



## *Moribaetis brachiostrinus* (Ephemeroptera: Baetidae), a new species of mayfly from Costa Rica

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### Abstract

A new species of *Moribaetis* is described based on nymphs from the Nicoya peninsula. The new species can be distinguished from the other described species of the genus, among other characteristics, by its short antennae, strongly curved lateral branches of the epicranial suture, long mandibular incisors projected beyond labrum margin, violet-colored gills, and a distinctive triangular projection on paraprot. *Moribaetis brachiostrinus*, *M. macaferti* and *M. salvini* share certain characters that set them apart from *M. maculipennis* suggesting that the latter represents a separate branch within this genus. *M. brachiostrinus* has the lowest altitudinal distribution of the genus in Costa Rica and represents the first record of a *Moribaetis* occurring on the oldest emerged lands in the country. Comments on the age-related changes in the mandibular incisors and a key to mature nymph of *Moribaetis* species are also provided.

**Key words:** Ephemeroptera, Baetidae, *Moribaetis*, Nicoya Peninsula, Costa Rica

### Introduction

The genus *Moribaetis* was erected by Waltz & McCafferty (1985) to include several species from Central America originally assigned to *Baetis* Leach (1815); later, Lugo-Ortiz & McCafferty (1996) established the *Baetodes* complex where they included *Moribaetis* along with related genera. All the genera in this complex (*Moribaetis*, *Mayobaetis* Waltz & McCafferty (1985), *Lugoiops*, McCafferty & Baumgardner (2003), *Spiritiops* Lugo-Ortiz & McCafferty (1998), *Prebaetodes* Lugo-Ortiz & McCafferty (1996), and *Baetodes* Needham & Murphy (1924)) are restricted to the New World and as a group they are recognized in the nymphal stage by having tarsal claws with one or more strong subapical setae (Nieto 2016). Presently *Moribaetis* includes three Central American species, *M. macaferti* Waltz, in Waltz & McCafferty (1985), *M. maculipennis* (Flowers 1979), and *M. salvini* (Eaton 1885), all known from the nymphal and adult stages, and one species from United States and Mexico, *M. mimbresaurus* McCafferty 2007, known only from the adults; the genus is absent in South America (Cruz & Salles 2014).

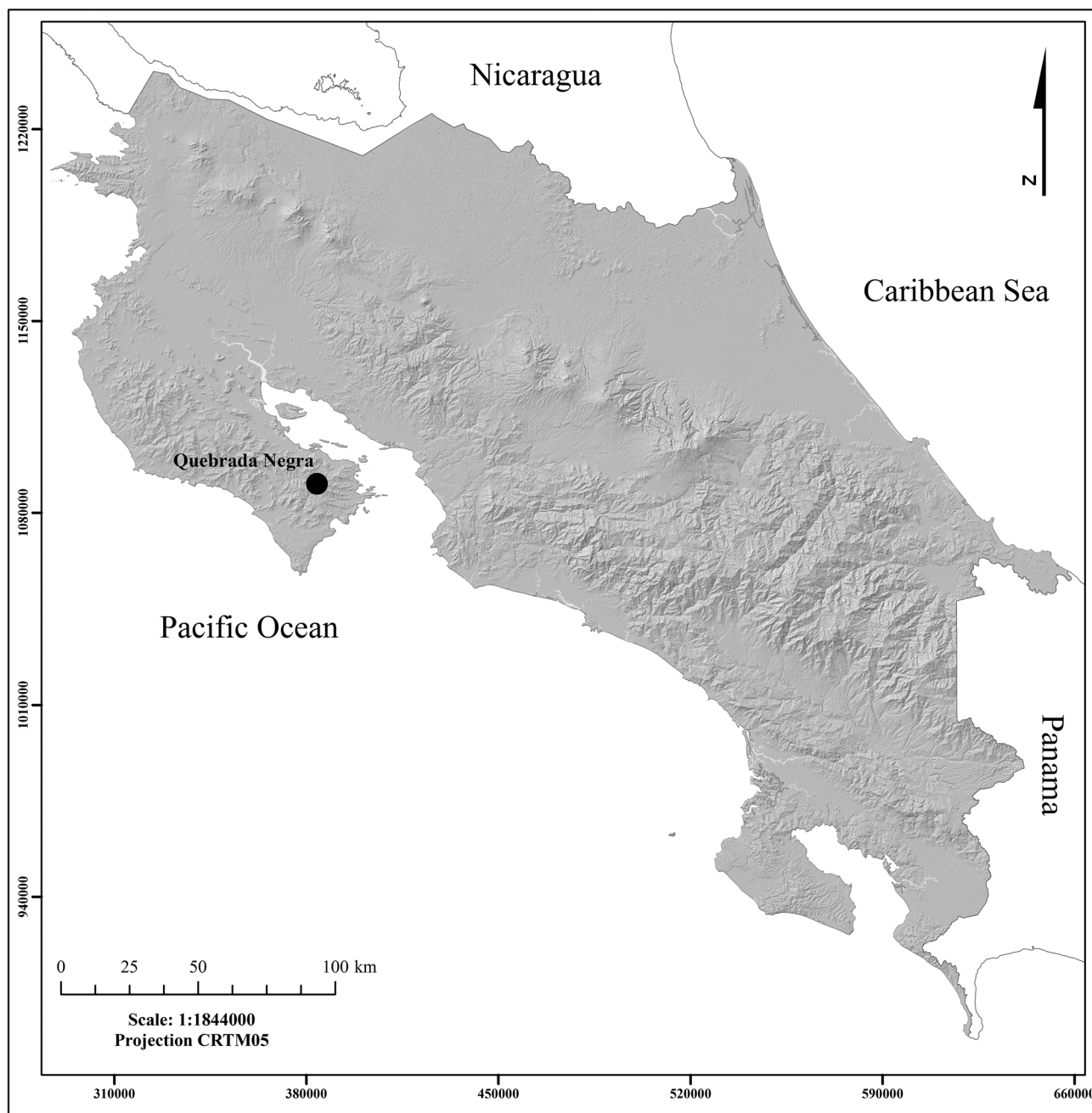
In Costa Rica *Moribaetis* is one of the commonest genera of Baetidae in middle altitude streams. Known species are often found in an altitudinal range between 900–1500 m (Romero, unpubl. data); nymphs usually cling to rocks exposed to fast currents and are sometimes found just above the water level, and they also can be found in leaf packs in slow-flowing streams. While carrying out a survey of the mayflies and stoneflies of the Karen Mogensen Biological Reserve in the Nicoya Peninsula, Guanacaste province, the nymph of a new, lowland species of *Moribaetis* was found which is described herein.

