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## Monograph

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# ***Arumatia*, a new genus of Diapheromerinae stick insects (Insecta, Phasmatodea) from Brazil, with the description of five new species and a reassessment of species misplaced in Australian genera**

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**Abstract.** Two species of stick insect with a distinctive morphology, *Candovia evoneobertii* (Zompro & Adis, 2001) and *Echetlus fulgens* Zompro, 2004, were considered to be native to Australia and introduced into Brazil. However, *Heteronemia dubia* (Caudell, 1904) and *Heteronemia fragilis* (Brunner von Wattenwyl, 1907), both described more than a hundred years ago from South America, exhibit striking similarities with the two purportedly introduced species and are found to be conspecific with *C. evoneobertii*. Careful analysis of the literature and specimens revealed that these species belong to the Neotropical tribe Diapheromerini (Diapheromeridae) and represent a new genus, *Arumatia* Ghirotto gen. nov. We therefore propose *Arumatia fulgens* (Zompro, 2004) gen. et comb. nov. and *Arumatia dubia* (Caudell, 1904) gen. et comb. nov. We further redescribe *A. dubia* (Caudell, 1904) gen. et comb. nov. based on several specimens and synonymize *Heteronemia fragilis* syn. nov. and *Candovia evoneobertii* syn. nov. under it. Additionally, five new Brazilian species are described: *Arumatia diamante* Ghirotto gen. et sp. nov. from Abaíra, Bahia; *Arumatia aramatia* Ghirotto gen. et sp. nov. from Porto Nacional, Tocantins; *Arumatia motenata* Ghirotto gen. et sp. nov. from Serra do Cipó, Minas Gerais; *Arumatia crassicerca* Ghirotto, Crispino & Engelking gen. et sp. nov. from Alto Paraíso de Goiás, Goiás; and

*Arumatia anyami* Ghirotto, Crispino & Neves gen. et sp. nov. from Costa Marques, Rondônia. Species of *Arumatia* gen. nov. occur mostly in the Cerrado domain, and represent the first Diapheromeridae recorded in this area. Most species are known exclusively from females with only *A. aramatia* gen. et sp. nov. and *A. motenata* gen. et sp. nov. known from both sexes. Adult and egg morphology are described and illustrated in detail for all species, as well as the nymph stages for *A. dubia*. Biological observations are presented, including parthenogeny in *A. dubia* and one of the few detailed accounts of sexual behaviour in Euphasmatodea (for *A. motenata* gen. et sp. nov.). Finally, a species of Diapheromerini described in error from Brazil, *Diapheromera armata* Piza, 1973, is synonymized under the North American *Megaphasma denticrus* (Stål, 1875) (syn. nov.).

**Keywords.** Phasmida, Diapheromeridae, Neotropical, *Candovia*, *Echetlus*.

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## Introduction

Neotropical stick insects are generally poorly studied: many species are known only from their original descriptions and relatively few have been covered in recent taxonomic works (see, e.g., Gutiérrez-Valencia *et al.* 2017; Conle *et al.* 2020; Crispino *et al.* 2020; Madeira-Ott *et al.* 2020; Chiquetto-Machado & Canello 2021; Ghirotto 2021; Chiquetto-Machado *et al.* 2022). Compared to the fauna of other continents, Neotropical phasmids are underrepresented in phylogenetic analyses, reflecting the lack of basic scientific work concerning them (Robertson *et al.* 2018; Simon *et al.* 2019). Nevertheless, some Neotropical representatives were included in the recent analysis by Simon *et al.* (2019) and were mostly placed in the large clade Occidophasmata Simon *et al.*, 2019 which contrasts with the Old-World clade Oriophasmata Simon *et al.*, 2019.

Two stick insect species found in Brazil, *Candovia evoneobertii* (Zompro & Adis, 2001) and *Echetlus fulgens* Zompro, 2004, were recently described by Zompro & Adis (2001) and Zompro (2004b), both in the genus *Echetlus* Stål, 1875. Although Zompro (2004b) estimated a close relationship between *E. fulgens* and *Echetlus evoneobertii*, only *E. evoneobertii* was transferred to *Candovia* Stål, 1875 by Brock & Hasenpusch (2007) with no mention of *E. fulgens*. Due to their peculiarities and overall resemblance to Australian lineages, both species were considered to be native to or originating from Australia (as stated by Zompro 2004b) where other *Echetlus*, *Candovia* and related groups occur (Stål 1875; Brock *et al.* 2022). These genera belong to Asian-Oceanian lineages in the Oriophasmata clade (Simon *et al.* 2019) and do not inhabit the Neotropical region or the Americas. It was thought they had been introduced into Brazil via imported *Eucalyptus* l'Héritier de Brutelle trees (Zompro & Adis 2001) but the putative origin of *C. evoneobertii* was questioned by Brock & Hasenpusch (2009). The only other note on this issue is within the stick insect catalogue Phasmida Species File online (Brock *et al.* 2022), where *C. evoneobertii* is stated to most likely not belong to any Old-World lineage.

Besides this peculiar case, no phasmid species is regarded as introduced to the Neotropics (Baker 2015; Brock *et al.* 2022). More common, however, are mislabelling of specimens or the historical inclusion of species in genera from other continents due to overall resemblance (Bradley & Galil 1977; Zompro 2001, 2004a, 2004b). These historical associations among taxa from different regions of the world are further influenced by the high phenotypic convergences across Phasmatodea Jacobson & Bianchi, 1902 (Buckley *et al.* 2009).



Intriguingly, two species extremely similar to *C. evoneobertii* were described much earlier for the Neotropical region: *Heteronemia dubia* (Caudell, 1904) and *Heteronemia fragilis* (Brunner von Wattenwyl, 1907) (Heteronemiidae Rehn, 1904). Both were originally described in the subgenus *Bacunculus* Burmeister, 1838 which was later elevated to genus level and then synonymized under *Heteronemia* Gray, 1835 by Rehn (1904), a synonymy that was largely ignored until Zompro (2001). *Heteronemia dubia* was described from the Paraguarí department of Paraguay and *H. fragilis* for “America Meridionalis” (= South America). Neither species has been reviewed until now, as even Zompro (2004a) did not mention these species under *Heteronemia*.

In the present work we synonymize *Heteronemia fragilis* syn. nov. and *Candovia evoneobertii* syn. nov. under *Heteronemia dubia*, while *E. fulgens* is regarded as a closely related species. Both *H. dubia* and *E. fulgens* are known only from females and have a distinctive morphology among South American phasmids leading us to describe the new genus *Arumatia* Ghiorotto gen. nov. to accommodate these species together with five new species. Representatives of *Arumatia* gen. nov. do not occur in Australia; in fact they key out as members of the heterogeneous New World lineage Diapheromerini Kirby, 1904 (Diapheromerinae Kirby, 1904, Diapheromeridae Kirby, 1904), as correctly pointed out by Brock & Hasenpusch (2009), and are native to Brazil and Paraguay.

We propose the new combinations *Arumatia fulgens* (Zompro, 2004) gen. et comb. nov. and *Arumatia dubia* (Caudell, 1904) gen. et comb. nov. and describe *Arumatia anyami* Ghiorotto, Crispino & Neves gen. et sp. nov., *Arumatia crassicercata* Ghiorotto, Crispino & Engelking gen. et sp. nov., *Arumatia aramatia* Ghiorotto gen. et sp. nov., *Arumatia motenata* Ghiorotto gen. et sp. nov. and *Arumatia diamante* Ghiorotto gen. et sp. nov. Additionally, we propose one further taxonomic change in Diapheromerini, synonymizing *Diapheromera armata* Piza, 1973 syn. nov. under *Megaphasma denticrus* (Stål, 1875).

## Material and methods

Specimens were collected in the following areas in Brazil: Brasília (Distrito Federal), Santana do Riacho, Araguari and Delfinópolis (Minas Gerais), Chapadão do Sul (Mato Grosso do Sul), Assis and Echaporã (São Paulo) and Alto Paraíso de Goiás (Goiás). Specimens were encountered by searching vegetation mostly at night. Subsequently, some specimens were raised in captivity under natural lighting conditions and room temperature in screened 20L plastic containers with their food plants in a flask with water. The containers were sprayed with water two to three times per week. Eggs laid by females were periodically removed and incubated in small plastic containers with tissue covered holes for ventilation that contained mildly humid vermiculite or sphagnum moss as substrate.

Upon hatching, the insects were placed in rearing cages as described and some individuals were kept isolated in order to track their development. Specimens were raised until natural death or killed by freezing and then were either placed in 70% ethyl alcohol or pinned and dried. Some of the eggs were dried for preservation. Biological observations were casual and not rigorously controlled. Observations of pre-mating and mating behaviour for *Arumatia motenata* Ghiorotto gen. et sp. nov. were performed at night in dim light, facilitated by placing a single male near a resting female on a single branch in the lab but outside of the container for easy observation.

Specimens examined are deposited in the collections of the Universidade de Brasília, Brasília, Brazil (UNB), Museu de Entomologia Luiz de Queiroz, Universidade de São Paulo, Piracicaba, Brazil (MELQ – specimens are identified with the acronym ESALQENT), Universidade Estadual Paulista, Assis, Brazil (UNESP), Museu de Zoologia, Universidade de São Paulo, São Paulo, Brazil (MZUSP), Australian National Insect Collection, Canberra, Australia (ANIC) and Zoologisches Museum der Universität Kiel, Kiel, Germany (ZMUK). Pictures of type material housed at the National Museum of Natural History, Washington, United States of America (USNM) and Museo Nacional de Ciencias Naturales, Madrid,

Spain (MNMS) were examined on the Phasmida Species File Online website (Brock *et al.* 2022). Additional material deposited at MELQ and MZUSP was also examined. Supplementary information deduced from specimen labels is given in brackets.

In order to complement distribution records of *Arumatia* Ghiorotto gen. nov., we traced and reviewed images of stick insects in South America on the online citizen-science platform iNaturalist (<http://inaturalist.org>) tagged in the projects “Bichos-Pau do Brasil” and “Insectos Palo Sudamericanos” that are curated by members of Projeto Phasma and other phasmid researchers. The distribution map was prepared in ArcGIS ver. 10.2 and presents the ecoregions proposed by Olson *et al.* (2001).

Descriptions were based on the examination of a variable number of specimens under a Zeiss Stemi 2000 stereo microscope and a Leica M205C stereo microscope. Descriptions of colours were based on live insects when possible. The redescription of *Arumatia dubia* gen. et comb. nov. was based on individuals from several localities, including the holotype, and type specimens of the junior synonyms. Internal genitalia were initially examined in alcohol after dissection with a fine scissor and forceps and later re-examined after treatment in hot solution of 10% KOH. Eggs of *A. dubia*, *A. motenata* Ghiorotto gen. et sp. nov. and *A. crassicercata* Ghiorotto, Crispino & Engelking gen. et sp. nov. were laid by live individuals, whereas eggs of *A. anyami* Ghiorotto, Crispino & Neves gen. et sp. nov., *A. aramatia* Ghiorotto gen. et sp. nov. and *A. diamante* Ghiorotto gen. et sp. nov. were carefully dissected from the abdomen of preserved specimens. While some eggs of *A. anyami* were obtained from near the ovipositor, eggs of the only known female of *A. aramatia* and of *A. diamante* were obtained from more anterior portions of the abdomen and therefore are not fully developed. Habitus photos and living specimens were photographed with a Samsung J7 Prime cell phone and with Canon SL1 and Canon 7D digital cameras, both equipped with Canon EF 100 mm macro lenses. Other pictures were taken under a Leica M205C stereo microscope with LAS Core software. Specimens were measured in dorsal view with a Mitutoyo calliper (0.05 mm accuracy). The terminology of external structures follows Friedemann *et al.* (2012) for the head and Chiquetto-Machado & Canello (2021) and Ghiorotto (2021) for the body and genitalia. Structures of the male genitalia were named in order to tentatively assign homologies with structures previously described for other phasmids (Chiquetto-Machado & Canello 2021; Ghiorotto 2021). The terminology of the egg capsule follows Sellick (1997).

