



The adults and nymphs of *Asthenopus angelae* new species (Ephemeroptera: Polymitarciidae) from Argentina, Bolivia, Brazil and Colombia

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Abstract

Asthenopus angelae sp. nov. is described based on male and female imagos and associated nymphs from Argentina, Bolivia, Brazil and Colombia. The new species described is similar to *A. curtus* (Hagen). The nymphal and adult female stages are indistinguishable from those of that species. The male adults can be separated from its congeners by the following characters: penes tubular, with well developed median basal protrusion, curved ventro-medially, with apex acutely projected, furrow separating penial lobe from median basal protrusion reduced or absent; forceps relatively slender; forelegs of male 0.6–0.7 × the length of the forewing; fore tarsal claws slightly widening distally; fore wings with 5–11 marginal intercalary veins relatively short.

Key words: Asthenopodinae, burrowing mayfly, Ephemeroidea, taxonomy

Resumo

Asthenopus angelae sp. nov. é descrita baseada em imagos machos e fêmeas e ninfas associadas provenientes da Argentina, Bolívia, Brasil e Colômbia. A nova espécie é similar a *A. curtus* (Hagen), as ninfas e os imagos fêmeas são indistinguíveis, mas os machos adultos podem ser diferenciados pela seguinte combinação de características: pênis tubulares, com membrana basal bem desenvolvida, curvados ventro-medialmente, ápice projetado na porção mediana, sulco que separa os lobos penianos da membrana basal reduzido ou ausente; fórceps relativamente esguio; pernas anteriores relativamente longas, medindo 0.6–0.7 × o comprimento das asas anteriores; garras tarsais anteriores levemente alargadas no ápice; asa anterior com 5–11 veias intercalares marginais relativamente curtas.

Key words: Asthenopodinae, efemerópteros escavadores, Ephemeroidea, taxonomia

Introduction

Polymitarciidae is a relatively diverse cosmopolitan mayfly family, with 55 Neotropical species classified in 4 genera: *Campsurus* Eaton, 1868 (40 spp), *Tortopus* Needham & Murphy, 1924 (5 spp), *Tortopsis* Molineri, 2010 (8 spp), and *Asthenopus* Eaton, 1871 (4 spp) (Traver 1950, Domínguez *et al.* 2006, Emmerich & Molineri 2011, Molineri 2010, Molineri *et al.* 2011). *Asthenopus* is restricted to the tropical and subtropical region of South America and is characteristic from lowland rivers and lakes, where the nymphs burrow soft plant tissues and rotten wood (Sattler 1967). The nymphal stage is only known for *A. curtus* (Hagen, 1861), the type species, and the other three species are known only in the adult stage: *A. gilliesi* Domínguez, 1988, *A. picteti* (Hubbard, 1975), and *A. crenulatus* Molineri *et al.*, 2011.

In the present paper we describe male and female imagos, eggs and associated nymphs of a new species, *Asthenopus angelae*, known from a broad geographic range including the Amazon Basin (Bolivia, river Itenez; Brazil and Colombia, river Amazonas or Solimoes) and the Paraná-Paraguay basin (Argentina, Formosa; Brazil, Ladário).

Material and methods

Specimens are preserved in 96% ethanol, wings were mounted dried, legs and genitalia were mounted in Canada Balsam. Photographs were taken with camera coupled in stereomicroscope Leica MZ16 and adjusted using the program Auto Montage® or CombineZP (Hadley, 2010). Photographs of eggs and female sternum VIII were taken with a scanning electron microscope JEOL 35CF SEM at 25 kV. The studied structures were dehydrated in a graded ethanol series, dried by critical point-method (using CO₂ in a Bomar apparatus), mounted with double-sided tape on SEM stubs, and sputter coated with gold. Measures used in the description of genitalia and wings are illustrated in the figures. Depositories abbreviations: DZRJ (Coleção Entomológica Prof. José Alfredo Pinheiro Dutra, Departamento de Zoologia, Universidade Federal do Rio de Janeiro); IBN (Instituto de Biodiversidad Neotropical, Tucumán, Argentina), MUSENUV (Museo de la Universidad del Valle, Cali, Colombia), and CZNC (Coleção Zoológica Norte Capixaba, Universidade Federal do Espírito Santo, São Mateus, Brazil).