### Materials and methods

The specimens were collected on September 22<sup>th</sup> 2015, at the Karen Mogensen Reserve, located in the Nicoya Peninsula (Fig. 1). The reserve has 960 ha of protected land composed mainly of secondary forest and acts as a vital part of the biological corridor of the peninsula. The material was collected in Quebrada Negra, a small first

order stream bordered by secondary forest, (9°52'7.84"N/ 85° 3'33.89"W), which is one of the three tributary streams of the Río Blanco that drains into the Gulf of Nicoya.

Nymphs were collected by scraping the surface of stones with a small hand net. The specimens were preserved in 90% ethanol. Later, in the laboratory, head, mouthparts, legs, gills, antennae and paraprocts were dissected and mounted with euparal on permanent slides for detailed study. Line drawings were made from original pictures taken with an AmScope 1803 digital camera adapted to a Premier® (MRP-161) microscope or to a Premier® (SMZ-05) stereomicroscope. The material examined is deposited in the following institutions: LEUNA (Laboratorio de Entomología of the Universidad Nacional, Heredia), MZUCR (Museo de Zoología, Universidad de Costa Rica, San José), MNCR (National Museum of Costa Rica, Santo Domingo, Heredia) and PERC (Purdue Entomological Research Collection, West Lafayette, Indiana, USA).



**FIGURE 1.** Geographic distribution of *Moribaetis braquiostrinus* sp. nov. in Costa Rica.

## Results

### *Moribaetis brachiostrinus* Romero & Esquivel, sp. nov.

Known from male and female nymph in last instar, adult unknown.

**Material examined:** **Holotype**, mature ♀ nymph; Costa Rica, Puntarenas prov., Península de Nicoya, Reserva Biológica Karen Mogensen, Quebrada Negra, 9°52'7.84"N/ 85° 3'33.89"W, 300 m. elev., 22 September 2016, F. Sibaja-Araya coll., deposited at the MNCR. **Paratypes**, 1 mature ♂ nymph, same data as holotype, deposited at MZUCR; 2 immature nymphs, same data as holotype, deposited at the MZUCR; 1 ♀ nymph, same data as holotype, deposited at PERC; 1 immature nymph, same data as holotype, deposited at PERC; 1 mature nymph ♂ and 3 immature nymphs, same data as holotype, deposited in the collection of LEUNA.