## Results

Order Phasmatodea Jacobson & Bianchi, 1902  
Family Diapheromeridae Kirby, 1904  
Subfamily Diapheromerinae Kirby, 1904  
Tribe Diapheromerini Kirby, 1904

Genus *Arumatia* Ghiorotto gen. nov.  
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Figs 1–52

### Type species

*Arumatia aramatia* Ghiorotto gen. et sp. nov. by present designation.

### Species included

*Arumatia dubia* (Caudell, 1904) gen. et comb. nov.  
*Arumatia fulgens* (Zompro, 2004) gen. et comb. nov.  
*Arumatia anyami* Ghiorotto, Crispino & Neves gen. et sp. nov.  
*Arumatia crassicercata* Ghiorotto, Crispino & Engelking gen. et sp. nov.

*Arumatia aramatia* Ghirotto gen. et sp. nov.

*Arumatia motenata* Ghirotto gen. et sp. nov.

*Arumatia diamante* Ghirotto gen. et sp. nov.

### Diagnosis

Elongate, small- to medium-sized, apterous stick insects. General features that allow the distinction of *Arumatia* Ghirotto gen. nov. from almost all other Diapheromerinae genera are the elongate head and body, thin legs with carinae bearing spiniform setae and very long basitarsi. Females can be further distinguished by the very long cerci and a shortened and acute subgenital plate covering the gonapophyses and gonoplac. Males are further distinguishable by the shortened sternum IX (lacking a portion anterior to the poculum) with asymmetric anterior margin delimiting an asymmetric poculum that is also partly fused to the sternum VIII. In most phasmids the male sternum IX is divided into an anterior portion that is similar in aspect to other sterna and a posterior specialised symmetric poculum that holds the male genitalia. In *Arumatia* gen. nov. the sternum IX is entirely specialised as an asymmetric poculum.

*Arumatia* Ghirotto gen. nov. has remarkable similarities with representatives of *Phantasca* Redtenbacher, 1906 (Diapheromerinae: Diapheromerini), including the general aspect of the subgenital plate, gonapophyses and gonoplac in females, the shortened, asymmetric and partly fused sternum IX and the tergum IX with lateral margins approaching each other ventrally in males, as well as general egg morphology.

*Arumatia* Ghirotto gen. nov. can be distinguished from *Phantasca* by the following set of characters. In both sexes: smaller and less protruding eyes and more elongate head and basitarsi. In females: narrower and longer legs, tergum VIII not significantly shorter than tergum X, very long and large cerci (always longer than tergum X), shortened and thicker gonapophyses, straight gonapophysis VIII (long and upcurving in *Phantasca*) and longer gonoplac. In males: absence of wings, longer metanotum and much shorter median segment, large and elongate vomer and sternum VIII and tergum VIII not fused but clearly separated (fused in *Phantasca*). Although males of *Arumatia* gen. nov. are readily distinguishable even by the naked eye from males of *Phantasca* by the significantly more elongate head, smaller eyes and absence of wings, females of *Arumatia* gen. nov. can be somewhat difficult to distinguish at first sight from females of some slender species of *Phantasca* with relatively long cerci.

### Etymology

Taken in reference to the word *Arumatia*, an indigenous name for stick insects in Brazil first recorded by Marcgravi (1648) and still used as a popular name for stick insects in some regions of the country. The gender is feminine.

### Description

LENGTH. 66–113 mm for females; 56–70 mm for males.

HEAD. Elongate and smooth with sparse setae, vertex flat. Eyes small and slightly oval in outline. Galea elongate to broad, elliptical and bearing long setae, apically with dense tuft of hairy and large microtrichia forming round patch or band along apical edge. Galealobulus present, small, widely round and basally fused to galea. Labrum strongly notched anteromedially, round and asymmetric with right lobe significantly larger than left one. Antennae long, scapus longer than wide, basally constricted in dorsal view and slightly compressed dorsoventrally. Pedicellus subglobose.

THORAX. Smooth. Pronotum slightly longer than wide, transverse sulcus conspicuous and straight to gently curved. Profurcasternum round in females and oval in males. Mesothorax 4.8–7× as long as prothorax. Mesonotum with a pair of lateral carinae continuing through metanotum and median

segment, mesepisternum lanceolate and regularly widening posteriorly, mesepimeron moderately elongate and slightly exceeding end of mesothorax. Metepimeron extremely elongate extending across entire length of median segment, posteriorly pointing and slightly exceeding posterior margin of median segment. Posterior margin of metanotum and anterior margin of median segment slightly widened, more conspicuously in females.

**LEGS.** Slender, and unarmed. Anterior legs ca as long as or slightly longer than hindlegs, midlegs distinctly shorter. Profemur with distinct basal curvature. Femora and tibiae with five carinae with or without few sparse setae among them. Carinae of profemora and protibiae distinctly keeled, mid and hind femora and tibiae weakly to distinctly keeled. Carinae of all femora, tibiae and tarsi bear one or two rows of short setae. On antero-, posteroventral and ventral carinae, last 1–3 setae stouter and spiniform in most species, and in some species on anterodorsal and posterodorsal as well. In two species, these three ventral carinae ending in apical spiniform projection. Ventral, antero- and posteroventral carinae of basitarsi frequently with longer or stouter (spiniform) setae mainly present on mid and hindlegs. All basitarsi very elongate, of about same length to significantly longer than respective following tarsomeres combined. Euplantulae well developed in all tarsomeres; composed of two symmetrical pads separated by a median groove in tarsomeres I–III, of two symmetrical pads to single domed pad in tarsomere IV, and of single flattened lobed pad in tarsomere V (which can be less developed in some species).

**ABDOMEN.** Smooth and bearing few setae across entire length. Median segment ranging from slightly more than half the length to same length as metanotum. Median segment anteriorly marked by two parasagittal ovoid stains. Combined length of segments II–X slightly longer than combined length of head, thorax and median segment. Terga II–VII and sterna II–VIII bear discrete lateral carinae near lateral margins. All segments longer than wide. Segments III–VII longest. **In females:** tergum X conical in lateral view, in dorsal view just slightly narrower towards apex, posterior margin round to strongly emarginate. Epiproct domed in dorsal view, short to very elongate. Paraprocts elongate and posteriorly acute, straight, setose on posterior margin, laterally bearing the cerci and not concealing them from ventral and lateral views. Cerci extremely elongate, straight, pointing to posterior, gradually tapering and ranging from slightly longer than terga IX to longer than IX, X and epiproct combined. Praeopercular organ absent, small and verruciform or conspicuously lobed and pointing towards posterior region. Subgenital plate roundly lanceolate to slightly more acute, reaching from  $\frac{1}{4}$  of length of tergum X to slightly exceeding posterior margin of tergum X, bearing two parasagittal carinae beginning on anterior margin and running half the length of segment before becoming flatter and more setose, gradually tapering towards posterior. Subgenital plate totally covering gonapophyses and gonoplacs. Gonapophyses and gonoplacs flattened, dorsoventrally for gonapophyses VIII, lateroventrally for IX and laterally for gonoplacs. Gonapophyses VIII shorter in some species or longer than IX and gonoplacs in others, IX shorter than VIII and gonoplacs or slightly longer than VIII, gonapophyses VIII linear to lorate (having form of strap) and blunt to tapering towards the posterior, IX lorate to conical and tapering towards posterior. Gonapophyses IX ventrally folded to fit within gonapophyses VIII. Gonangulum distinctly reduced, flat and not lobed. Gonoplacs significantly elongate, basally widened, subsequently linear to lorate, setose, slightly shorter than both gonapophyses or exceeding both gonapophyses. **In males:** tergum X longer than wide, slightly widening towards posterior and roundly or v-shaped emarginate on posterior end. Thorn pads composed of ca 25 to 35 strong curved teeth, restricted to ventral area of posterior margin or extending ventrally and laterally on ventral area of posterior margin of latero-ventral flat flexing expansions. Cerci slightly shorter than tergum X, inwardly curved and with round apex. Epiproct discrete and hidden from dorsal view. Vomer elongate, dorsoventrally flattened (similar to most stick insects) or convex, terminal hook elongate and strongly sclerotized, either acute, single pointed or symmetrically bifid near posterior margin, presenting round apices. Tergum VIII very slightly longer than IX, curving towards ventral region near posterior margin and tapering towards anterior in lateral view. Sternum VIII completely separated from tergum VIII and partly fused with sternum IX. Delimitation between terga VIII and IX



as asymmetric sulcus extending towards anterior on left side. Sternum IX reduced, presenting only as poculum without evident anterior region. Due to asymmetry, poculum shorter on right side than left side. Poculum conical to round in lateral view, slightly wider than long, or longer than wide when viewed ventrally, posterior margin with wide emarginate curvature medially. Phallic organ bearing very elongate dorsal sclerite penetrating inside body cavity, wide longitudinal lobe with fine granulation and smaller basal lobe ventrally on right side.

#### **Egg**

Relatively small. Capsule subrectangular to ovoid and may or may not be constricted at opercular collar, laterally compressed. Capsule surface smooth, slightly roughly textured with lumpy or net appearance or roughly textured with small irregular reticulate ridges. Colour varying in shades of orangish or reddish brown, rarely greyish, with lighter band on dorsal surface extending towards anterior and posterior. Micropylar plate elongate, elliptical, with lighter elevated outer circle delimiting darker inner flat region connected to micropylar cup. Micropylar cup small and rounded, only slightly elevated. Median line short. Opercular collar narrower (constricted) than rest of capsule or of same width, not constricted. Opercular collar with minute and delicate bristles along edge. Operculum oval and with non-stalked capitular structure formed by irregularly reticulated or radially directed ridges and elevations of amber-like colour and texture.

