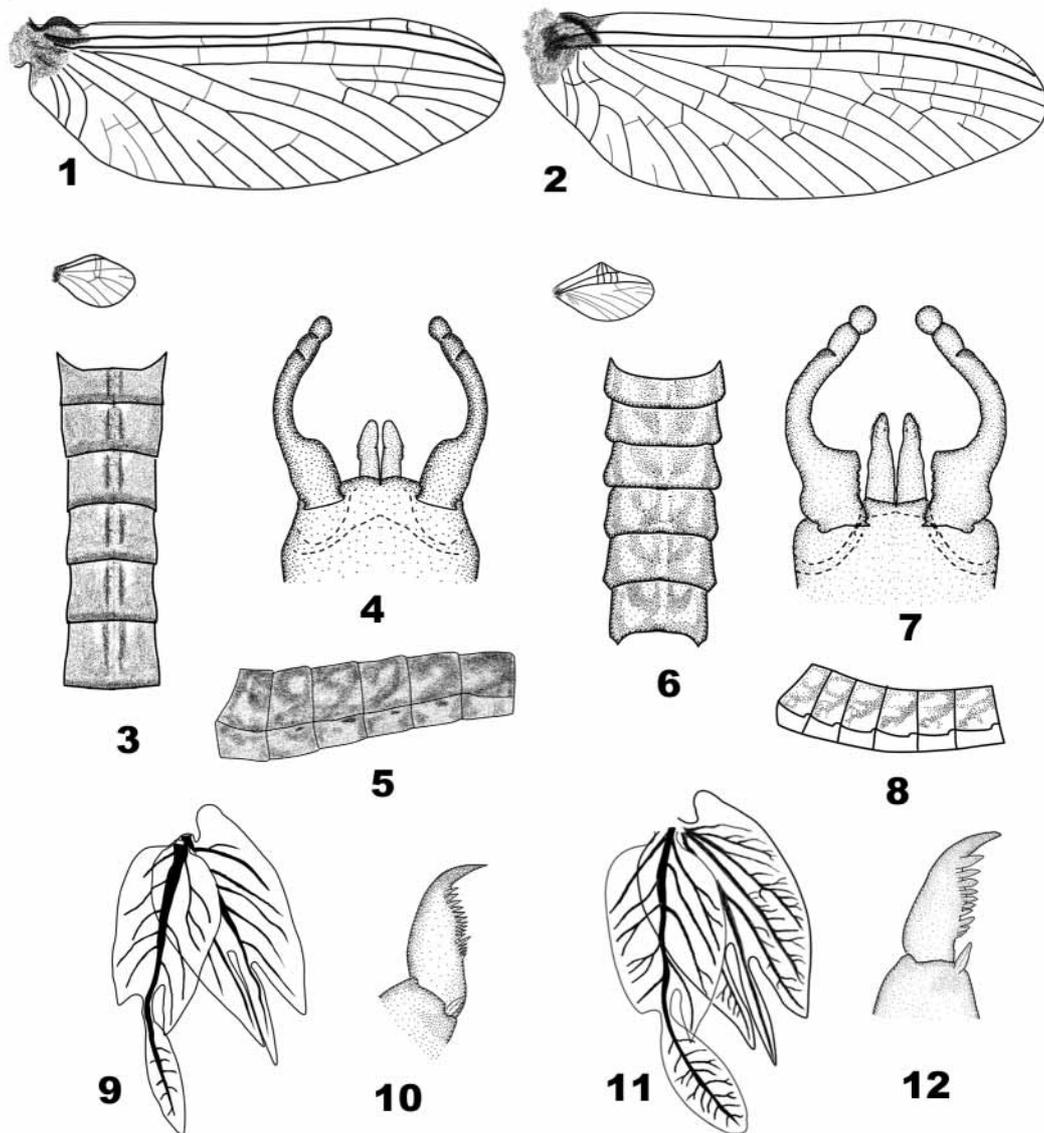
Genitalia (Fig. 4): forceps expanded in basal 1/3; styliger plate whitish, forceps brown, penes whitish. Penis lobes elongate, membranous, with a tiny pair of spines in apical third along midline. Caudal filaments broken off and missing.

Allotype. Female subimago (reared with nymphal exuviae). Length: body 4.6mm, forewing 5.1mm. Coloration as in male imago except: head yellowish white marked with dark brown between ocelli and on vertex; antenna whitish. Thorax yellowish brown, meso- and metanota darker brown laterally, membranes whitish washed with grey. Wing membrane whitish, veins translucent. Legs yellowish white, dark spots as in male imago except fore femur has an additional apical dark spot. Abdomen yellowish white with dark brown markings as in male imago. Subanal plate yellowish white, cone-shaped, without apical notch. Caudal filaments white with narrow dark bands on annuli.