**FIGURE 2.** Coloration pattern of *Moribaetis brachiostrinus* sp. nov. for male and female mature nymph.



**FIGURE 3.** Gill coloration for mature nymph of *Moribaetis brachiostrinus* sp. nov.

**Diagnosis. Mature nymph.** The following combination of characters can be used to recognize *M. brachiostrinus* as follows: 1) light-violet colored gills (Fig. 3); 2) short antennae (Fig. 4 a, b), deflected downward reaching gill 1 to 2; 3) lateral branches of epicranial suture with two pronounced curves (Fig. 4 a, b); 4) mandibles with incisive area very long, projected beyond labrum margin, and two tufts of short setae between prostheca and mola (Fig. 5 b, c); 5) segment 1 of labial palp near 1,5 length of segment 2, and segment 2 with 7 dorsal setae (Fig. 6 c); 6) paraglossa with two rows of apical setae; 7) maxillary palp longer than galea-lacinia (Fig. 6 a); 8) paraproct with a distinctive triangular projection (arrow in Fig. 7 d)

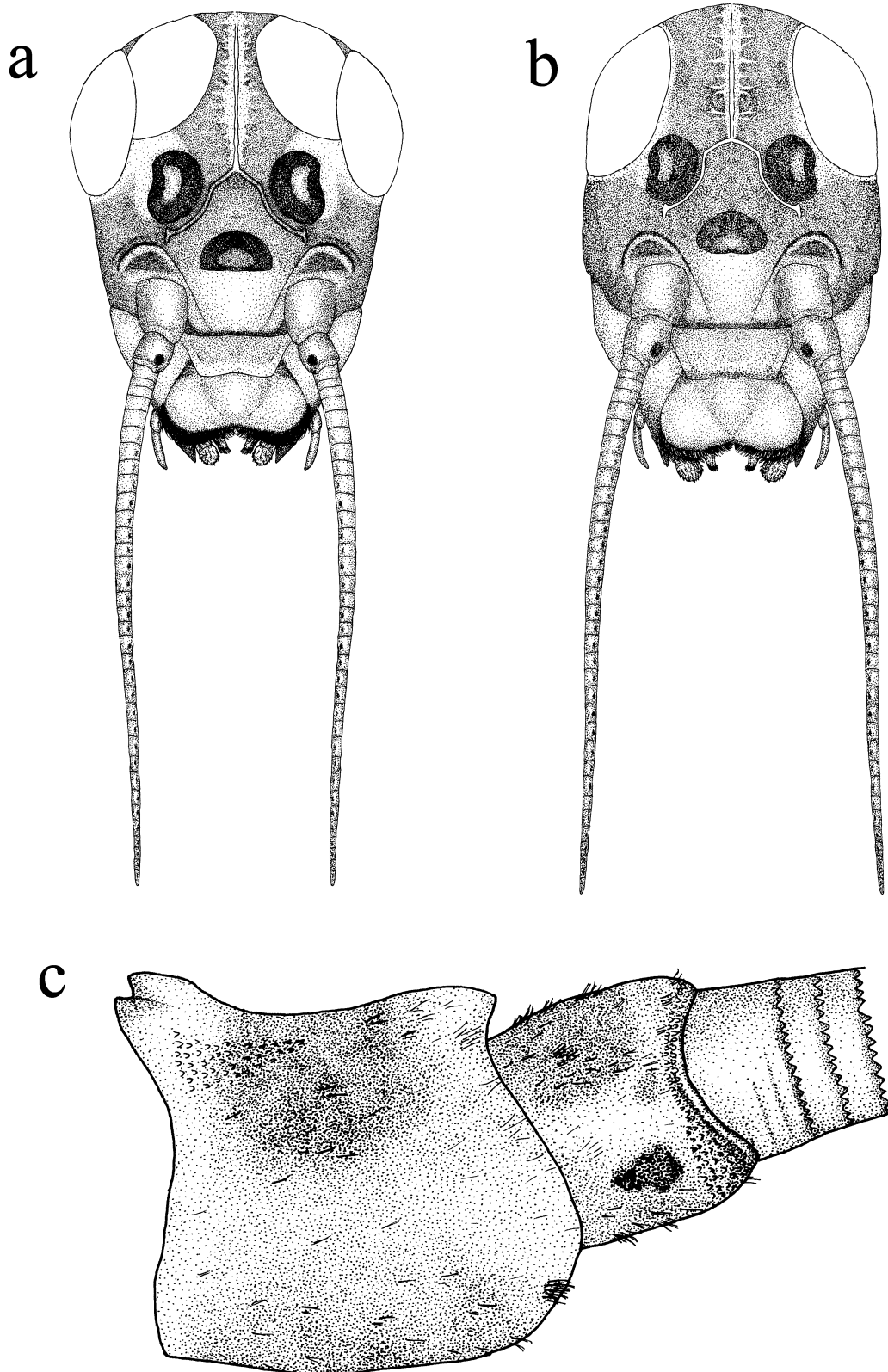
Size: male larva: body length 7,5 mm; antennae 3,0 mm; cerci 8,5 mm, terminal filament 3,0 mm; female larva: body length 9,5 mm; antennae 3,0 mm; cerci 10,5 mm, terminal filament 3,5 mm.