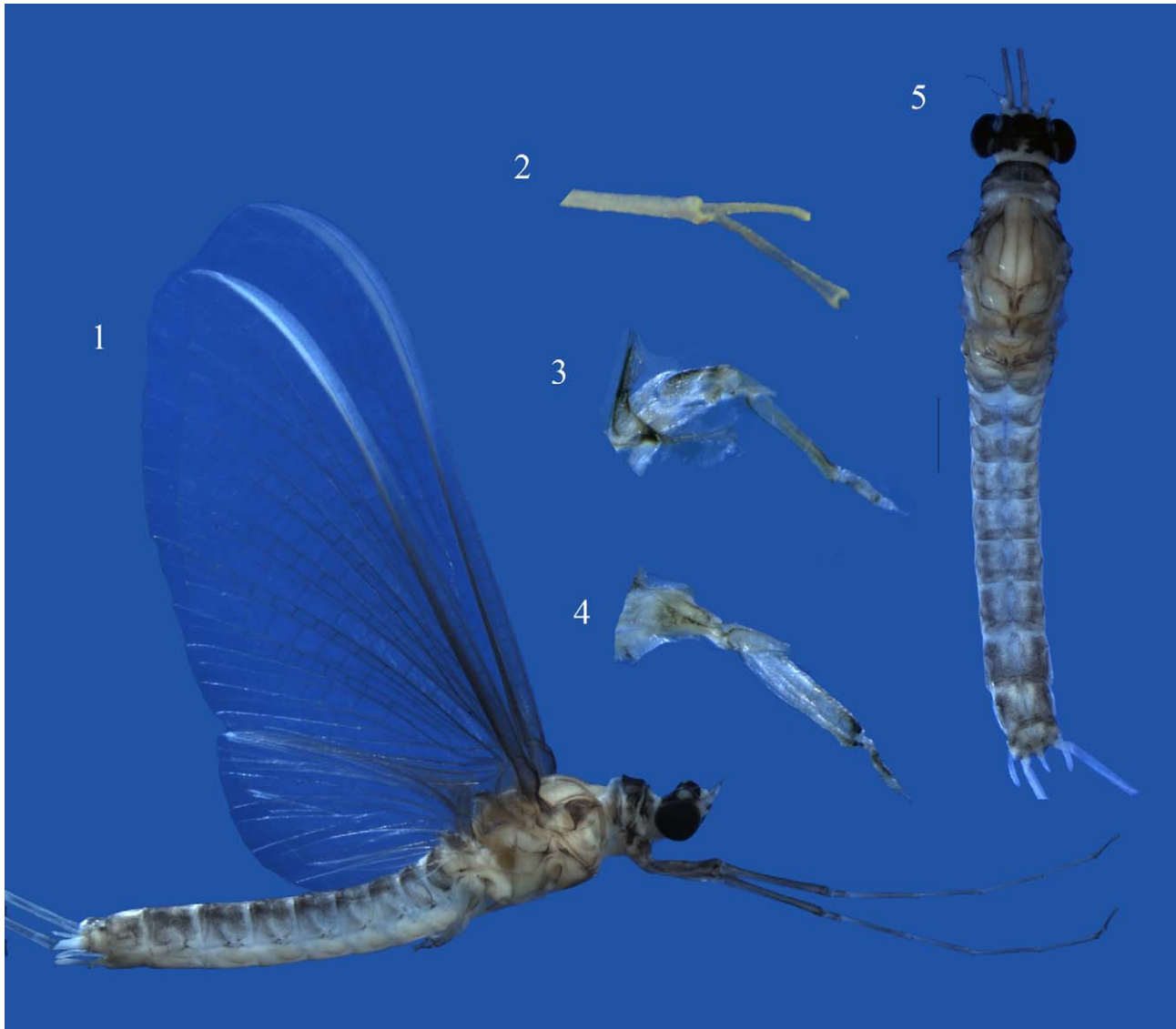
Results

Asthenopus angelae sp. nov.