Mature nymph (in alcohol): Body length 4.6–5.1mm. Head: yellowish brown washed with darker brown, pale spot anterior to the median ocellus, and pale areas between eyes and lateral ocelli. Vertex and area between ocelli washed with black. Antenna yellowish white. Mouthparts: labrum (Fig. 13) with maximum length slightly less than maximum width, anteromedian emargination well developed with three irregular denticles, a row of short dorsal subapical seta present immediately behind anteromedian emargination, and a second row of long dorsal present on apical third, length of this row slightly more than one third the total width of labrum; mandibles (Fig. 15, 16) with outer margins obtusely angled, a tuft of setae at angle; maxilla (Fig. 19) with anteromedian tooth obsolete, galea-lacina with inner subapical row of 17–18 pectinate setae; hypopharynx as in Fig. 20; segment 2 of labial palpi 3/4 the length of segment 1, segment 3 slightly shorter than segment 2, (Fig. 23) with 5 large dorsal seta on segment 3; labrum, basal 2/3 of mandibles, outer margin of maxilla brown, labium yellowish brown. Thorax: terga yellowish tan, pronotum with crescent-shaped submedian spots and lateral margins dark brown; mesonotum washed with brown on lateral margins; pleura washed with dark brown, sterna yellowish brown. Legs: yellowish white, femora with dark brown median and apical spots, tibiae and tarsi pale yellowish brown, tarsi paler at base and apex; claw with denticles divided into two sections of 8–10+4–5 denticles (Fig. 9) with denticles in both sections increasing in size toward apex. Abdomen: terga washed with dark brown, pale markings as in male imago; sterna yellowish brown, male with dark brown at base of each segment in lateral 1/4; female with sterna washed with orange-brown; posterolateral spines present on segments IV–IX. Gills (Fig. 10) whitish grey, trachea gray-violet, secondary tracheae lacking side branches. Caudal filaments pale yellowish brown.

Etymology

gregoryi, masculine. This species is dedicated to the senior author's youngest son, Gregory Juseppy Porras, who at six years old is already an enthusiastic aquatic entomologist.



FIGURES 1–12. *Choroterpes*. 1, 3–5, 9–10. *C. gregoryi*; 1, wings; 3, tergites II–VII of male abdomen; 4, male genitalia; 5, segments II–VII of male abdomen, lateral; 9, gill IV; 10, foreclaw of nymph. 2, 6–8, 11–12 *C. mairena*; 2, wings; 6, tergites II–VII of male abdomen; 7, male genitalia; 8, segments II–VII of male abdomen, lateral; 11, gill IV of nymph; 12, foreclaw of nymph.

Specimens examined

Male imago **HOLOTYPE** labeled COSTA RICA, Guanacaste, Nandayure, Queb. Maquenco. Fecha: 16-XII-2005 Elev. 392m. N 9° 58'21.48" W 85° 15'35.52" Col. S. Ávila, R. W. Flowers. Female subimago **ALLOTYPE** labeled COSTA RICA, Puntarenas, Golfito, Pavones, Queb. El Macho, Fecha: 16-IV-2005, Elev. 40m. N8° 20'39.78" W 83°

08°09.6" Col. S. vila, Cria 21-IV-2005. PARATYPES (3 ♂♂, 1 ♀♀, 10 nymphs): 2 ♂♂, 5 nymphs (2 nymphs, MZUCR; 2 nymphs, INBio) same data as holotype; 1 ♂ subimago (reared), 1 ♀ subimago (reared), 1 nymph (INBio), same data as allotype; 3 nymphs (INBio), same locality as allotype, Fecha: 18-I-2005, S. Ávila, R. W. Flowers; 1 nymph (INBio), Puntarenas Province, Parrita, Queb. Pirrís, 47m. N 9° 36' 1.02" W 84° 19' 19.08" Fecha: 13/02/2005; 3 nymphs (INBio), San José Province, La Cangreja, Queb. Grande, 200m, 13-II-2005, S. Ávila, R. W. Flowers. Nymphs from La Cangreja had a paler ground color on the abdomen and correspondingly darker lateral markings than the nymphs from the other localities.