Coloration pattern: the same in both sexes (Fig. 2): dorsally yellow-brown, ventrally brown-pale; pronotum and mesonotum with dark midline; abdominal terga yellow-brown, terga 5 and 9 pale, terga 2–8 with two middle dark markings and dark lateral marginal spots, lighter on 5. Head grayish brown, vertex darker with irregular pattern of spots; scape and pedicel grayish brown with shading on fringes, pedicel with dark spot. Legs gray-brown; anterior face of femora with pale patch at base and apex, posterior face pale with dark brown median spot; tibia and tarsus uniformly colored. Gills membrane violet with dark tracheae (Fig. 3) Cerci yellow-brown, paler ventrally, with a dense row of dark setae on inner margins and with a short, lighter segment on the base and near the middle; terminal filament with a dense row of dark setae on the margins, clearer on the base.

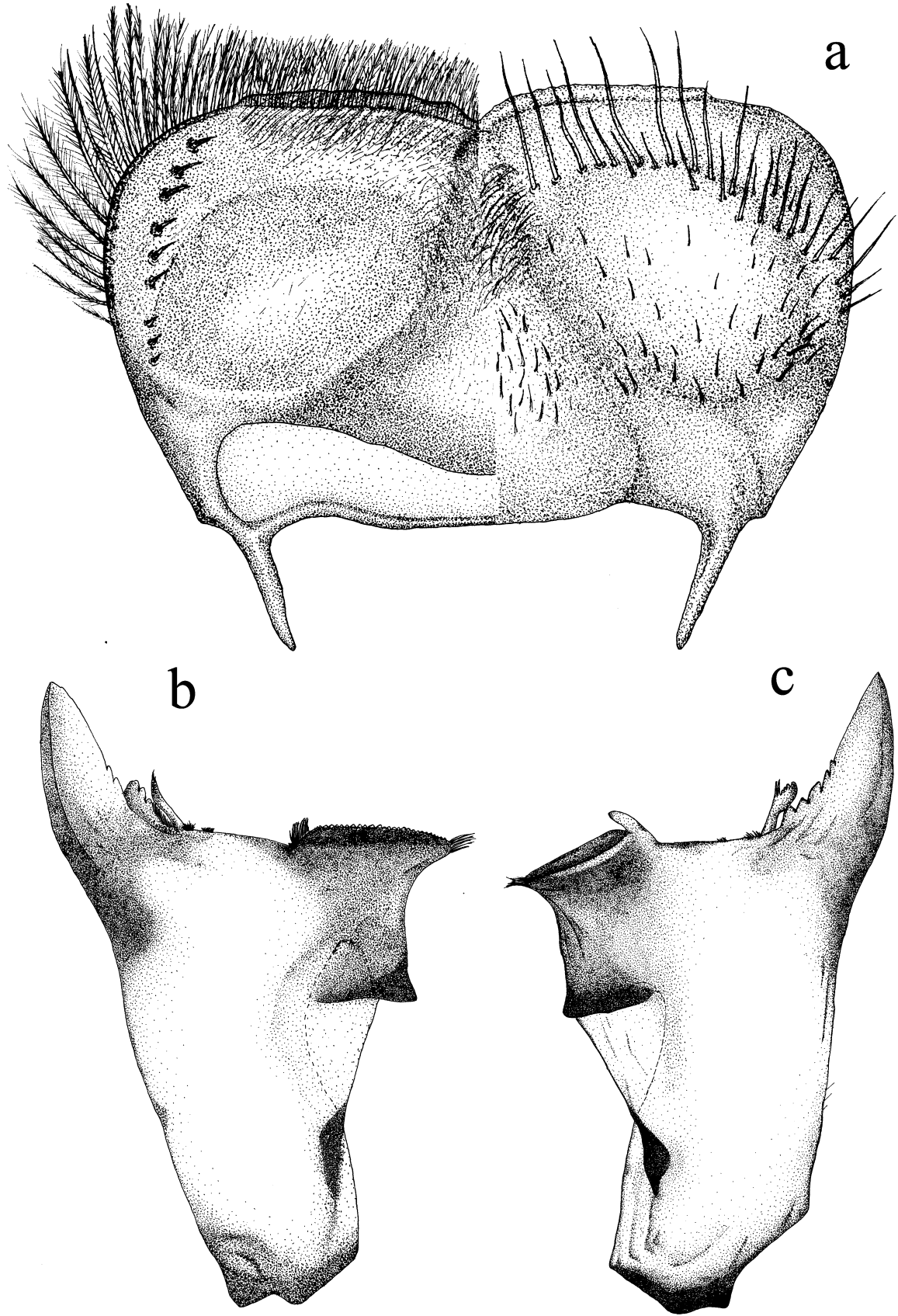
**Body morphology. Head:** Epicranial suture with two pronounced curves on the lateral branches; frons extended but not forming a keel (Fig. 4 a). Antennae (Fig 4 b) ventrally deflected reaching gill I or II; scape and pedicel with scales, clumped setae and fine setae; scape with brown shading on margins, pedicel with dark spot on inner side. Labrum (Fig. 5 a) narrowed basally with anterior margin rounded, prominent basomedial area, dorsal surface covered with short setae and 18–20 submarginal setae; ventrally with long plumose setae on anterior margin, and a row of 8–9 spines in sublateral margin. Mandibles with two tufts of short setae between prostheca and molar area; incisors