Male imago (Figs. 1–7; 10–12): Length (mm): body, 6.5–9.2; fore wing, 7.0–10.0; hind wing, 2.9–4.1; foreleg, 5.1–6.3; cerci, 23.0–27.0 (terminal filament almost completely reduced). General coloration yellowish shaded with gray and brown dorsally. Head yellowish white shaded with black between eyes and ocelli (some males with a posteromedian pale area on occiput). Antennae: scape and flagellum whitish shaded gray, pedicel yellowish with grayish apical ring. Thorax. Pronotum blackish with many small yellowish spots and median yellowish line. Membrane between anterior and posterior rings pale yellowish. Meso- and metanotum yellowish except margins and carinae blackish (Fig. 5); thoracic sterna whitish yellow, shaded with gray on mesokatepisternum. Legs (Figs. 1–4) yellowish white. Ratio of foreleg segments (to tibia): tibia (1.2–1.4 mm): femur (0.6–0.8): tarsomere I (0.1–0.2): tarsomere II (0.5–0.6): tarsomere III–V (–0.5 each). Foreleg (length from base of trochanter to apex of claw): 0.6–0.7 the length of forewing; shaded with gray on dorsum of coxae, trochanter, femora, tibia and first tarsal segment; remaining tarsal segments and tarsal claws whitish shaded more slightly with gray (Fig. 1); dorsal margin of femur and first tarsomere with stout setae; tarsal claws of unequal size, slightly widening apically, apex 1–1.5 times width of stalk (Fig. 2). Middle and hind legs atrophied, shaded with blackish on coxae, then pale and shaded with blackish from apical third of femur to apex of tarsus (Figs. 3–4). Wings (Figs. 1, 6 and 7) membrane hyaline except for costal and subcostal areas, grayish basally and whitish apically. Veins grayish but gradually becoming hyaline toward distal margin (Fig. 1). Fore wing with 5–11 marginal intercalary veins, generally shorter than distance between longitudinal veins (mi in Fig. 6); 1–4 cross veins between MA and R basally to R stem (arrows in Fig. 6), ratio Rs length from fork to margin (B in Fig. 6)/stem length (A in Fig. 6) = 3.6–4.6. Ratio MA length from fork to margin/stem length = 4.1–7.7. Hind wing with 0–2 marginal intercalaries (Fig. 7). Abdomen (Fig. 5). Terga yellowish white widely shaded with brownish gray dorsally. Terga I and II with pair of lateral yellowish spots and median triangular mark (intersegmental membrane) extending to posterior margin. Intersegmental membrane between terga I and II larger than between terga II–III. Remaining terga with a yellowish median longitudinal line (wider on terga VIII–IX) with a pair of pale spots, one at each side of the line. Pleural membranes whitish with small blackish spots. Sterna whitish turning yellowish laterally, shaded with blackish on paraprocts and basally to terminal filament. Genitalia (Figs. 10–12): styliger short and broad, slightly convex medially and laterally (Fig. 10); forceps yellowish white, penes yellowish. Forceps relatively long, ratio length/basal width: 6.5–7.1, pedestals subrectangular to subovate, relatively large (Fig. 10). Penes tubular, slightly curved ventro-medially; penes relatively short, ratio length/basal width: 4.0–4.7. Median basal protrusion on inner margin of penes present, relatively well developed (Fig. 12), ratio penes length/membrane length: 2.0–2.3. Penes acutely pointed (Fig. 11). Caudal filaments whitish.

Female imago (Figs. 8, 9 and 13). Length (mm): body, 8.0–11.2; fore wing, 12.0–13.0; hind wing, 4.6–5.3; cerci, 3.0–4.0. Similar to male except that shading on head, pronotum and abdominal terga stronger and more uniform. Head shaded almost completely with black on occiput, frons with two submedian black lines. Mesothorax relatively paler than in male; fore wing with 15–19 anastomosed marginal intercalary veins, 3–4 cross veins between MA and R, basad to R stem (Fig. 8); hind wing with 6–8 marginal intercalaries (Fig. 9). Sternum VIII with a small anteromedian keel (inconspicuous at stereoscopic microscope), sockets reduced to a small basal indentation at both sides of the keel; cuticle smooth anteromedially but finely sculptured elsewhere (Fig. 13).

Eggs (Fig. 14). Length, 213–225 μm . Width, 150–163 μm . Polar caps, width: 115–135 μm . Two polar caps (type III, Koss & Edmunds 1974) formed by 3 to 5 extremely large threads loosely coiled about each pole. Chorion covered with many discoid and apparently adhesive formations 6–12 μm in diameter which are entire or subdivided (2–4 times). These discs are very loosely attached to the smooth chorion and sit on a shallow groove.