#### **Distribution** (Fig. 52)

*Arumatia* gen. nov. is restricted to South America and so far only recorded from Brazil and Paraguay. While *Arumatia anyami* gen. et sp. nov. possibly occurs in the Amazon Forest along the border with Bolivia, all other species occur in the Cerrado (Fig. 53). *Arumatia dubia* gen. et comb. nov. is widely distributed in the Cerrado but is also recorded from the Chaco. The Cerrado, Chaco and other biomes such as the Caatinga are part of the South American Dry Diagonal, presenting environmental and faunal similarities (Vanzolini 1963; Prado & Gibbs 1993; Collevatti *et al.* 2020). Records from iNaturalist (Fig. 52: grey dotted shields) and the occurrence of species in close contact with the Caatinga (Fig. 52: x mark) suggest that the genus is also present in the xeric Caatinga biome. The Cerrado domain is a complex of biomes (see Fig. 53), and representatives of the genus are recorded for seasonal forests and savannah formations (Fig. 53). It is worth noting that *A. anyami*, the only Amazonian species of the genus, occurs in a region in close contact with the Beni savannahs of Bolivia (Fig. 52) and there is a possibility that it inhabits savannah formations present in small patches around the type locality. In Fig. 52, the shield symbol represents unidentified and potentially new species: one unidentified nymph in the MZUSP collection, in the Cerrado in the south of Mato Grosso State (Fig. 52: dark grey shield) and two records from iNaturalist of a potentially new species from Olho d'Água das Flores, Alagoas State and Campo Formoso, Bahia State, both in the xeric Caatinga biome (Fig. 52: grey dotted shields). We further plotted five points in Fig. 52 representing photographic records from iNaturalist of *A. dubia* from several localities, in Paraguay as well as Southeast and Central-West Brazil (Fig. 52: grey dotted circles).

#### **Remarks**

As mentioned in the diagnosis of *Arumatia* gen. nov., this genus shares a number of features with representatives of *Phantasca*, including the male sternum IX entirely specialised as an asymmetric poculum. *Phantasca* was revised by Hennemann *et al.* (2018) and is restricted to the Amazon region in South America, with most species inhabiting French Guiana. Although these authors discussed the absent or reduced anterior portion of the sternum IX which occurs in *Phantasca* and other Diapheromerinae genera (as well as in *Arumatia* gen. nov.), they did not mention the asymmetry of the poculum, a feature

present in several species of *Phantasca* as seen from pictures provided by them (Hennemann *et al.* 2018: figs 13, 24, 32, 62, 70, 77, 97, 116). However, to the best of our knowledge, no other Diapheromerinae is known to have an asymmetric poculum, which also includes representatives of genera with an absent or reduced anterior portion of sternum IX (that however have a symmetric poculum), which according to Hennemann *et al.* (2018) are closely related to *Phantasca*.

Males and eggs of *Arumatia* gen. nov. are completely different from those of *Echetlus*, *Candovia* and other related Old-World taxa. For example, males of *Arumatia* gen. nov. lack granules and tubercles on the body, have a relatively longer and thinner body that is especially evident in the metathorax, and have thinner cerci and an asymmetric poculum. Eggs of *Arumatia* gen. nov. are smooth, lacking the strongly rugose texture of those of *Echetlus* and *Candovia* and have a longer and narrower micropylar plate. Although the females of *Arumatia* Ghirotto gen. nov. may superficially resemble those of *Echetlus* and *Candovia*, the overall morphology and proportions of the body and legs readily distinguish them from females of these Old-World taxa (Paul Brock, pers. comm., 2022).

#### Key to species of *Arumatia* gen. nov.

##### Females

1. Median segment as long as metanotum; cerci longer than terga IX and X combined; praeopercular organ absent ..... 2
  - Median segment shorter than metanotum; cerci as long as terga IX and X combined or shorter; praeopercular organ present or absent ..... 3
2. Cerci shorter than terga VIII–X combined but longer than IX and X combined; subgenital plate reaching only half the length of tergum X; Brazil (São Paulo, Minas Gerais, Paraná, Distrito Federal, Goiás) and Paraguay (Paraguari) ..... *A. dubia* (Caudell, 1904) gen. et comb. nov.
  - Cerci about as long as terga VIII, IX and X combined; subgenital plate exceeding tergum X; Brazil (Mato Grosso) ..... *A. fulgens* (Zompro, 2004) gen. et comb. nov.
3. Median segment slightly shorter than metanotum; cerci around the same length as of terga IX and X combined; subgenital plate reaching around  $\frac{3}{4}$  the length of tergum X; praeopercular organ present; Brazil (Tocantins) ..... *A. aramatia* Ghirotto gen. et sp. nov.
  - Median segment distinctly shorter than metanotum; other combination of characters ..... 4
4. Head oval in dorsal view, wider than pronotum; mid and hind tibiae with three stronger spiniform setae at the end of all carinae; cerci robust, only slightly longer than tergum X; subgenital plate reaching around  $\frac{3}{4}$  the length of tergum X; praeopercular organ present and small; Brazil (Goiás) ..... *A. crassicercata* Ghirotto, Crispino & Engelking gen. et sp. nov.
  - Head about as wide as pronotum or narrower in dorsal view; setae on carinae of tibiae otherwise; cerci significantly longer than tergum X, only slightly shorter than terga IX and X combined; praeopercular organ absent or present ..... 5
5. Head laterally convex, about as wide as pronotum in dorsal view; apical region of carinae of tibiae with uniform setae; epiproct short; subgenital plate reaching posterior margin of tergum X; praeopercular organ absent; Brazil (Rondônia), very likely Bolivia .....
  - ..... *A. anyami* Ghirotto, Crispino & Neves gen. et sp. nov.
  - Head significantly elongate, parallel-sided; all three ventral carinae of all tibiae with sessile apical spine; epiproct prominent and elongate; subgenital plate reaching around  $\frac{1}{4}$  to  $\frac{1}{3}$  the length of tergum X; praeopercular organ present ..... 6

6. Head  $2\times$  as long as wide; all terga smooth; epiproct about half the length of tergum X, with round apex; praeopercular organ prominent and lobed; cerci as long as terga IX and X combined; Brazil (Minas Gerais) ..... *A. motenata* Ghirrotto gen. et sp. nov.
- Head  $2.3\times$  as long as wide; tergum VI with two tubercles; epiproct more than half the length of tergum X, with roundly acute apex; praeopercular organ present but small; cerci shorter than terga IX and X combined; Brazil (Bahia)..... *A. diamante* Ghirrotto gen. et sp. nov.

#### Males

1. Head with convex sides in dorsal view; mid and hind tibiae with one to few stronger spiniform setae at end of all carinae; tergum IX longer than X; poculum elongate and conical, pointed in lateral view; tergum X without lateral expansions; thorn pads restricted to ventral area of posterior margin of tergum X; Brazil (Tocantins)..... *A. aramatia* Ghirrotto gen. et sp. nov.
- Head with parallel to concave sides in dorsal view; ventral carinae of all tibiae with sessile apical spine; tergum IX, about same length as X; poculum shortened and round in lateral view; tergum X with flat lateral expansions bent downwards; thorn pads reaching ventral area of lateral expansions; Brazil (Minas Gerais) ..... *A. motenata* Ghirrotto gen. et sp. nov.

*Arumatia dubia* (Caudell, 1904) gen. et comb. nov.  
Figs 1–13, 46, 52, 53A–D

*Bacunculus dubius* Caudell, 1904: 186.

*Bacunculus fragilis* Brunner von Wattenwyl, 1907: 336. **Syn. nov.**

*Echetlus evoneobertii* Zompro & Adis, 2001: 294. **Syn. nov.**

*Heteronemia dubia* – Zompro 2001: 223. — Otte & Brock 2005: 158.

*Heteronemia fragilis* – Zompro 2001: 223. — Otte & Brock 2005: 158.

*Echetlus evoneobertii* – Zompro 2004b: 138. — Otte & Brock 2005: 132. — Zompro & Domenico 2005: 257. — Zompro *et al.* 2006: 131 (specimen record for Australia in error, misidentification).

*Candovia evoneobertii* – Brock & Hasenpusch 2007: 7, 70; 2009: 151. — Araujo & Garraffoni 2012: 235.

#### Diagnosis

##### Females

From *Arumatia fulgens* gen. et comb. nov., *A. dubia* gen. et comb. nov. differs by the shorter subgenital plate not exceeding half the length of the tergum X, the slightly shorter cerci (not reaching the length of terga VIII–X combined) and the thinner body. From *A. anyami* gen. et sp. nov. it differs by the lack of a black spot on the ventral region of the prothorax, the longer median segment, equal in size to the metanotum (vs  $\frac{3}{4}$  the length of metanotum), the shorter subgenital plate, larger epiproct, posterior margin of anal segment less emarginate, tergum VII having a widened and incurved posterior margin and shorter gonapophyses VIII, and narrower gonoplac. Some mouthparts differ between the two species, because *A. dubia* has a different microtrichia pattern as a band on the galea and not a circle, has less and stouter setae on the lacinia, a narrower galea and narrower labial palp segments than those of *A. anyami*. From *A. crassicerca* gen. et sp. nov. it differs by the lack of a praeopercular organ, the longer median segment, much longer cerci and thinner legs with less prominent keels. *Arumatia dubia* also has fairly less and stouter setae on the lacinia and shorter microtrichia of the galea than *A. crassicerca*, and the microtrichia are arranged in a band, not a circle. From *A. aramatia* gen. et sp. nov. it differs by the shorter, less elongate head, the more elongate galea, the longer median segment, as long as the metanotum, the shorter terga VIII–X, the emarginate posterior margin of tergum X, the slightly shorter subgenital plate, the lack of a praeopercular organ and the shorter gonapophyses VIII. From *A. motenata* gen. et sp. nov.

and *A. diamante* gen. et sp. nov. it differs by the shorter, less elongate head, the more elongate galea, the shorter microtrichia of the galea, the longer median segment, as long as the metanotum, the presence of stronger spiniform setae on the carinae of the tarsi and on the apex of mid and hind tibiae, the absence of an apical sessile spine on the apex of the ventral, antero- and posteroventral carinae of the tibiae, the slightly longer cerci, the shorter epiproct, the longer subgenital plate, the absence of a praeopercular organ, the narrower gonoplac and the shorter gonapophyses VIII.

### Eggs

The egg of *Arumatia dubia* gen. et comb. nov. has a smoother capsule than that of *A. anyami* gen. et sp. nov., and a lumpier and grosser texture (rather than finely punctuated) than that of *A. motenata* gen. et sp. nov. or *A. crassicercata* gen. et sp. nov. The egg also has a reticular, netted aspect of the keels of the capitulum rather than radial on the capitulum of the eggs of *A. aramatia* gen. et sp. nov., *A. motenata* and *A. diamante* gen. et sp. nov. as well as a widened posteriormost region of the micropylar plate and dorsal region less convex in lateral view than that of *A. crassicercata*.

### Type material

PARAGUAY • 1 ♀, holotype of *Bacunculus dubius*; Sapucay; W.T. Foster leg.; “10-3[?]/[?]”, “*Bacunculus dubia* ♀ type. Caudell; Type No. 8027. U.S.N.M.”; USNM 8027 (examined from photo).

SOUTH AMERICA • 1 ♀, holotype of *Bacunculus fragilis*; “America merid.” [South America]; Bol. leg.; MNMS (examined from photo).