Ecology

This species was collected from leaf packs in pools and in slow-flowing areas of streams along the southern Pacific coast of Costa Rica. Associated mayfly species include *Ulmeritoides acosa* Ávila & Flowers, *Tikuna atramentum* (Traver), *Farrodes* sp. *Thraulodes* sp. *Caenis* sp., and *Tricorythodes* sp. All streams in which this species was found are permanent.

Diagnosis

Choroterpes gregoryi can be separated from other Middle and Central American species of *Choroterpes* by the following combination of characters. In the imago: (1) abdomen dark with color pattern as in Figs. 3,5; (2) male genitalia with basal expansion of forceps 1/3 of their total length; (3) apices of penes rounded. In the nymph: (1) mandibles lacking anterolateral expansion basal to incisors; (2) maxilla with 17–18 apical pectinate setae and lacking an anteromedian tooth; (3) abdominal gills (Fig.) with outer and inner processes of both lamellae pointed. Of the other Western Hemisphere *Choroterpes*, *C. gregoryi* most closely resembles dark forms of *C. basalis* (Banks) from the eastern United States, but can be distinguished by the following combination of characters: In the imago the penes of *C. basalis* are more elongate than those of *C. gregoryi* and their apices are slanted outward. In the nymph, the labrum of *C. basalis* lacks the low irregular denticles found in *C. gregoryi*.

***Choroterpes mairena* Ávila and Flowers (new species)**

(Figs. 2, 6–8, 11, 12, 14, 17, 18, 21, 22, 24, 25)