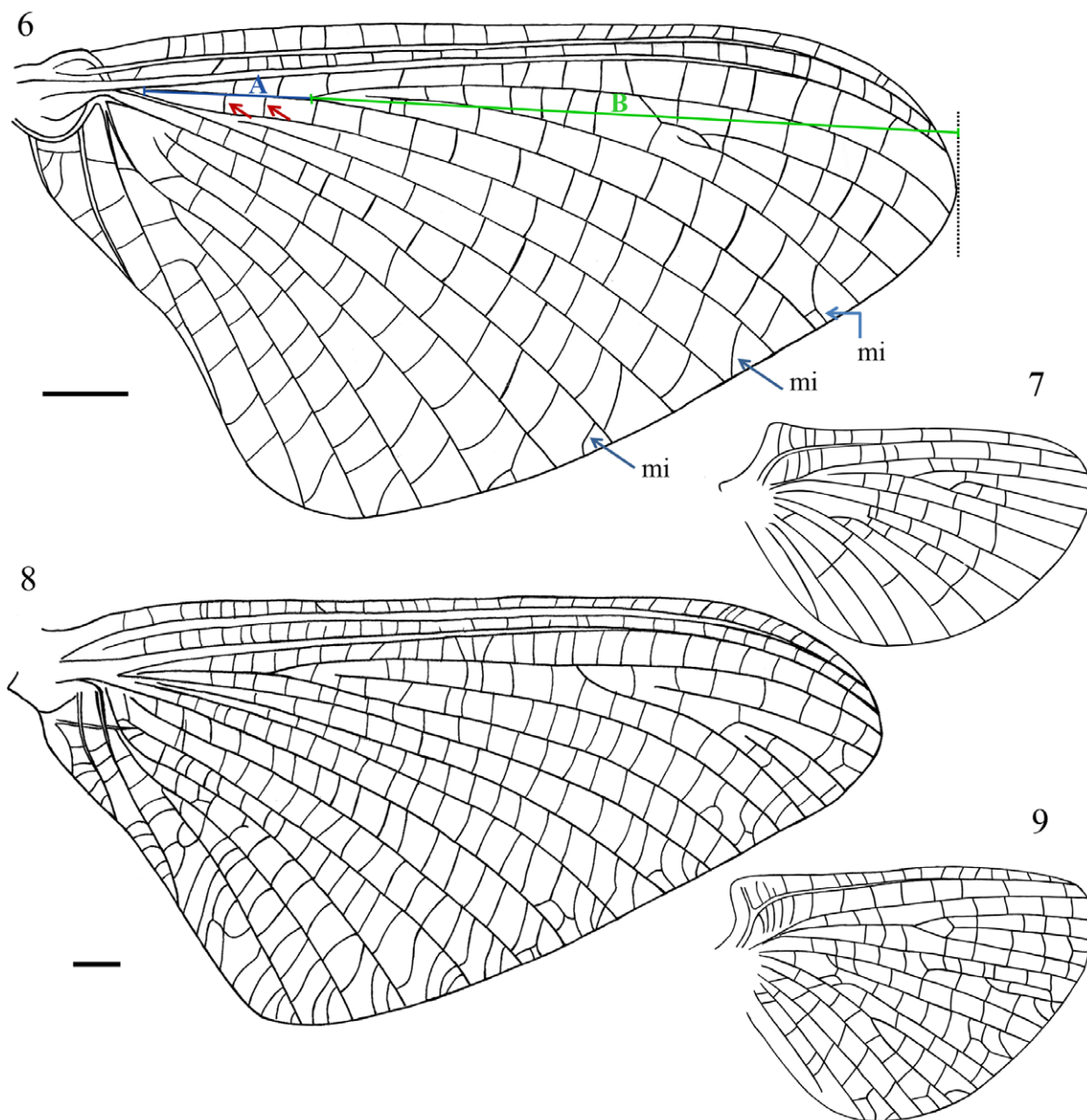
FIGURES 1–5. *Asthenopus angelae* sp. nov. Male imago: (1) lateral view; (2) tarsal claw of foreleg; (3) Middle leg; (4) hind leg; (5) dorsal view.

Nymph (Figs. 15–27): Length (mm): body, 9.1–13.0; cerci, 4.5–6.0; terminal filament, broken. Head (Figs. 15 and 27) brownish with blackish netted pattern (Fig. 27), with a transverse blackish band between lateral ocelli. Frons paler with two lateral black areas, anterior margin of frons basally to clypeus, straight, (Fig. 15); small spine-like projection located subapically on lateral margin. Clypeus bare, whitish (Fig. 15). Antennae yellow, pedicel with dorsal tuft of setae, scape twice the length of pedicel. Head dorsally with few scattered fine simple setae,