BRAZIL • 1 ♀, holotype of *Echetlus evoneobertii*; São Paulo, Boa Esperança do Sul; 18 Feb. 1998; J.A. Cerignoni leg.; MZUSP 0035 (examined) • 1 ♀, eggs, paratypes of *Echetlus evoneobertii*; São Paulo, Piracicaba, ESALQ/USP; Sep. 2000; “criado em laboratório em folhas de *Eucalyptus*” [raised in lab with *Eucalyptus* leaves]; MZUSP 0036 (examined) • 1 ♀, paratype of *Echetlus evoneobertii*; same collection data as for preceding; MZUSP 0037 (examined) • 1 egg, paratype of *Echetlus evoneobertii*; same collection data as for preceding; ANIC (examined from photo) • 1 ♀, paratype of *Echetlus evoneobertii*; same collection data as for preceding; ANIC (not examined) • 5 ♀♀, paratypes of *Echetlus evoneobertii*; same collection data as for preceding; MZUSP (not traced) • 2 ♀♀, paratypes of *Echetlus evoneobertii*; São Paulo, Boa Esperança do Sul; 18 Feb. 1998; J.A. Cerignoni leg.; ZMUK 457-1, 457-3 (not traced) • 5 eggs, paratypes of *Echetlus evoneobertii*; same collection data as for preceding; ZMUK 457-7 (not traced).

### Other material examined

BRAZIL – **Paraná** • 1 ♀; Londrina; 6 Apr. 1998; E.P. Frazão leg.; ESALQENT 000438. – **Distrito Federal** • 1 ♀; Brasília, urban area near Parque Olhos D’água; 15°44’56.6” S, 47°53’25.1” W; 2020; J. Góis and P. Souza leg.; MZUSP. – **Mato Grosso do Sul** • 2 ♀♀; Chapadão do Sul, margin of Sucuriú River; 19°28’31.3” S, 52°32’17.7” W; 30 Nov. 2020; E.B. Crispino and D. Castro-Pereira leg.; in cerradão [deciduous forest]; MZUSP V0534, V0535 • 2 ♀♀, nymphs, eggs; same collection data as for preceding; MZUSP. – **Minas Gerais** • 3 ♀♀; Paraopeba; 18 Jun. 1988; J.A. Cerignoni leg.; in *Eucalyptus* sp.; ESALQENT 000439, 000444, 000451 • 1 ♀; Delfinópolis, Pousada Cachoeira Paraíso, near Serra da Canastra; 20°20’35.5” S, 46°47’14.0” W; E.W. Engelking leg.; in cerrado [savannah formation]; UNESP • 1 ♀; Araguari, near Emborcação Dam; 18°27’23.0” S, 48°00’40.7” W; 20 Jan. 2021; V.M. Ghirotto leg.; in cerradão [deciduous forest]; MZUSP V0547 • eggs; same collection data as for preceding; from female V0547; MZUSP • 1 ♀, first instar nymph; Minas Gerais, Araguari; reared by V.M. Ghirotto 2021 from female V0547; MZUSP V0556 • 1 ♀, second instar nymph; same collection data as for preceding; MZUSP V0557 • 1 ♀; same collection data as for preceding; MZUSP V0676. – **São Paulo** • 1 ♀; Piracicaba, ESALQ; Jun. 1992; J.A. Cerignoni leg.; host plant *Psidium guajava*; *Echetlus evoneobertii* ♀ det. O. Zompro Nov. 2003; ESALQENT 000443 • 1 ♀; Piracicaba; Jun. 2001;



S.S. Prado leg.; ESALQENT 000442 • 1 ♀; Piracicaba; 16 May 2000; R.A. Polanczyk leg.; ESALQENT 000436 • 1 ♀; Piracicaba, ESALQ; 18 May 1998; S.R. Magro leg.; ESALQENT 000450 • 1 ♀; Piracicaba, ESALQ, Dept. Entomology; 17 May 1998; V.D.A. dos Reis leg.; ESALQENT 000440 • 3 ♀♀; Limeira; 23 Jan. 2004; P. Milano leg.; ESALQENT 000446, 000447, 000448 • 1 ♀; Limeira; 10 Jun. 1999; “criação particular” [culture stock] P. Milano; ESALQENT 000445 • 1 ♀; Descalvado; 26 Apr. 1968; Renato leg.; ESALQENT 000441 • 1 ♀; “R. Preto” [Ribeirão Preto]; Lordello leg.; “4-51”; ESALQENT 000437 • 1 ♀; “Boa Esperança” [Boa Esperança do Sul]; 21 Apr. 1998; R.B.Q. Silva leg.; ESALQENT 000449 • 8 ♀♀; Ibaté; Jan.–Jul. 2019; reared by V.M. Ghirotto, culture obtained at ESALQ entomology lab; MZUSP 1222, 1224, 1227, V0314, V0315, V0333, V0415, V0503 • 1 ♀, first instar nymph; same collection data as for preceding; MZUSP V0272 • eggs; same collection data as for preceding; MZUSP • 2 ♀♀; same collection data as for preceding; 2021; MZUSP V0542, V0558 • eggs; same collection data as for preceding; MZUSP • 2 ♀♀; Assis, Campus UNESP; 22°39'00.2" S, 50°26'18.8" W; Aug. 2018; P.W. Engelking leg.; UNESP WE059 • 2 ♀♀; Echaporã, Trilha da cachoeira Stn Rosa; 22°25'23.8" S, 50°11'60.0" W; Sept. 2020; P.W. Engelking and G.A. Nunes leg.; UNESP WE060.

### Remarks

The Australian specimen of *Arumatia dubia* gen. et comb. nov. reportedly housed at the Zoological Museum of the Christian-Albrechts University of Kiel in Germany (as *Candovia evoneobertii*) could not be traced (Thies Büscher, pers. comm., 2021) and no description or illustration of this specimen was provided by Zompro *et al.* (2006). It is very likely that this specimen was misidentified and represents some distinct species native to Australia (Paul Brock, pers. comm., 2021).

### Redescription

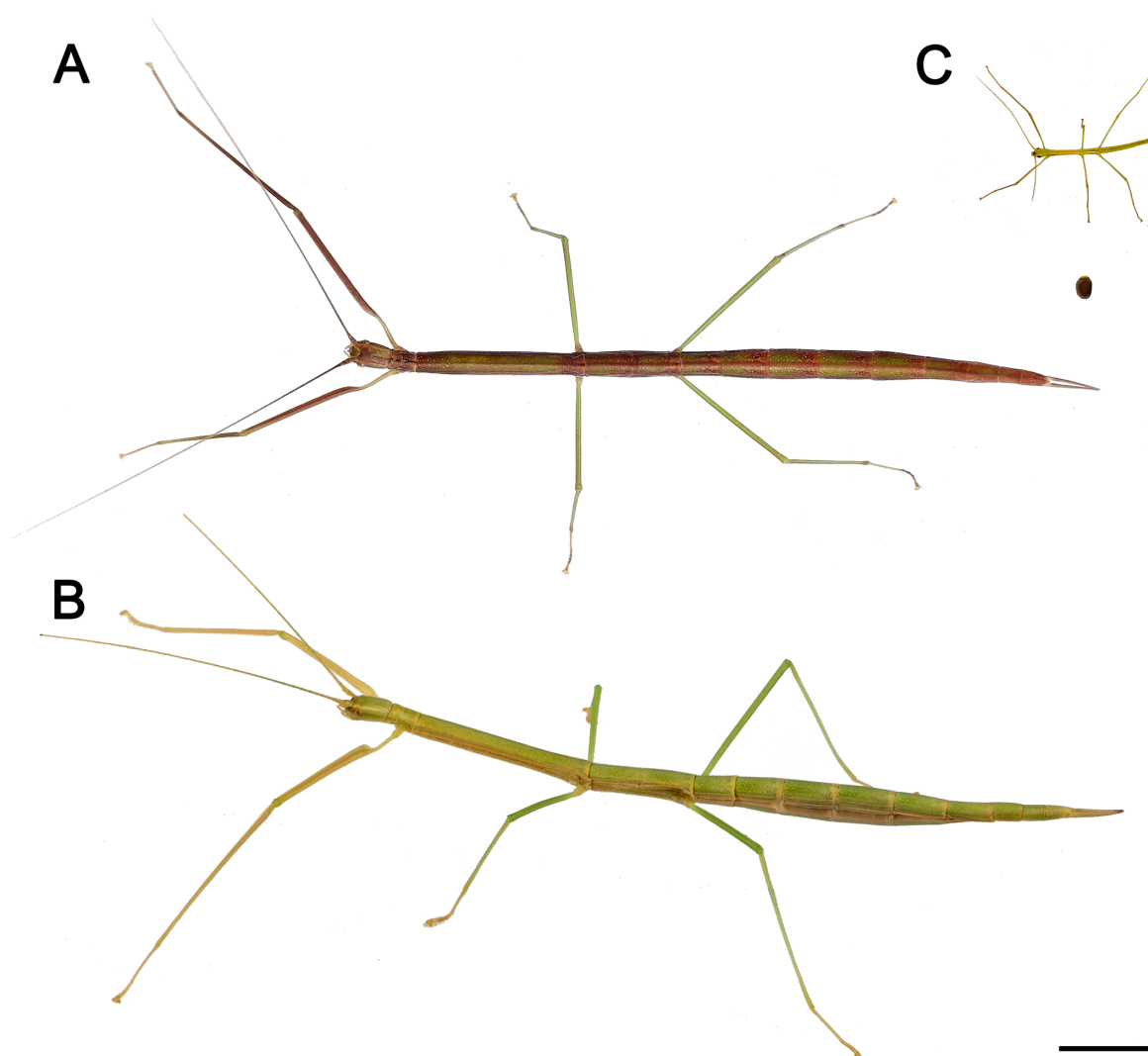
#### Female

MEASUREMENTS (in mm, N = 3). Body (without cerci) 69.1–72.4, head 4–4.1, antennae 43.5–48.5, pronotum 2.4–2.6, mesonotum 15.7–16.6, metanotum 4.5, median segment 4.5, abdomen (excluding median segment, with cerci) 37.6–39.4, cercus 4.7–5.0, profemur 15.9–16.4, protibia 16.5–17.2, mesofemur 11.2–11.8, mesotibia 10.8–11.6, metafemur 14.2–14.9, metatibia 15.5–16.9.

COLOUR (Figs 1–2, 13). Body generally light to dark green, yellow, beige, salmon, orange, brown, grey or black with or without light granulations on body and legs (mostly femora) and with or without irregular stains of different tones (Fig. 13). Some individuals with longitudinal band running along entire body, slightly darker than body to black (Fig. 13A, F). Eyes same colour as rest of body but darker, or reddish brown. Antennae darker ventrally. Apical palp segments and other mouthparts in same colour as body or brownish to beige.