projected beyond labrum margin (generally truncate in mature nymphs). Right mandible (Fig. 5 b): innermost incisors tridentate, arranged in descending order, free from outermost incisor and with basal row of short setae at the base; slender, comb-shaped apex prostheca extending beyond the level of innermost incisors. Left mandible (Fig. 5 c): innermost incisors fused apically with outermost incisors; prostheca well developed; subtriangular process on the base of mola (thumb) elongate and curved, mola with reduced denticles. Hypopharynx (Fig. 6 a): lingua apically trilobate and covered with fine, short setae, which are longer at apex; superlinguae bilobate with fine, long setae on dorsal and ventral surfaces, outer lobe larger, with triangular shape towards the apex; base of superlinguae acute, with inner margin comb-shaped. Maxilla (Fig. 6 b): Segment II of the maxillary palp similar in size to segment I and exceeding the length of the galea-lacinia; lacinia with a strong apical seta; galea with a line of long setae at the base, and two rows of setae of different lengths on the outer margin of the apex, two of which are pectinate and robust. Labium (Fig. 6 c): labial palps not exceeding the length of paraglossa; segment I of labial palp near 1,5 the length of segment II, segment II with weak inner apical lobe and 7 dorsal setae, segment III broader than long and heavily covered of fine setae and a few spines; paraglossae with three apical rows of bristles and long setae on outermost margin; glossae with long setae on inner margin and without fine setae on dorsal surface.