transverse row of curved setae between antennae; occiput well developed, dorsally rounded; spine-like projection on anterolateral margins of head capsule. Mouthparts (Figs. 15–22). Labrum (Fig. 15): small, hidden under clypeus and other mouthparts, apical half with long setae, with subapical row of long setae, particularly longer on both ends. Mandibles (Figs. 16–18 and 23): basal half bearing “U” shaped row of setae (Figs. 18 and 23); inner margin of tusk with one subapical tubercle and one strong basal tubercle both with hair-like setae on base, outer margin crenulated with sublateral hair-like setae (Figs. 16–18); basally on dorsal surface with a small tubercle (Figs. 16–17) and scattered short spine-like setae; cleft incisors; spine-like protheca; mola with serial ridges forming a crenulated surface. Left tusk with three strong apical teeth, the median one smaller than the others (Figs. 17 and 27). Right mandible similar but with two strong apical teeth (Figs. 17–18). Maxillae (Fig. 19): apex of galea-lacinia covered with long hair-like setae; inner margin with plumose and hair-like setae and outer margin bare; bi-segmented palpi, article I bare, article II with numerous setae on inner margin and with long hair-like setae on outer margin and apex. Labium (Figs. 20–21): glossae narrowing toward apex, distal 1/3 bearing fine setae; paraglossae heavily covered with long setae and a row of stout setae at outer margin; bi-segmented palpi, article I with short setae on outer margin, article II covered with long setae. Hypopharynx (Fig. 22): lingua almost bare, except by apex with short fine setae; superlingua slightly longer than lingua with distal 1/3 bearing dense long plumose setae. Thorax. Pronotum short and ring like, with anterior ring 1/3 the length of posterior ring, anterolateral corners with spine-like projection (Figs. 23 and 27). General coloration blackish except medial line whitish. Mesonotum and metanotum overall yellowish, possessing several blackish marks (Fig. 27). Sterna paler. Wingpads with whitish veins, membrane basally grayish and paler apically (Figs. 24 and 27).

Legs (Figs. 23–24) light yellow. Leg I (Fig. 23) fossorial and robust. Coxae widely shaded with blackish. Femora with apical blackish mark on both sides. “U” shaped row of setae present basally on inner margin, few setae external to this row. Tibia and tarsus fused, fusion line visible; tibia with two “U” shaped rows of setae extending from base to apex, on outer and inner margins respectively. Tibiotarsus with subapical black ring with several rows of long setae, particularly longer and denser at apical 1/4 of internal and external margins. Pectinated setae apically. Tarsal claw with 20–24 denticles increasing in size distally, the apical one larger. Leg II (Fig. 24): coxae widely shaded with blackish, femora with blackish mark apically, tibia and tarsi not fused. Femora with long setae and short and blunt spine-like setae on outer margin; inner margin only with long setae at base. Tibia with blackish line extending from base to apex; outer margin with row of long setae; apical 1/2 of inner margin with dense row of short setae; with distal row of contiguous strong spine-like setae. Tarsi with several short setae. Tarsal claw curved and smooth. Leg III (Fig. 24): similar to leg II, except outer margin of femora and tibia with row of long setae, particularly denser apically on femora; inner margin of both with dense pilose area; subapical dorsal surface of femora with short spine-like setae; tibia with a row of short spine-like setae along apical margin; tarsi with long setae on outer margin. Abdomen (Figs. 25–27). Terga grayish except for yellowish median line, a submedian pale spot and a sublateral oblique pale dash (Fig. 27). Pleural folds with strong black dots basally to gill insertion. Sterna pale lightly suffused with gray laterally on sterna II–VII, but more widely on VIII and IX; sternum X blackish laterally. Gills pale shaded almost completely with purplish gray, except pale medially; main trachea and fringes completely shaded. Gill I with two lobes of different sizes, relatively long and slender (Fig. 25). Cerci and median filament yellowish white, with long setae and spine-like setae, terminal filament with black basal ring. Tergum X with spine-like projection on postero-ventral corner (Fig. 26).