HEAD (Figs 3–4). Elongate, smooth, with sparse setae mostly on dorsal region, vertex flat but gently convex at posterior margin to fit underneath the pronotum, frontal convexity developed and frontal suture round (Fig. 3A–D). Eyes small and slightly elongate, approximately 0.2 × as long as head. Cervix covering more than half of head, cervical sclerites elongate and weakly sclerotized. Gula somewhat spatulate, bearing setae and covering ca more than half of cervix (Fig. 3D). Subgena narrow with posterior projection ca as high as eye. Submentum narrow and only slightly curved backwards, mentum simple, prementum somewhat wide. Glossa elongate and rounded, paraglossa larger, roundly falcate and almost reaching labrum. Lacinia with three distal teeth, one large medially and two smaller laterally, with mesal edge bearing bundles of ca 12 large setae from base to sclerotized portion (Fig. 4D). Lobe over base of lacinia almost indistinct, showing as small and gentle round bump. Galea elliptical and bearing long setae (Fig. 4F), apically with dense tuft of hairy, large microtrichia forming band along apical edge. Dorsally and posteriad to this patch ca 29 distinct circular granules of same size as base of setae (Fig. 4E). Galealobulus present, small and widely round, basally fused to galea (Fig. 4D, F). Palpal segments cylindrical. Clypeus wide, approximately elliptical, anterior surface with two parasagittal

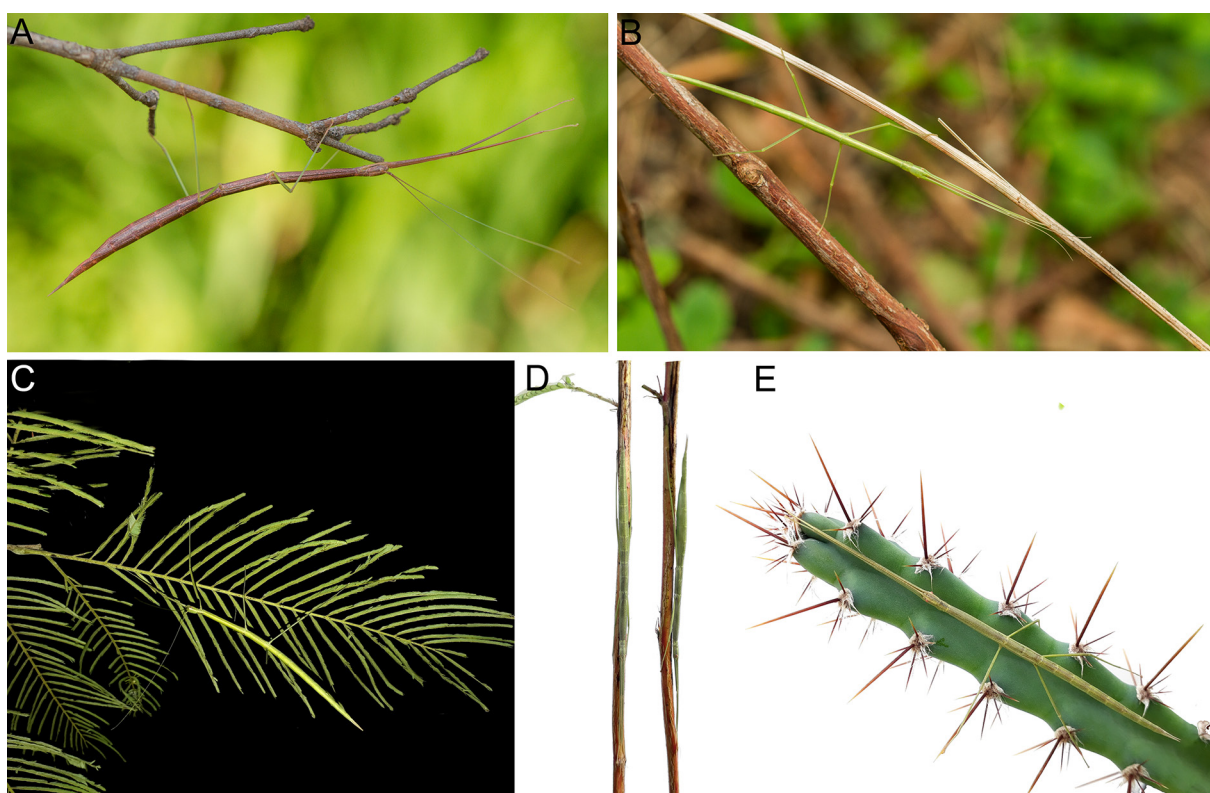
furrows and anterior margin medially with round, wide notch (Fig. 3C). Labrum strongly notched anteromedially, asymmetric with right lobe significantly larger than left one (Fig. 3C). Left mandible with two smooth and straight edges, dorsal one cutting and sharp, and ventral one blunt, mesal surface with convex globose protuberance near ventral cutting edge, and sinuous furrow between both edges (Fig. 4A, C). Right mandible with sharp dorsal cutting edge, straight but interrupted at border with ventral edge by round edge, ventral edge irregular, level and molariform with two larger projections, mesal surface without protuberances (Fig. 4A–B). Both mandibles with dense row of long setae at base of dorsal margin. Antennae filiform, extending approximately until posterior region of third abdominal segment and exceeding forelegs, scapus ca  $1.9\times$  as long as wide, basally constricted in dorsal view and slightly compressed dorsoventrally, pedicellus subglobose, large, more than half the length of scapus; composed of 68–72 segments. Antennomeres bear three types of setae (Fig. 3E–F), a very short, small and densely distributed one, a transparent and porrect one, and a black, slightly more elongate, straight one. From 47<sup>th</sup> segment, smaller setae becoming sparser, on segments 62–67 smaller type very sparse and almost absent and on segments 67–72 absent. Other two types of setae gradually becoming thinner



**Fig. 1.** Live habitus of *Arumatia dubia* (Caudell, 1904) gen. et comb. nov. **A.** Adult female (MZUSP V0547) from Araguari, Minas Gerais, Brazil. **B.** Adult female from Brasília, Distrito Federal, Brazil. **C.** Egg and first instar female nymph from the female from Brasília. Scale bar: 10 mm.

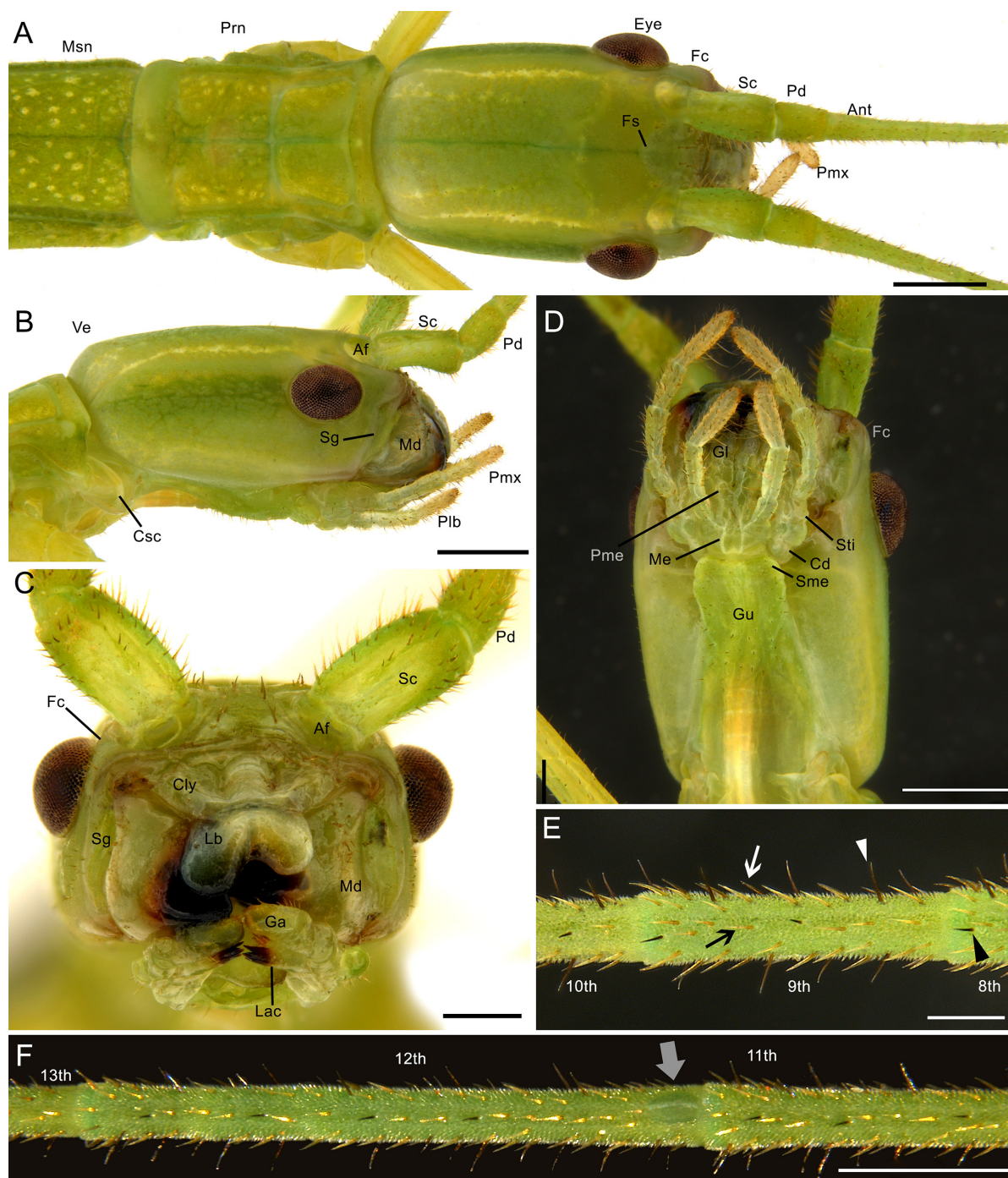
and more elongate towards last segments. Antennal bump very discrete on dorsal surface of posterior region of 12<sup>th</sup> antennomere (Fig. 3F).

**THORAX** (Figs 1–2, 5). Smooth with scattered setae inserted in paler small bumps. Pronotum slightly longer than wide and slightly constricted pre-medially, anteriorly and posteriorly convex in lateral view, transverse sulcus conspicuous and straight, gently curved in lateral edges, longitudinal median sulcus distinct. Paranota curved and ca 3 × as long as wide, procoxopleurite apically round (Fig. 5A–B). Probasisternum tapering towards anterior, profurcasternum round (Fig. 5C). Mesothorax 6 × as long as prothorax, as wide as prothorax anteriorly and slightly widening towards posterior region. Mesonotum with pair of distinct lateral carinae, mesepisternum lanceolate and regularly widening posteriorly, mesepimeron slightly elongate, pointing towards posterior and slightly exceeding end of mesothorax. Mesocoxopleurite indistinct, mesofurca Y-shaped. Metathorax continuing pair of lateral carinae of mesonotum, metepisternum long and similar to mesepisternum. Metepimeron extremely elongate, extending across entire length of median segment, posteriorly pointing and slightly exceeding posterior region of median segment. Metacoxopleurite very discrete but elongate, metafurca Y-shaped. Metanotum and median segment of about same length (Fig. 5E). Median segment anteriorly marked by two parasagittal ovoid stains (Fig. 5E), continuing pair of thoracic lateral carinae. Posterior margin of metanotum and anterior margin of median segment slightly widened (Figs 1, 13).



**Fig. 2.** Live habitus of *Arumatia dubia* (Caudell, 1904) gen. et comb. nov. **A–B.** ♀♀ from Barretos, São Paulo, Brazil. **C.** Adult ♀ (MZUSP V0547) from Araguari, Minas Gerais, Brazil. **D–E.** Adult ♀ (MZUSP V0561) of captivity stock from Ibaté, São Paulo, Brazil. **A.** Adult ♀. **B.** Female nymph camouflaging. **C.** Adult ♀, foraging at night under an angico leaf food plant (Mimosoideae), in situ. **D.** Captive adult ♀, camouflaging on a twig, dorsal and lateral views, respectively. **E.** Captive adult ♀, camouflaging on a potted cactus. Images not to scale.