**Thorax:** Procoxal osmobranchiae present and curved, appressed against the coxae (Fig. 7 a). Legs (Fig. 7 c): dorsal edge of femora fringed with fine setae and with short spine-like setae spaced regularly, clustered on apex above insertion of tibiae; ventral edge with short and stout scattered setae; tibiae with fine setae and spine like-setae spaced irregularly on dorsal edge, and scattered on ventral edge; dorsal margin of tarsi with short setae, 4 rows of dense setae on distal section, and 3 ventral stout setae; claws with 8-9 denticles and a long, curved seta inserted above second denticle.

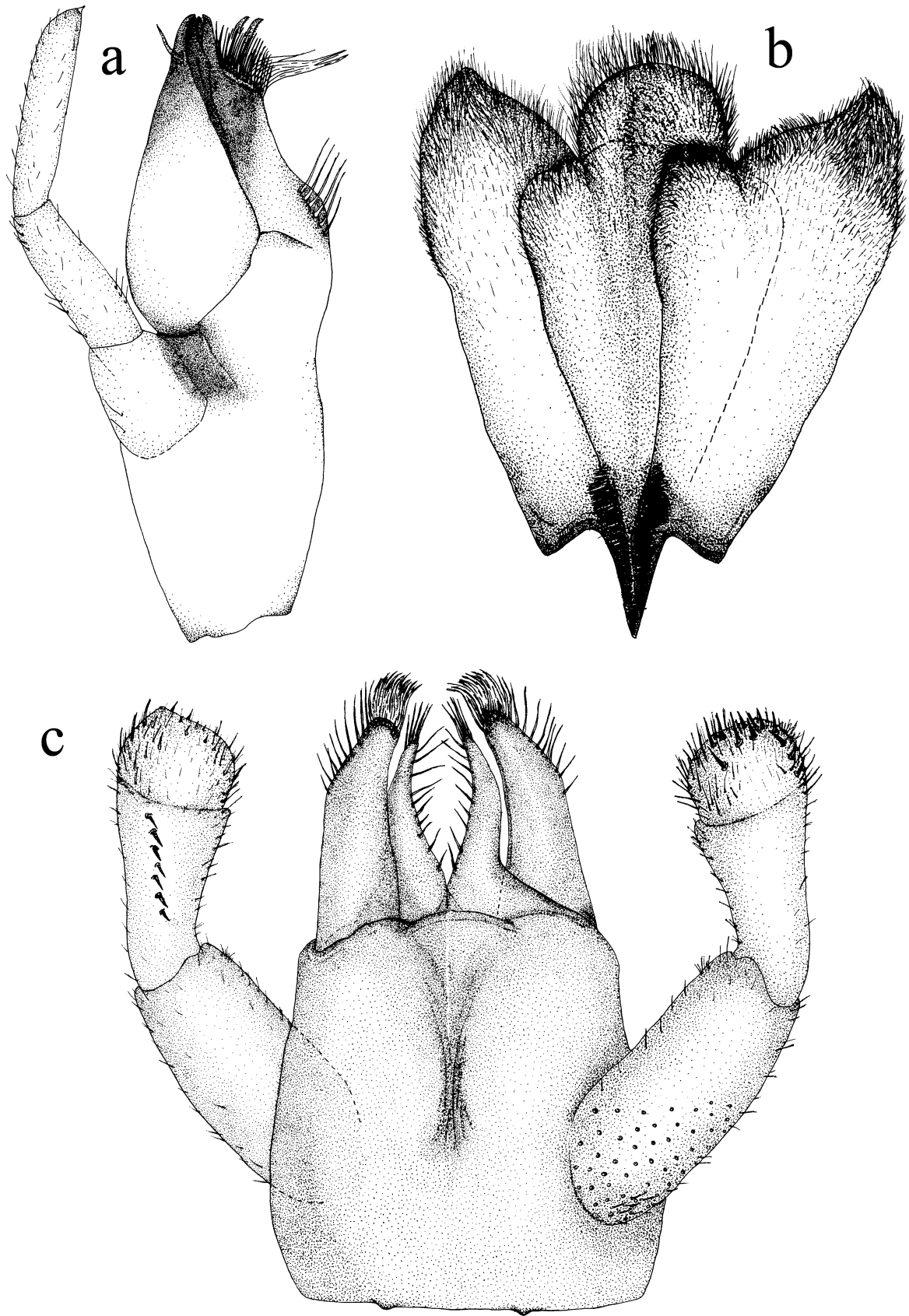
**Abdomen:** Gills of segment 1 smaller than those of following segments, with sclerotized margins, anterior margin serrate with 4–6 fine denticles and short setae among serrations, posterior margin covered with long, fine setae (Fig. 7 b). Terga (Fig. 8): posterior margin with sharp denticles, irregular in length, and some fine setae between denticles; dorsal surface densely covered with trapezoid protuberances. Paraprocts with short spines on posterior margin, increasing in size towards apex on the large lobe and of similar size on the small lobe, with a distinctive triangular projection on the middle of posterior margin, surface with some dispersed trapezoid protuberances, setae absent (Fig. 7 d). Cerci with dense row of setae on inner margins; terminal filament with dense row on lateral setae.



**FIGURE 4.** *Moribaetis brachiostrinus* sp. nov., a) mature nymph head (male left; female right). b) Antennal scape and pedicel detail.



**FIGURE 5.** *Moribaetis brachiostrinus* sp. nov., mature nymph mouthparts. a) labrum (left v. v., right d. v.), b) right mandible, c) left mandible.



**FIGURE 6.** *Moribaetis brachiostrinus* sp. nov., mature nymph mouthparts. a) maxilla, b) hypopharynx (left v. v., right d. v.), c) labium (left d. v., right v. v.).