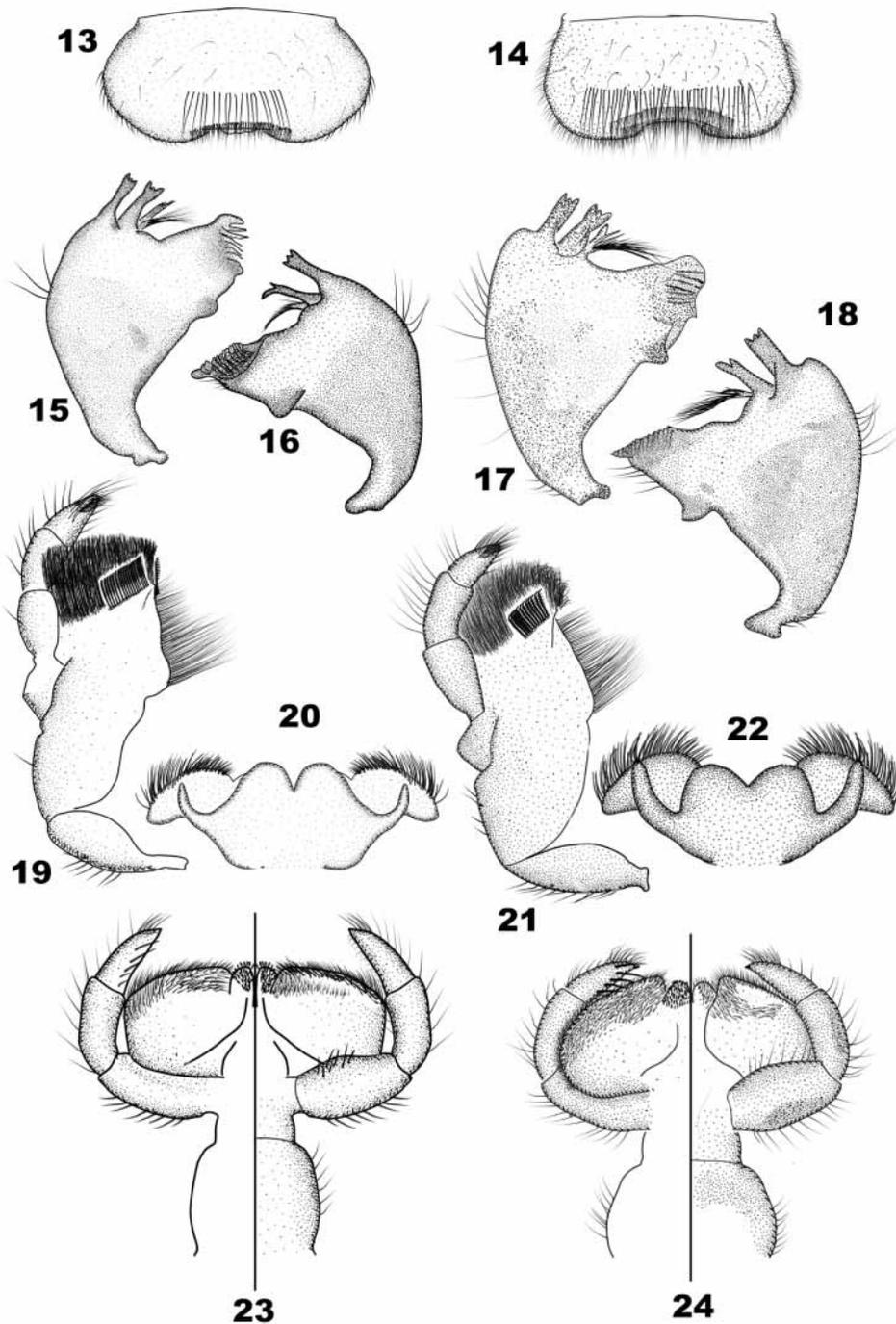
Discription

Holotype: Male imago (in alcohol). Length: body 4.8mm, forewing 4.6mm. Head: light brown, washed with blackish brown, antenna light brown. Upper portion of eyes orange-brown, lower portion dark grey. Ocelli whitish, their bases dark brown. Thorax: pronotum light brown with dark brown lateral margins and washed with dark brown on submedian areas; mesonotum dark brown, paler on midline, mesoscutellum piceous;

metanotum dark brown. Pleura brown, membranous area light brown. Thoracic sterna dark brown. Forewing (Fig. 2): membrane hyaline, longitudinal veins translucent yellowish brown, cross veins hyaline. Hind wing (Fig. 2): membrane hyaline, C and Sc translucent yellowish brown, remaining veins hyaline. Foreleg: light brown, tibia and tarsus whitish; femur washed with darker brown at mid-length and apex; tarsal formula 0.15: 1.00 (0.52mm): 0.65: 0.34: 0.23. Hind legs whitish, femora with dark brown spots at mid-length and apex, tibiae dark brown at femoral joint. Abdomen (Figs. 6, 8): terga whitish, washed with dark brown, with pale median and lateral markings, tergum 10 brown washed with darker brown. Abdominal sterna white, sternum 9 white with brown basal and lateral margins. Genitalia (Fig. 7): styliger plate pale brown, forceps with an almost quadrate inner basal angle and an exterior basal bulge, whitish; penes light brown, whitish in apical third. Penis lobes elongate, membranous with numerous short spines. Caudal filaments whitish.

Allotype: Female imago (reared with nymphal and subimaginal exuviae). Length: body 4.3mm., forewing 5.0mm. Coloration as in male imago except: head heavily washed with dark brown on vertex and between ocelli. Thorax and pleural sclerites orange-brown, membranes washed with gray. Abdomen bluish green (due to eggs of same color), marked with dark brown as in male imago. Subanal plate yellowish white at base, translucent apically, cone-shaped without apical notch.

Mature nymph: Body length 4.1–5.8mm. Head yellowish brown washed with dark brown, clypeus whitish, and whitish spots present anterior to median ocellus and between lateral ocelli and eyes. Area between ocelli and sublateral spots on vertex washed with black. Antenna white, basal segments pale yellowish brown. Mouthparts: labrum (Fig. 14) with maximum length less than maximum width, anteromedian emargination well developed, a row of short dorsal subapical seta present behind anteromedian emargination and a row of long dorsal setae on apical third, length of this row slightly less than three-fourths the total width of labrum; mandibles (Figs. 17, 18) with a prominent anterolateral flange on the outer margin at the base of incisors, outer margins obtusely angled, a short row of setae at angle and short seta above basal condyle; maxilla (Fig. 21) with anteromedian tooth obsolete, galea-lacinia with inner subapical row of 13 pectinate setae; hypopharynx as in Fig. 22; segment 2 of labium 4/5 the length of segment 1, segment 3 3/4 the length of segment 2, (Fig. 22) with 6–7 large dorsal seta on segment 3; labrum, basal 2/3 of dorsal surface of mandibles, outer margin of maxilla and posterior margins of segment I of labial palpi brown, a pale spot on dorsal side of mandibles at angles; remaining mouthparts pale yellowish brown. Thorax: terga yellowish brown, pronotum with dark brown sublateral bands; mesonotum washed with brown on lateral margins; pleura grey, sterna pale yellowish brown. Legs: yellowish brown, femora with dark brown median and apical spots, area between these spots pale yellow; claw with denticles divided into two sections of 7+3 denticles (Fig. 12) with denticles in both sections increasing in size toward apex. Abdomen: terga yellowish brown, washed with darker brown,