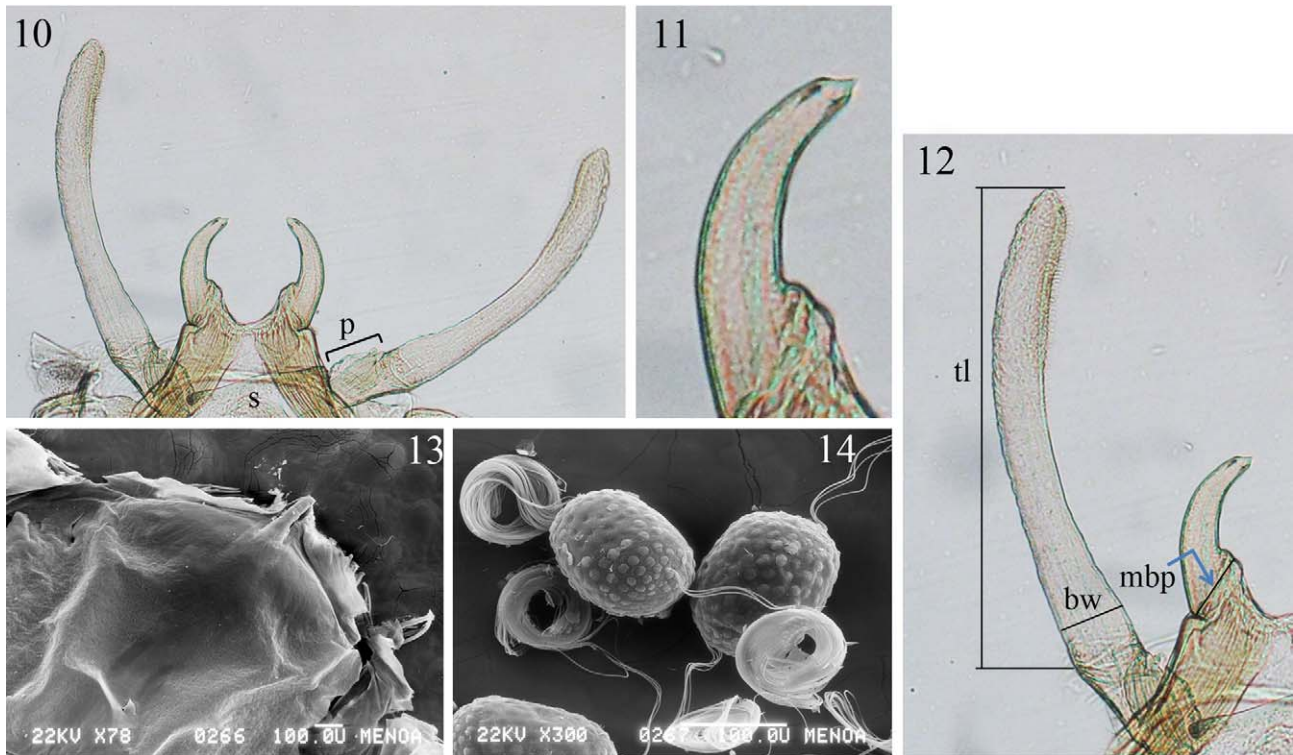
Type material. Holotype male imago. BRAZIL, Mato Grosso do Sul, Ladário, Pantanal, Planície de inundação do Rio Paraguai, lago próximo à pousada Porto Vitória Régia, 19°01'10,0" S / 57°33'02,1" W, Sanseverino, AM *leg.*, light trap (white light), 13.ix.2008 (DZRJ—Ephemeroptera 2300). Paratypes: BRAZIL, Mato Grosso do Sul, same data as holotype, collected in 17.ix.2008, 1 male imago, genitalia and wings on slide (DZRJ—Ephem. 2301); same data, collected in ix.2008, 4 male imagos (DZRJ—Ephem. 2302); same data, collected in 18.ix.2008, 16 male imagos (DZRJ—Ephem. 2303); same data, collected in 16.ix.2008, 2 male imagos (DZRJ—Ephem. 2304); same data, collected in 13.ix.2008, 2 male imagos and 1 female subimago (DZRJ—Ephem. 2305); same data, collected in 14.ix.2008, 1 male reared subimago and nymphal exuvia (DZRJ—Ephem. 2306); same locality, collected in 18.ix.2008 on *Eichornia azurea*, 1 nymph (DZRJ—Ephem. 2307); same data, 1 nymph damaged, labrum and labium lacking (DZRJ—Ephem. 2308).



FIGURES 6–9. *Asthenopus angelae* sp. nov. Wings: (6) fore wing of male; (7) hind wing of male; (8) fore wing of female; (9) hind wing of female. *mi* = marginal intercalary vein. Scale bars: 1 mm.

Other material (non-types). BRAZIL, Ilha da Paciencia, Nossa Senhora da Conceicao, Lago Jacitara (A14 barco), 3°16'40.7"S / 60°16'34.5"W, 19.ix.2003, luz UV1 A, 8 male imagos, 1 male subimago and 10 female adults; Coari, Monte das Oliveiras, Lago do Quintino (A08-Lago), 3°56'33"S / 63°21'9"W, 9.xii.2003, luz UV1, 10 male and 10 female imagos; Manacapuru, Cristo Ressucitado, Lago Galo (Camao), (A13 L6), 3°34'48"S / 60°49'44.6"W, 17.ix.2003, 100 nymphs (including 1 pharate male subimago); Tefé, Sao Joao do Catuaí, Lago da Piranha, (A07 lago), 3°37'32S / 64°11'23"W, 15.ix.2003, 100 nymphs; and photographs of male genitalia of two male imagos from Lago do Castanho, near Manaus, 27.ii.1976, R. Braga col. COLOMBIA/PERU, río Amazonas, Caballococha, (no date), Rincón, ME leg., 1 female (IBN slide 573) and two male (IBN slide 478) imagos. BOLIVIA, Beni, río Itenez, Bella Vista, Laguna La Granja, 9.v.2006, 137 m, 13°14'1.4"S / 63°43'22.2"W, Domínguez, E & Molina, C. legs., 3 male imagos (IBN slide 523). ARGENTINA, Formosa, 10 km S de Formosa, arroyo Torhue, 8.xii.1986, Domínguez, E leg, 2 male imagos (IBN slide 476). The material from Colombia is deposited in MUSENUV, 1 male from Bolivia is at UMSA and the remaining material in IBN. The specimens from Brazil are deposited at CZNC, except for Braga's material (studied by Berner) in FAMU.