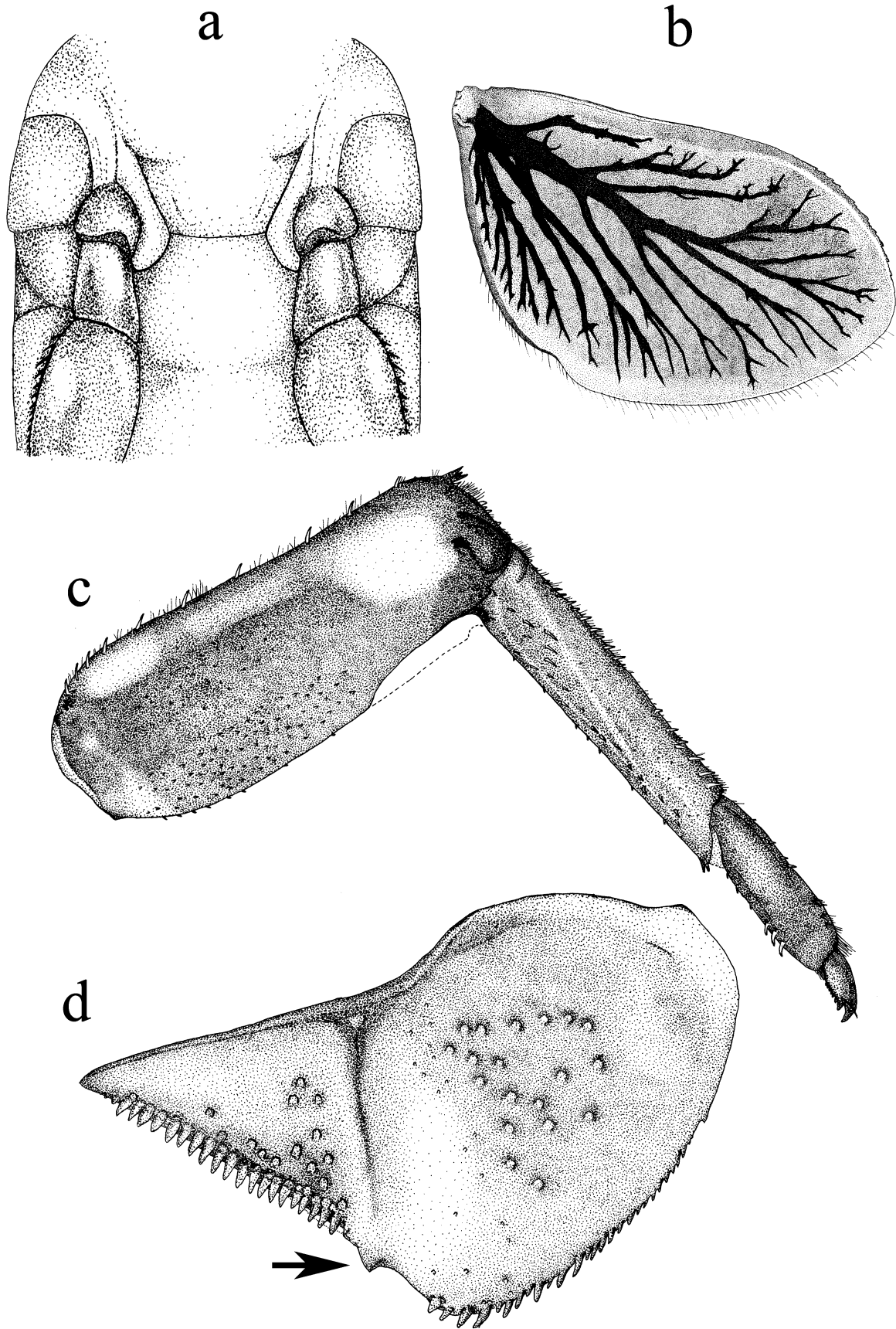
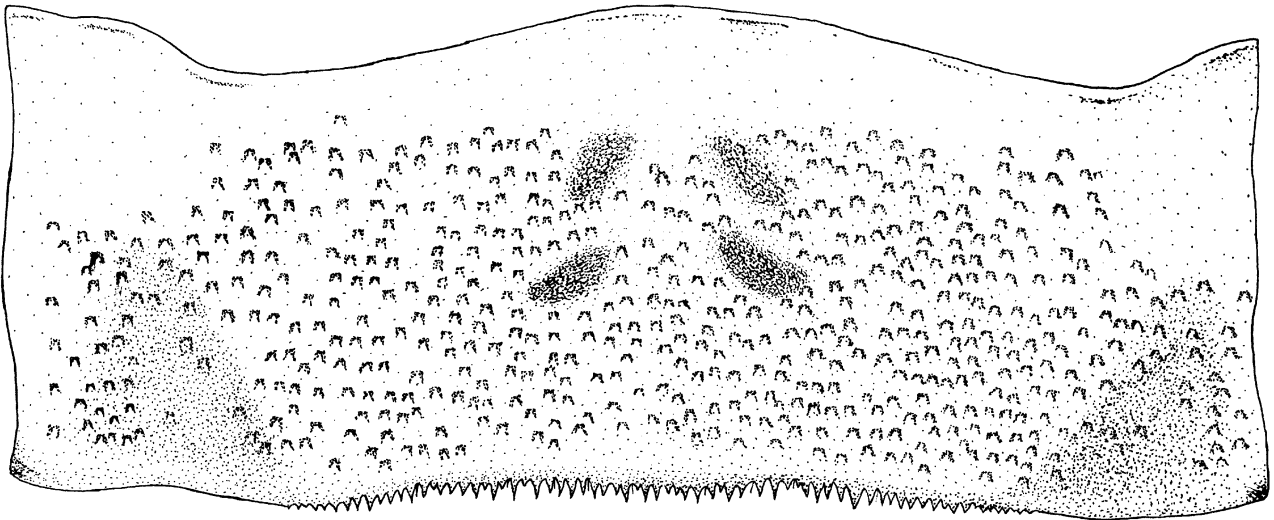


FIGURE 7. *Moribaetis brachiostrinus* sp. nov., mature nymph. a) procoxal osmobranchia detail, b) gill, c) leg, d) paraproct.



**Etymology:** *brachia*, L. meaning gill; *ostrinus*, L. meaning purple, in reference to the distinctive gill color of this species.