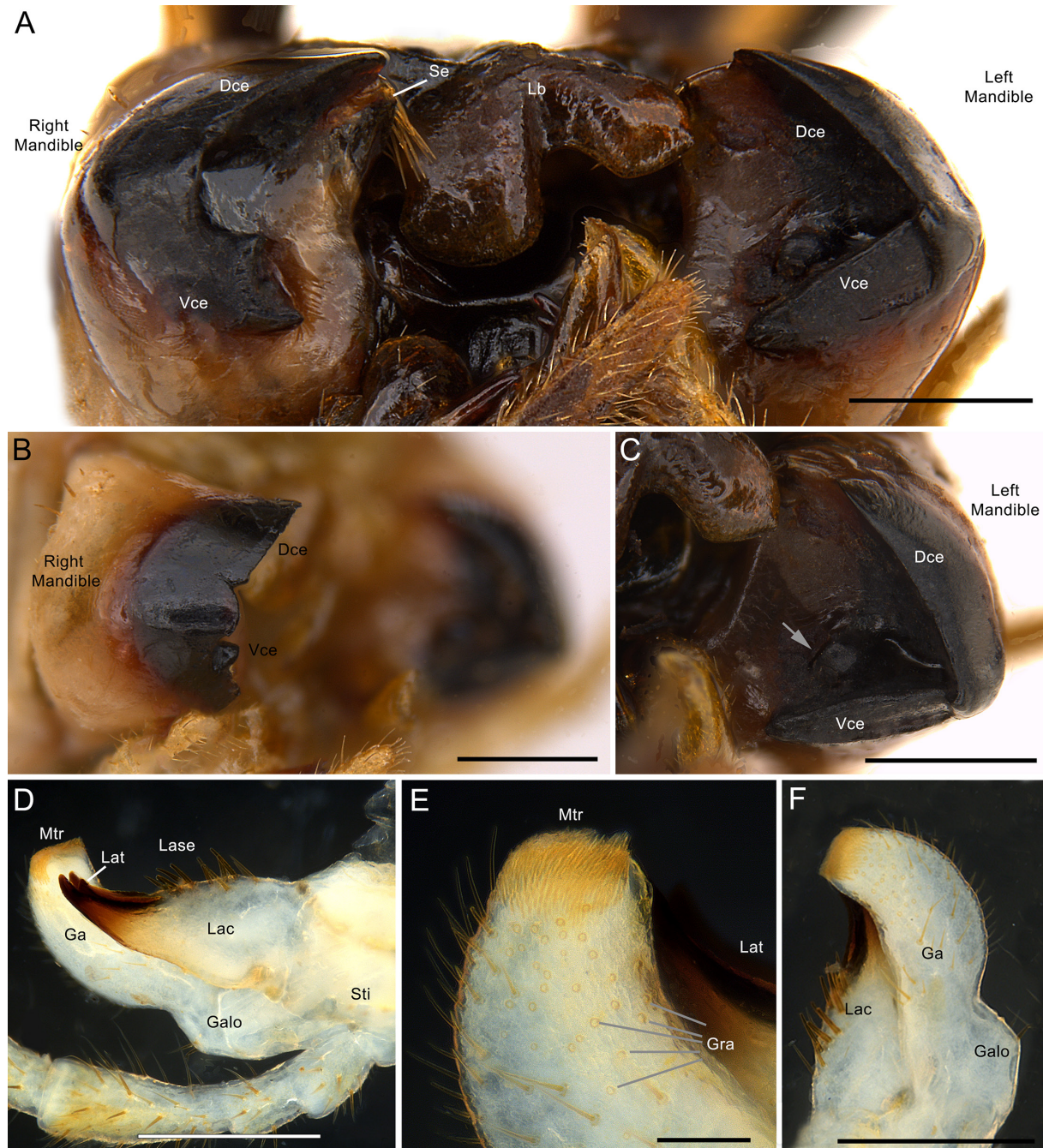




**Fig. 3.** Head morphology of *Arumatia dubia* (Caudell, 1904) gen. et comb. nov., adult ♀ (MZUSPV0542) from stock from Ibaté, São Paulo, Brazil. **A.** Head in dorsal view. **B.** Head in lateral view. **C.** Head in anterior view. **D.** Head in ventral view. **E.** Antennomeres showing three types of setae: very short densely distributed setae (covering the surface area), stiff and straight setae (arrowheads) and porrect transparent setae (arrows). **F.** Antennomeres showing antennal bump (arrow). Abbreviations: Af=antennal field; Ant=antennomere; Cd=cardo; Cly=clypeus; Csc=cervical sclerite; Eye=compound eye; Fc=frontal convexity; Fs=frontal suture; Ga=galea; Gl=glossa; Gu=gula; Lac=lacinia; Lb=labrum; Md=mandible; Me=mentum; Msn=mesonotum; Pd=pedicellus; Plb=labial palpus; Pme=prementum; Pmx=maxillary palpus; Prn=pronotum; Sc=scapus; Sg=subgena; Sme=submentum; Sti=stipes; Ve=vertex. Scale bars: A–B, D=1 mm; C, F=0.5 mm; E=0.2 mm.



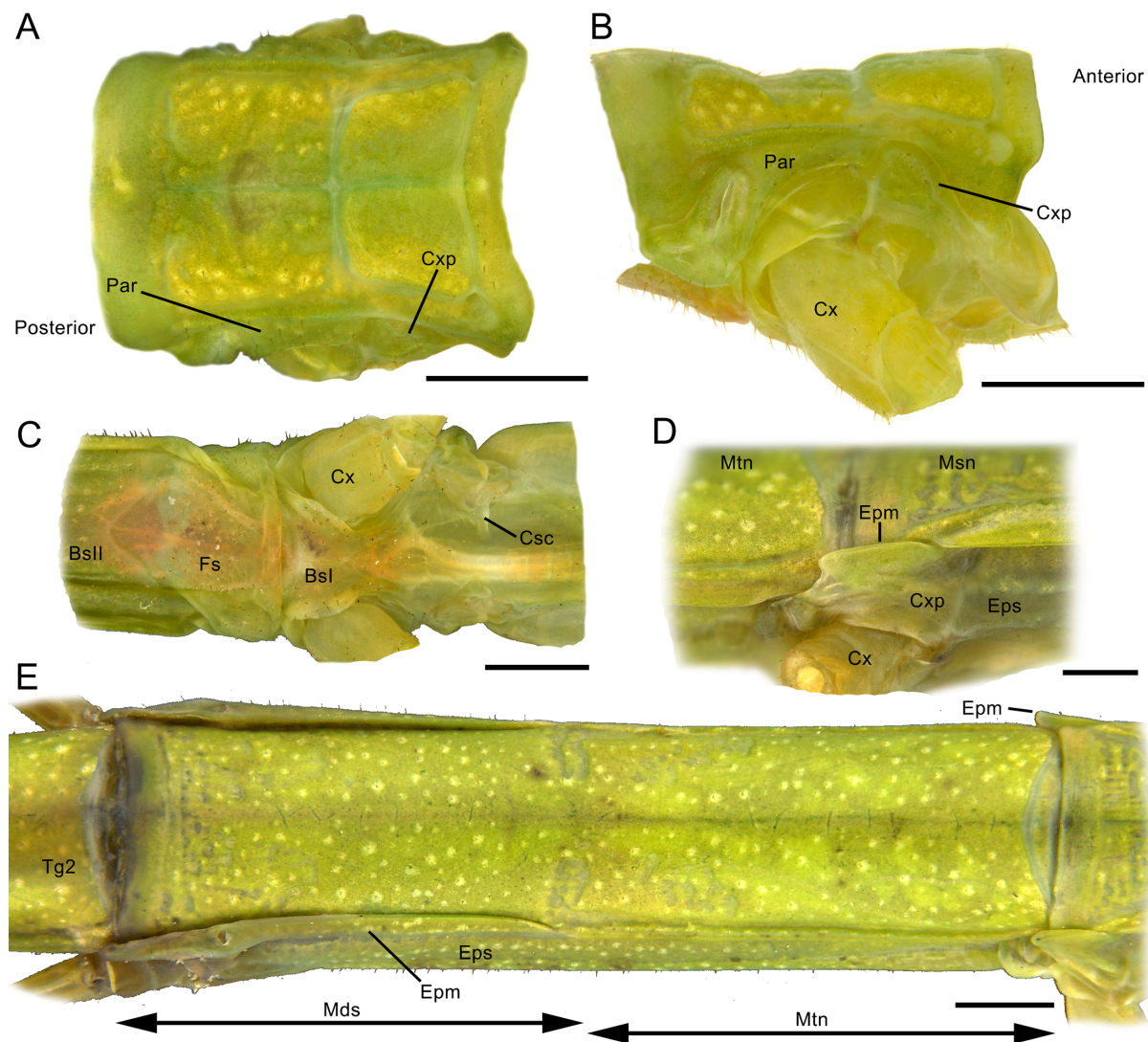
LEGS (Figs 1–2, 6). Slender. Hindlegs slightly extending beyond epiproct but not cerci, anterior legs ca as long as hindlegs, midlegs distinctly shorter. Midlegs slightly longer in some individuals. Coxae smooth (Figs 5B–C, 6A). Profemora of around same length as mesothorax, mesofemora about  $0.7\times$  as long as



**Fig. 4.** Mouthparts of *Arumatia dubia* (Caudell, 1904) gen. et comb. nov., adult ♀♀ from stock from Ibaté, São Paulo, Brazil. **A.** Both mandibles spread showing internal view. **B.** Right mandible in anterior view. **C.** Left mandible, internal view, showing mesal protuberance (arrow). **D.** Right maxilla, ventral (external) view. **E.** Detail of left maxilla, dorsal (internal) view. **F.** Left maxilla, dorsal (internal) view. Abbreviations: Dce=dorsal cutting edge; Ga=galea; Galo=galealobulus; Gra=granules; Lac=lacinia; Lase=lacinal setae; Lat=lacinal teeth; Lb=labrum; Mtr=microtrichia; Se=setae; Sti=stipes; Vce=ventral cutting edge. Scale bars: A–D, F=0.5 mm; E=0.1 mm.