Etymology. This species is named after Angela M. Sanseverino, the entomologist responsible for collecting part of the Brazilian specimens.

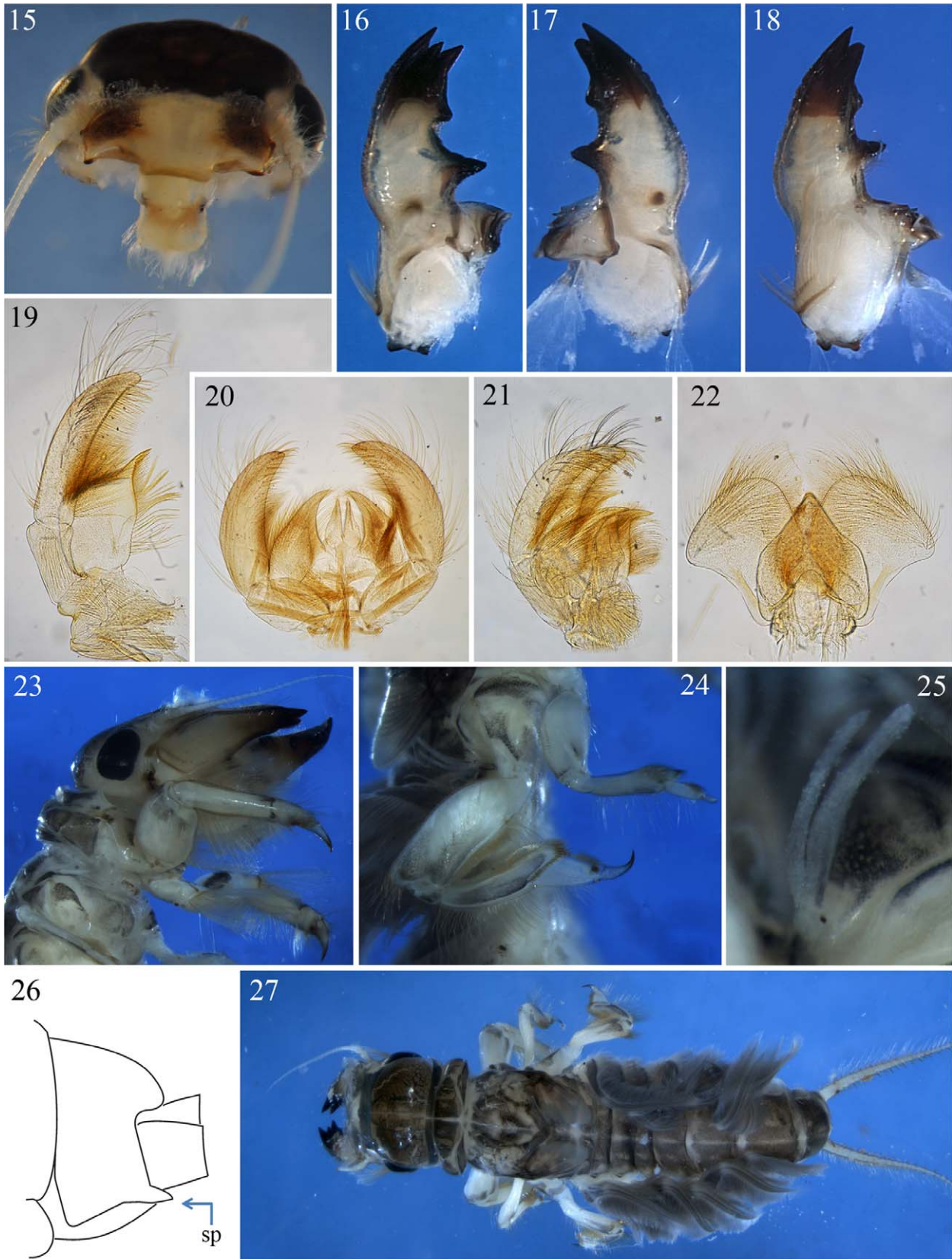


FIGURES 10–14. *Asthenopus angelae* sp. nov. Genitalia and eggs: (10) male genitalia, ventral view; (11) detail of penis lobe; (12) detail of forceps and penis lobe; (13) detail of female sternum VIII; (14) eggs. Abbreviations: *bw* = basal width; *mbp* = median basal protrusion; *p* = pedestal; *s* = styliger (not in natural position); *tl* = total length.