**FIGURE 8.** IV tergum detail of *Moribaetis brachiostrinus* sp. nov., mature nymph.



**FIGURE 9.** Specific microhabitats (pointed by arrows) of *Moribaetis brachiostrinus* sp. nov. nymph at Quebrada Negra creek, Karen Mogensen Reserve, Nicoya Peninsula, Costa Rica (photo by F. Sibaja).

## Discussion

The most conspicuous characteristic to separate the nymphs of *M. brachiostrinus* from other described species are the purple colored gills (Fig. 3), other species of the genus have uncolored gills. Other traits that set this species apart from the other *Moribaetis* are its shorter antennae (Fig. 4 a-b); *M. brachiostrinus* has the shortest antennae in the genus, ventrally deflected just reaching gill I or II, in *M. macaferti* and *M. salvini* the antennae reach gills the gill III–V; *M. maculipennis* has the longest antennae, reaching gill VII (Waltz & McCafferty 1985). Also the paraprocts of *M. brachiostrinus* have a distinctive triangular projection on the middle of posterior margin (Fig. 7 d) that is absent in the other species. Among *Moribaetis* species, *M. maculipennis* seems to be the sister group of the remainder species; it has a body length larger than 10 mm, antennae deflexed reaching gill 7, highly fused mandibular incisors forming a single blade, base of mandibles narrowed, and labial palps significantly long, exceeding the length of paraglossae. These characteristics are the opposite in *M. macaferti*, *M. brachiostrinus* and *M. salvini* suggesting that these species are a sister group within the genus. The results of cladistics analysis of Baetidae in South America by Nieto (2010) support this hypothesis. Therefore variations on these and other characters should be carefully examined in future taxonomic studies to determine the species arrangement between these two groups.

The age-related changes in the mandibular incisors of *M. brachiostrinus* should be remarked. In order to discern the mandible's structure it was necessary to study the mandibles of nymphs on penultimate instar. Mature, pre-emergent nymphs show from partial to total wearing of the incisors as result of their feeding activity, a condition displayed by most mature nymphs studied. Additionally, immature nymphs have a line of long setae between the mola and the incisors, but this characteristic is lost in later stages where these setae shorten and decrease to one or two groups at the base of the prostheca. This suggests that the changes observed on these setae are the result of developmental processes and not necessarily produced by feeding activity.

According to the information provided in the original descriptions of the three previously described species of *Moribaetis* (Eaton 1885, 1892; Flowers 1979; Waltz & McCafferty 1985) and the examination of fresh material of these species from many sites of the country (unpub. data), the lowest altitudinal occurrence of this genus in Costa Rica is 900 m above sea level, on large stones located in riffles and the splashing zone characteristic of swift, well oxygenated, medium and high altitude rivers (Flowers & De la Rosa 2010). However, *M. brachiostrinus* was found in a first order stream at 300 m above sea level thus expanding the lower altitudinal range for the genus. Interestingly enough the Quebrada Negra creek, where *M. brachiostrinus* was found, although at a much lower altitude, also offers these conditions; this river has a stony bed with prevalence of periphyton-covered ophiolite rocks forming slow riffles that were the favorite habitat of the species along with *Baetodes* spp. It should also be noted that this is the first record of a *Moribaetis* occurring on the Nicoya Ophiolite Complex, which are considered the oldest emerged lands in the country (Savage *et al.* 2005).

*M. brachiostrinus* would key out at couplet 2a of Waltz & McCafferty's (1985) key to nymph of *Moribaetis* species; however, since its antennae only reach to gill 1 or 2 it would not fit into this choice completely. The following modification of this key will lead to a correct identification of *M. brachiostrinus*.

### Key to described mature nymph of *Moribaetis* species (modified from Waltz & McCafferty 1985)

1. Incisors of mandible fused into one blade-like structure lacking denticles; antennae often reaching or surpassing gill 6 or 7; frons with distinct medial pigmented area between ocelli . . . . . *M. maculipennis*  
- Incisors of mandible with easily discernible denticles; antennae reaching gill 1–5; frons without medial pigmented area . . . . . 2
2. Paraglossa with three apical rows of setae; segment II of labial palp with four dorsal setae; maxillary palp not exceeding 3/4 of galea-lacinia length (unpub. data). . . . . *M. macaferti*  
- Paraglossa with two apical rows of setae; segment II of labial palp with six or more dorsal setae; maxillary palp subequal to galea-lacinia in length . . . . . 3
3. Antennae reaching gill 1–2; labrum with 8–9 spines in ventral sublateral row; paraproct with a distinctive triangular projection on posterior margin (Fig. 7 d) . . . . . *M. brachiostrinus*  
- Antennae reaching gill 3–5; labrum with 10 or more spines in ventral sublateral row (unpub. data); paraproct without triangular projection on posterior margin . . . . . *M. salvini*

\* Note. *M. mimbresaurus* was described only on the basis of adults, so it was not included in the key.

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