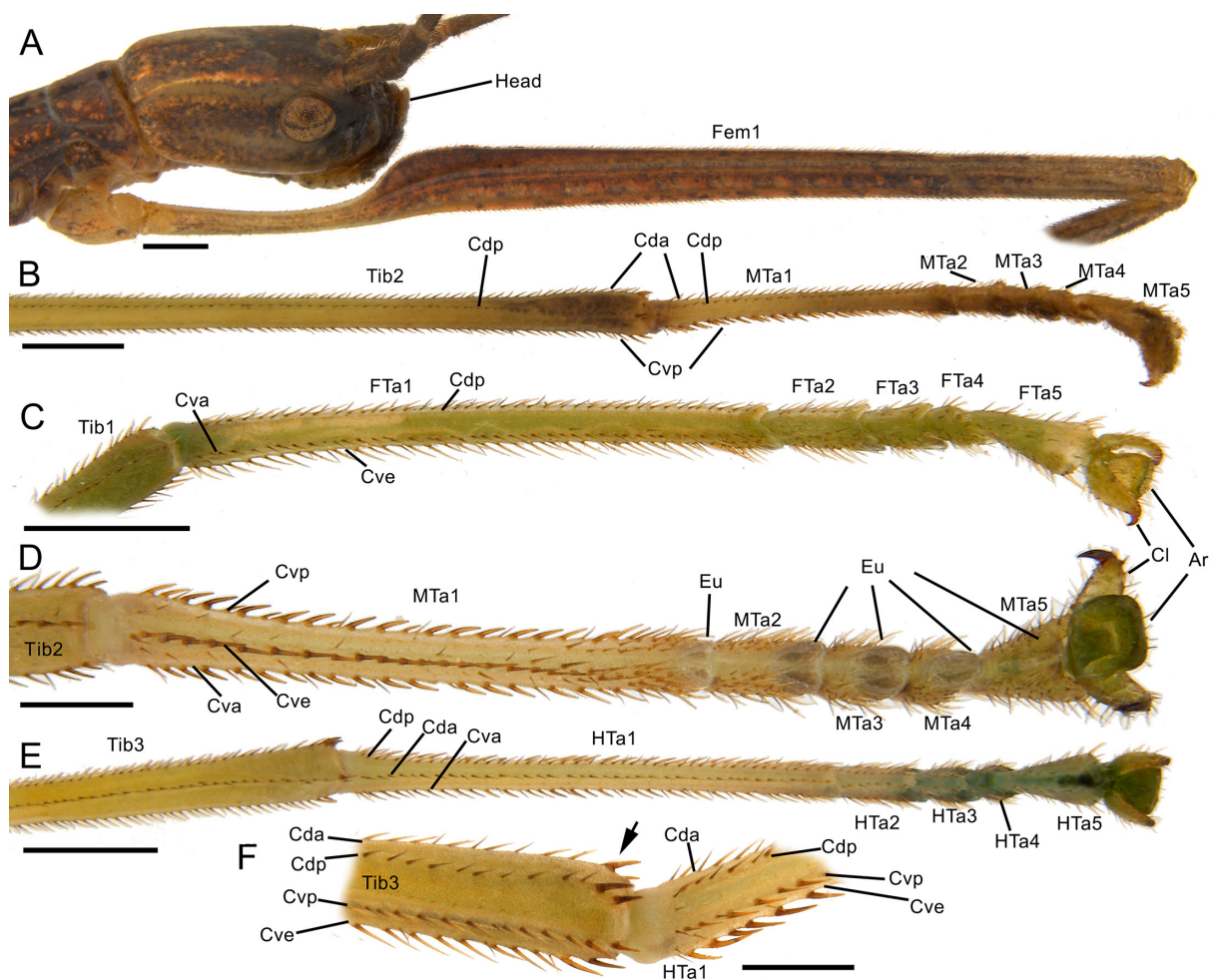


profemora and metafemora slightly shorter than mesothorax. Protibia varying from slightly shorter to longer than profemur, mesotibia ca as long as mesofemur, metatibia slightly longer than metafemur. Profemur with distinct basal curvature (Fig. 6A). Femora and tibiae with five carinae without setae between them (Fig. 6B). Carinae of profemora and protibiae distinctly keeled, mid and hind femora and tibiae weakly keeled. Antero- and posteroventral carinae of femora with apical toothed prominence. Carinae of all femora, tibiae and tarsi bear row of short setae, last two setae of all five carinae of meso- and metatibiae stouter and spiniform (Fig. 6B–F). In tarsi, setae on ventral carinae of probasitarsi longer (but not stouter), while setae on ventral, antero- and posteroventral carinae of meso- and metabasitarsi stouter and spiniform, distributed across entire length except for apex of mesobasitarsi and on basal half to three quarters of metabasitarsi, stronger on ventral carinae (Fig. 6D–F). Some individuals with weaker,



**Fig. 5.** Thorax morphology of *Arumatia dubia* (Caudell, 1904) gen. et comb. nov., adult ♀ (MZUSP V0542) from stock from Ibaté, São Paulo, Brazil. **A–C.** Prothorax, dorsal (A), lateral (B) and ventral (C) views. **D.** Detail of mesepimeron between meso- and metathorax, lateral view. **E.** Metathorax and median segment in dorsal view, arrows indicate the length of each segment. Abbreviations: BsI-II= pro- and mesothoracic basisterna; Csc=cervical sclerite; Cx=coxa; Cxp=coxopleurite; Epm=epimeron; Eps=episternum; Fs=prothoracic furcasternite; Mds=median segment; Msn=mesonotum; Mtn=metanotum; Par=paranotum; Tg=tergum. Scale bars: A–C, E=1 mm; D=0.5 mm.

not spiniform setae on antero-ventral carinae of metabasitarsi. All basitarsi very elongate, significantly longer than respective following tarsomeres combined (Fig. 6B–E), with hairy setae restricted to apical portion on ventro-lateral patches (Fig. 6C–D). Remaining tarsomeres with setae on ventro-lateral patches in portions not covered by euplantulae. Tarsomeres I–III with discrete dorsal round apical projection. Arolium round and broad, bearing setae dorsally. Pretarsal claws symmetrical with setae dorsally and laterally. Euplantulae well developed in all tarsomeres, composed of two symmetrical pads separated by median groove in tarsomeres I–III, of single pointing domed pad in tarsomeres IV and of single flattened lobed pad in tarsomeres V, present only apically at tarsomeres I–II, covering ca half length of tarsomeres III, covering two thirds length of tarsomeres IV and covering almost entire ventral surface of tarsomeres V (Fig. 6D).



**Fig. 6.** Leg morphology of *Arumatia dubia* (Caudell, 1904) gen. et comb. nov. **A–B.** Adult ♀ (MZUSP V0547) from Araguari, Minas Gerais, Brazil. **C–F.** Adult ♀ (MZUSP V0534) from Chapadão do Sul, Mato Grosso do Sul, Brazil. **A.** Anterior region of body and fore leg, lateral view. **B.** Apex of left midleg (mirrored), retrolateral view. **C.** Left fore tarsus, retrolateral view. **D.** Right mid tarsus, ventral view. **E.** Right hind tarsus (mirrored), dorsal view. **F.** Detail of apex of right hind tibia showing stronger apical spines (arrow), retrolateral view. Abbreviations: Ar=arolium; Cda=dorsal anterior carina; Cdp=dorsal posterior carina; Cl=claw; Cva=ventral anterior carina; Cve=ventral carina; Cvp=ventral posterior carina; Eu=euplantula; Fem=femur; FTa=fore tarsomere; HTa=hind tarsomere; MTa=mid tarsomere; Tib=tibia. Scale bars: A–C, E=1 mm; D, F=0.5 mm.



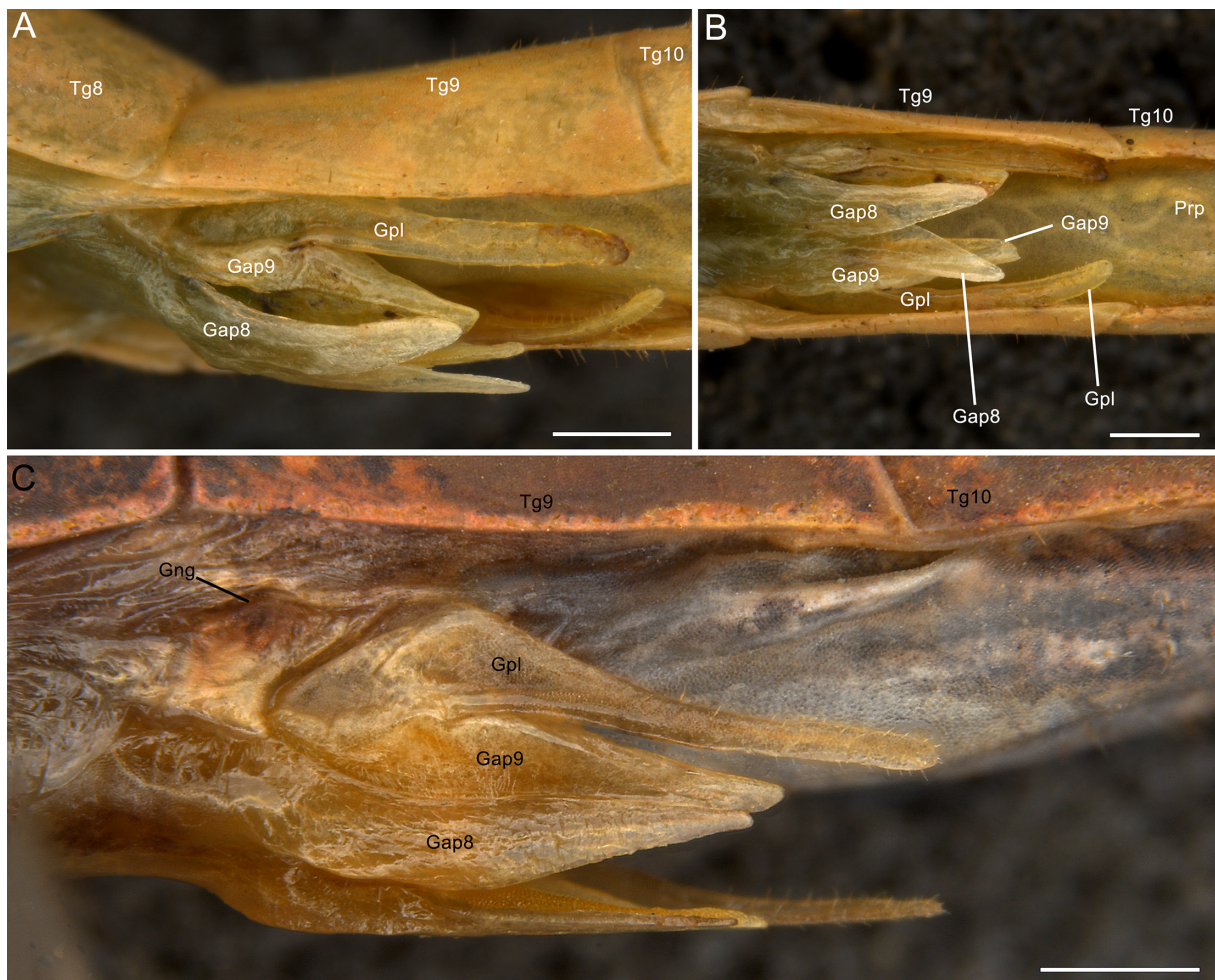
ABDOMEN (Figs 1–2, 7–8). External surface as in thorax, bearing few setae across its entire length. Median segment ca as long as metanotum (Fig. 5E). Combined length of segments II–X slightly longer than combined length of head, thorax and median segment. Terga II–VII and sterna II–VIII bearing discrete lateral carinae near lateral margins. All segments longer than wide (Fig. 1). Segment II as long as VII and slightly shorter than III, segments III–VI slightly increasing in size in relation to anterior segment, tergum VIII significantly shorter than preceding segment and slightly longer than IX, tergum X slightly longer than IX. Terga III–VI wider than II, VII and VIII. Terga IX and X slightly narrower