Diagnosis. *Asthenopus angelae* can be separated from the other species of the genus by the following combination of characters. In the male adults: 1) penes tubular, with well developed median basal protrusion, curved ventro-medially, with apex projected acutely, furrow separating penial lobe from median basal protrusion reduced or absent (Figs. 10–12); 2) pedestals subrectangular to subovate, relatively large (Fig. 10); 3) forceps relatively slender, ratio length/basal width 6.5–7.1; 4) forelegs of male 0.6–0.7 × the length of forewings; 5) hind wings with 0–2 marginal intercalaries, fore wing with 5–11 marginal intercalaries relatively short (Figs. 6–7); 6) foretarsal claws slightly widening distally, apex 1 to 1.5 times width of stalk (Fig. 2). Female adults: 1) fore wing length 12.0–13.0 mm; 2) head shaded almost completely with black on occiput, frons with two submedian black lines; 3) abdominal terga shaded uniformly gray; 4) fore wing with 15–19 anastomosed marginal intercalary veins, hind wings with 6–8 marginal intercalaries; 5) 3–4 cross veins between MA and R, basad to R stem. In the nymphs: 1) anterior margin of frons basally to clypeus, straight (Fig. 15); 2) anterior margin of clypeus straight, not projected; 3) mandibular tusks relatively stout, with 3 (left mandible) or 2 (right mandible) distal denticles, inner margin with a subdistal and a subbasal larger tubercle; 4) tarsal claw I with 20–24 denticles increasing in size distally, the apical one larger; 5) tergum X with posteroventral spine-like projection under cercus (Fig. 26).

Discussion. *Asthenopus angelae* is morphologically closer to *A. curtus* than to any other species in the genus and keys to this species in Molineri *et al.* (2011). Characters useful to distinguish *A. curtus* from *A. gilliesi* and *A. crenulatus* are also useful to separate *A. angelae* from these last two species: short intercalary marginal veins, stout penes wider basally, stout forceps (see diagnosis above).

The specific identity of *A. curtus* is a problematic issue (Traver 1950), since different authors have worked with apparently different species (Ulmer 1942, Berner 1978, Domínguez 1988). The type specimen in British Museum is damaged and the genitalia do not show any important structure, so one must to rely on Kimmins's figure of the type (1960, figure 60) as the only reliable source of data. Two important characters depicted on this figure, and also present in fresh material studied by us (two male imagos from Leticia, Colombia, IBN, and 3 male imagos from Amazonas, Careiro Island, Divinópolis, SE of Manaus, 29-VII-1961 E.J. Fittkau at FAMU), are the extremely robust forceps (ratio length/basal width: 5.4) and the long sclerotized penes with a slender acute apex (Kimmins's figure 60). These characters, together with the general aspect, size and coloration, are used to discriminate male adults of our new species from *A. curtus*. For the present time, the nymphal and adult female stages of



FIGURES 15–27. *Asthenopus angela* **sp. nov.** Nymphs: (15) head, frontal view, mandibles dissected; (16) left mandible, dorsal view; (17) right mandible, dorsal view; (18) right mandible, ventral view; (19) maxilla; (20) labium, ventral view; (21) labium lateral view; (22) hypopharynx, ventral view; (23) head, pro and mesothorax, lateral view; (24) middle and hind legs; (25) gill I; (26) segment X, lateral view; (27) habitus dorsal. Abbreviations: *sp* = spine-like projection.

both species are indistinguishable; the study of reared material of *A. curtus* from different localities is urgently needed but falls beyond the scope of the present work. Nevertheless, a list of characters is provided above for the nymphs and female adults of *A. angelae* that would serve to distinguish them.

As it was evident for Traver (1950): "Since this genus (*Asthenopus*) may be like *Campsurus* in the tendency of penes to change shape and thereby appear different from different angles, or even to become flaccid and fall over from the usual upright position, position may be less important than the contours of the individual parts", it is also clear for us that this kind of variation occurs in the male genitalia. But it is important to state that we have studied large series of males of different ages and hardness of their cuticles, and that the characters we use to distinguish our new species are not related to penes position or age of the male, but on the shape of those structures that proved to be rather constant.

Eggs of two undetermined species of *Asthenopus* were described by Koss & Edmunds (1974) (one of them in "*Asthenopodes*"). Their description of the eggs of "*Asthenopus* sp." coincides in many aspects with the eggs studied here except in the absence of smaller discs between the larger ones of *A. angelae*. Furthermore, the size of the discs are smaller in our species, about half of the length reported by Koss & Edmunds.

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