FIGURES 13–24. *Choroterpes*, nymphal mouthparts. Figs. 13, 15–16, 19–20, 23. *C. gregoryi*; 13, labrum; 15, left mandible, dorsal; 16, right mandible, dorsal; 19, maxilla, ventral; 20, hypopharynx, ventral; 23, labium: right, ventral; left, dorsal. Figs. 14, 17–18, 21–22, 24. *C. mairena*: 14, labrum; 17, left mandible, dorsal; 18, right mandible, dorsal; 21, maxilla, ventral; 22, hypopharynx, ventral; 24, labium: right, ventral view; left, dorsal.

segments II–VIII with a small pair of submedian spots on basal margin and a larger pair of sublateral spots at midlength, segment IX yellowish white with brown basal margin, segment X yellowish white with brown apical margin; sterna yellowish white, shaded with yellowish brown on lateral margins; posterolateral spines present on segments III or IV–IX Gills (Fig. 11) whitish grey, tracheae grey-violet. Caudal filaments pale yellowish brown.

Specimens examined

Male imago HOLOTYPE labelled COSTA RICA, Guanacaste, Cuajiniquil, Río Mairena, 21 m. N 10° 55'48.900" W 85° 41' 12.12", 25/01/2005, Col. R. W. Flowers, S. Ávila, M. M. Chavarría. Female imago ALLOTYPE (with nymphal and subimago exuvia), same locality and date as holotype, Col. R. W. Flowers, S. Ávila. PARATYPES (19 ♂♂, 11 ♀♀, 91 nymphs): Guanacaste Province, 13 ♂♂, 5 ♀♀, 31 nymphs (2 ♂♂, 5 nymphs, FAMU; 2 ♂♂, 1 ♀, 3 nymphs, IFML; 2 ♂♂, 2 ♀♀, 4 nymphs, MZUCR; 7 ♂♂, 2 ♀♀, 20 nymphs, INBio) same data as holotype; 1 ♀ subimago (with nymphal exuvia) (INBio), same locality and collectors as allotype, 27/01/2005; 31 nymphs (10, MZUCR; 21, INBio), same data as holotype; Area de Conservación Guanacaste, Parque Nacional Santa Rosa, Sector Santa Elena, Río Calera, 315m, N 10°51'50.0" W 85°39'49.4", 4 ♂♂, 4 ♀♀ (INBio), 2/12/2004, Col. S. Ávila, R. W. Flowers; 9 nymphs (4, MZUCR; 5, INBio), 13/07/2004, M.M. Chavarría, R. W. Flowers; 1 nymph (INBio), N 10°51'59.5" W 85°39'48.9", 5/09/2004, M. M. Chavarría; 4 nymphs (INBio), Queb. Calera, 315m, 10°52'13.4" W 85°38'49.5", 02/12/2004, S. Ávila, R. W. Flowers, M. M. Chavarría; 7 nymphs (INBio), N 10°52'48.7" W 85°38'49.1", 05/09/2004, M. M. Chavarría; Río Cuajiniquil, cruce de camino a Potrero Grande, 320m, N 10°52'48.7" W 85°36'41.3", 2♂, 2♀, 7 nymphs (INBio), 01/12/2004, S. Ávila, R. W. Flowers, M. M. Chavarría; 1 nymph (INBio), Queb. Loros, 368m. N10°50'50.9" W 85°41'52.8", 03/12/2004, S. Ávila, R. W. Flowers, M. M. Chavarría; 4 nymphs (INBio), Islas Murcielagos, Isla San José, N 10°51'44.2" W 85°54'47.4", M.M. Chavarría, E. Sequiera.

Ecology

This species is currently known only from the Santa Elena Peninsula where it is common and widespread in temporary streams that are without water five months of the year. Adults and emerging nymphs were most common in February in isolated pools in which the water decreased measurably from day to day. Other mayfly genera found in association with *C. mairena* were *Ulmeritoides acosa* and *U. chavarriae*, *Caenis* sp., *Tricorythodes* sp., and *Americabaetis* sp.

Diagnosis

Choroterpes mairena can be separated from other Middle and Central American species of *Choroterpes* by the following combination of characters. In the imago: (1) abdomen with color pattern as in Figs. 6 and 8, and with U-shaped dark margins on

sternum IX: (2) male genitalia with basal expansion of forceps 1/3 of their total length: (3) penes with their apices rounded and with numerous short spines. In the nymph: (1) mandibles with prominent anterolateral flange; (2) maxillae with 13 apical pectinate setae; (3) gills (Fig.11) with outer and inner processes of inner lamellae elongate and pointed but with only outer process of outer lamella acutely pointed. *Choroterpes mairena* is most similar (in the nymph) to *C. unguis* Lugo-Ortiz & McCafferty, but can be distinguished by the pointed apical angles of the gills (all angles are blunt and rounded in *C. unguis*).

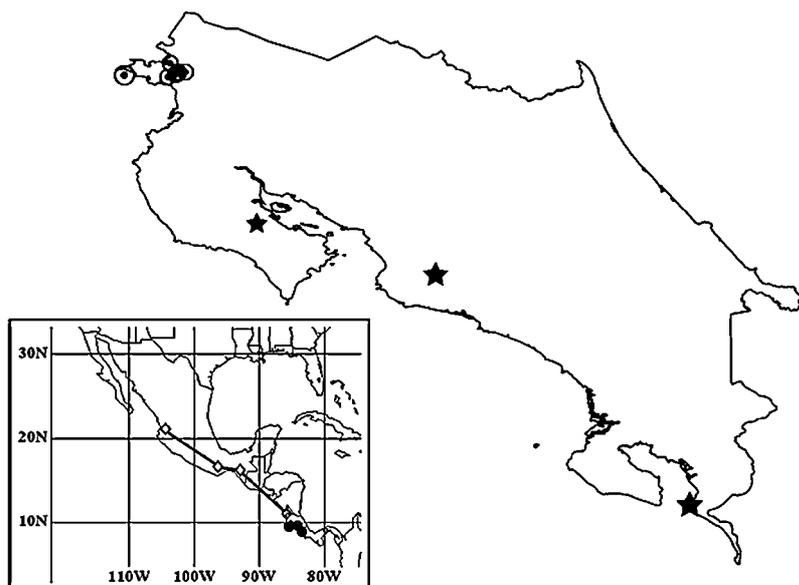


FIGURE 25. Distribution of *Choroterpes* in Costa Rica. *C. gregoryi*, black star; *C. mairena*, bull's-eye circles. Inset: distribution of *Choroterpes* in Central America. *C. mairena* and related forms, diamond and line; *C. gregoryi*, black dot.

Discussion

Choroterpes mairena, along with the Mexican *C. unguis*, and a small undescribed nymph found in the northwest of Mexico, appear to represent an endemic Central American-Mexican clade of *Choroterpes* (Fig. 25). This clade is distinguished by the anterolateral projection on the mandibles (Figs. 17, 18), a feature not known from any other North American *Choroterpes*. At present adults are unknown for *C. unguis*, nor is it known if either of these Mexican forms are temporary stream dwellers as is *C. mairena*.

Peters (1988) discussed the biogeography of *Choroterpes*, which at that time included three subgenera: *Choroterpes* (s.s.), *Choroterpes* (*Euthraulus*), and *Choroterpes* (*Neochoroterpes*) — *Neochoroterpes* was subsequently elevated to generic status (Henry 1993). The distribution map of *Choroterpes* s. l. given by Peters (1988) reveals a rather common Laurasian-Gondwanian pattern. Burian (1995) hypothesized that New World

Choroterpes (s.s.) originated in Laurasia prior to the opening of the Atlantic Ocean. However, the known distribution of *Choroterpes* (s.s.) could also be explained by a trans-Tethyan origin, similar to that shown by a variety of plants, insects, and marine invertebrates (Heads 2005). [The two South African “outliers” of *Choroterpes* (s.s.) shown by Peters are now thought to be incorrectly assigned (McCafferty and de Moor 1995).] It is interesting that two of the four diagnosable species groups in the *Choroterpes* + *Neochoroterpes* clade are found in México-Central America (the *C. ungulus* complex and *Neochoroterpes*), and that *Neochoroterpes* may be closer to the Old World *Choroterpes* (*Euthraulus*) than to the geographically adjacent *Choroterpes* (s.s.) (Peters 1988). A definitive biogeography of the *Choroterpes* complex must await additional morphological information on many of the described species, additional collecting for the genus in Central and northern South America, and a modern phylogenetic treatment that includes all species.

In Costa Rica the distribution of both *Choroterpes* species is limited to areas on or close to the Nicoya Complex terranes which are the oldest landforms in Central America. The same terranes that could have enabled early colonization of modern Costa Rica-Panamá by very ancient South American mayfly lineages (Savage et al. 2005) might have also been a center for other ancient lineages which have never been significantly present in South America.

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