**Fig. 7.** Terminalia morphology of *Arumatia dubia* (Caudell, 1904) gen. et comb. nov. **A–C.** Adult ♀ (MZUSP V0547) from Araguari, Minas Gerais, Brazil. **D.** Adult ♀ (MZUSP V0534) from Chapadão do Sul, Mato Grosso do Sul, Brazil. **E.** Adult ♀ from Brasília, Distrito Federal, Brazil. **A–C.** End of abdomen, dorsal (A), lateral (B) and ventral (C) views. **D.** Detail of sterna VII and VIII, ventral view. **E.** End of abdomen of a live individual holding an egg awaiting to be laid, lateral view. Arrowheads point to the incurving posterior region of tergum VII. Abbreviations: Ce=cercus; Ep=epiproct; Gap=gonapophysis; Gng=gonangulum; Gpl=gonoplac; Preg=praeopercular region; Prp=paraproct; Sp=subgenital plate; St=sternum; Tg=tergum. Scale bars: 1.0 mm.



than preceding segments. Lateral borders of tergum VII gradually widening and curving downwards and inwards near posterior margin (Fig. 7B–E). Tergum X conical in lateral view (Fig. 7B), in dorsal view just slightly narrower towards apex, posterior margin emarginate with broad round indent showing epiproct (Fig. 7A). Epiproct domed in dorsal view, dorsoventrally flattened, distinctly prominent, exceeding posteriormost margins of tergum X and visible dorsally and laterally (Fig. 7A–B). Paraprocts elongate, posteriorly acute, straight, setose on posterior margin, laterally bearing cerci and not concealing them from ventral or lateral view (Fig. 7C–E). Cerci extremely elongate, straight and basally narrower, fitting paraprocts, pointing to posterior, gradually tapering, slightly longer than terga IX, X and epiproct combined (Fig. 7). Cerci bearing four types of setae (as in nymphal stages, see Fig. 11F–G), three very similar to those of antennae, densely covered in very short, small setae similar to those of antennae, sparser transparent setae inclined towards posterior and black and slightly more elongate straight setae and with inner and ventral surfaces also bearing several sensory hairs significantly thinner than other setae. Praeopercular organ absent (see praeopercular region in Fig. 7C–E). Subgenital plate roundly lanceolate to slightly more acute, reaching medial region of tergum X and bearing two parasagittal carinae beginning at anterior margin and running half length of segment before becoming flatter and more

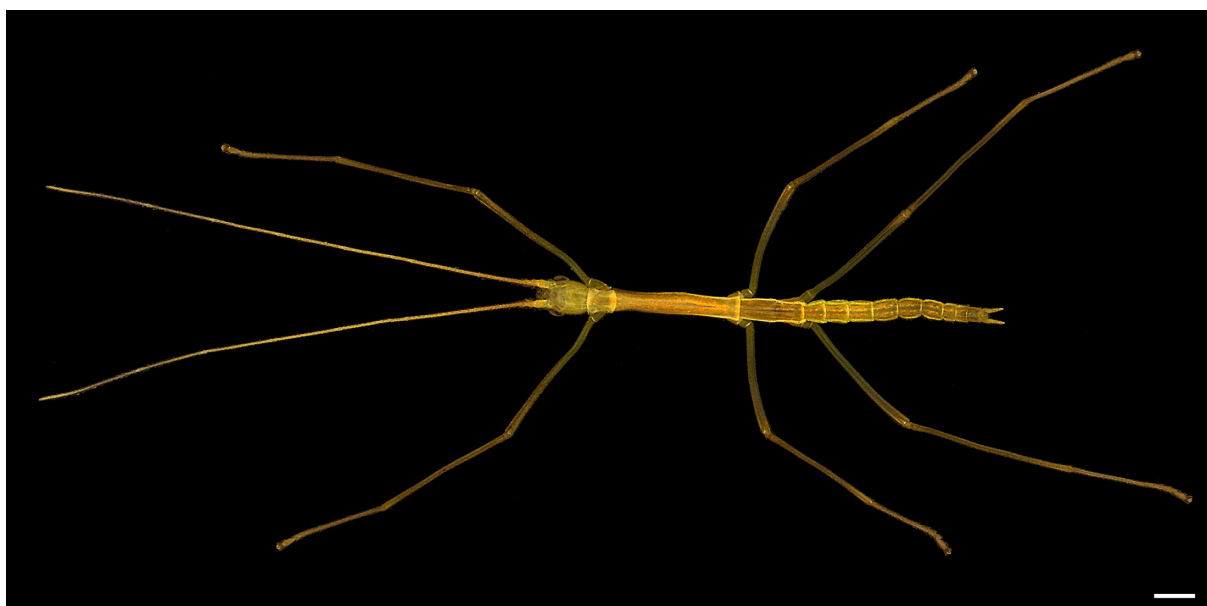


**Fig. 8.** External genitalia of *Arumatia dubia* (Caudell, 1904) gen. et comb. nov. **A–B.** Adult ♀ (MZUSP V0534) from Chapadão do Sul, Mato Grosso do Sul, Brazil, lateral (A) and ventral (B) views. **C.** Adult ♀ (MZUSP V0547) from Araguari, Minas Gerais, Brazil, lateral view. Abbreviations: Gap=gonapophysis; Gng=gonangulum; Gpl=gonoplac; Prp=paraproct; Tg=tergum. Scale bars: 0.5 mm.

setose, gradually tapering towards posterior and totally covering gonapophyses and gonoplac (Fig. 7C–E). Gonapophyses and gonoplac flattened, dorsoventrally for gonapophyses VIII, lateroventrally for IX and laterally for gonoplac (Figs 7E, 8). Gonapophyses VIII and IX short and of similar length, reaching ca  $\frac{3}{4}$  of length of tergum IX; VIII linear to lorate, blunt to tapering towards posterior, IX lorate to conical, tapering towards posterior (Fig. 8). Gonapophyses IX ventrally folded to fit within gonapophyses VIII. Gonangulum distinctly reduced, flat and not lobed (Fig. 8C). Gonoplac significantly elongate, widened basally, subsequently linear to lorate, bearing setae, exceeding both gonapophyses and reaching ca anterior margin of tergum X (Fig. 8). Distinct triangular sclerotization pointing towards posterior and slightly towards ventral present at dorsal face of gonapophyses, separating them from ventral wall of segment IX. Inside oviduct around median region of segment VIII with triangular and slightly sclerotized structure dorsoventrally flattened and pointing towards posterior.

#### Egg (Fig. 12)

Measurements in mm (N = 10): length 2.5, height 1.7–1.8, width 1.4–1.5. Relatively small, capsule ovoid, constricted at opercular collar, laterally compressed and ca  $1.8\times$  as long as wide and  $1.4\times$  as long as tall (Fig. 12A–D). Capsule surface slightly roughly textured with lumpy or net appearance. Colour varying in shades of orangish or reddish brown, rarely greyish, with lighter band on dorsal, anterior and posterior regions, surrounding operculum and polar region (Fig. 12A–D). Micropylar plate very elongate, occupying large area of dorsal region and varying around  $0.6\text{--}0.8\times$  as long as capsule and  $2.8\text{--}5.7\times$  as long as wide, elliptical with round margins and almost parallel-sided with posterior portion gently but noticeably widened (Fig. 12C–D, G). Micropylar plate with lighter elevated outer circle delimiting darker inner flat region confluent with micropylar cup (Fig. 12C–D). Internal micropylar plate closed, accompanying external micropylar plate, interior surface smooth. Micropylar cup small, rounded, only slightly elevated, dark and anteriorly merged to widened polar edge of micropylar plate. Median line short and of same colour and elevation as elevated margin of micropylar plate, almost reaching polar area (Fig. 12C–D). Opercular collar narrower (constricted) than rest of capsule, smooth and lighter, with minute and delicate bristles surrounding edge (Fig. 12F). Operculum elliptical with irregular reticular and sinuous elevation, with amber texture composing non-stalked capitulum (Fig. 12A–F). Very few eggs present flat, smooth and amber operculum (Fig. 12G–H).

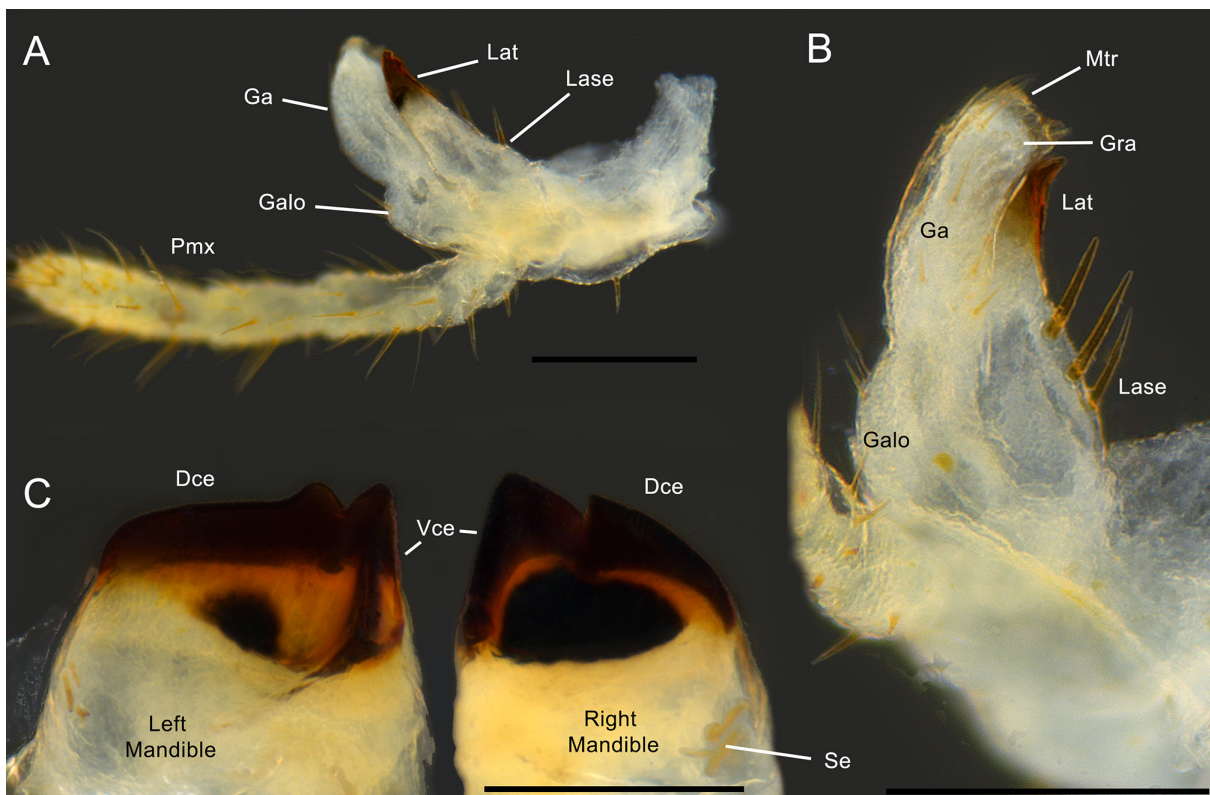


**Fig. 9.** Habitus of a recently deceased first instar female nymph of *Arumatia dubia* (Caudell, 1904) gen. et comb. nov. from stock from Ibaté, São Paulo, Brazil, in dorsal view. Scale bar: 1 mm.

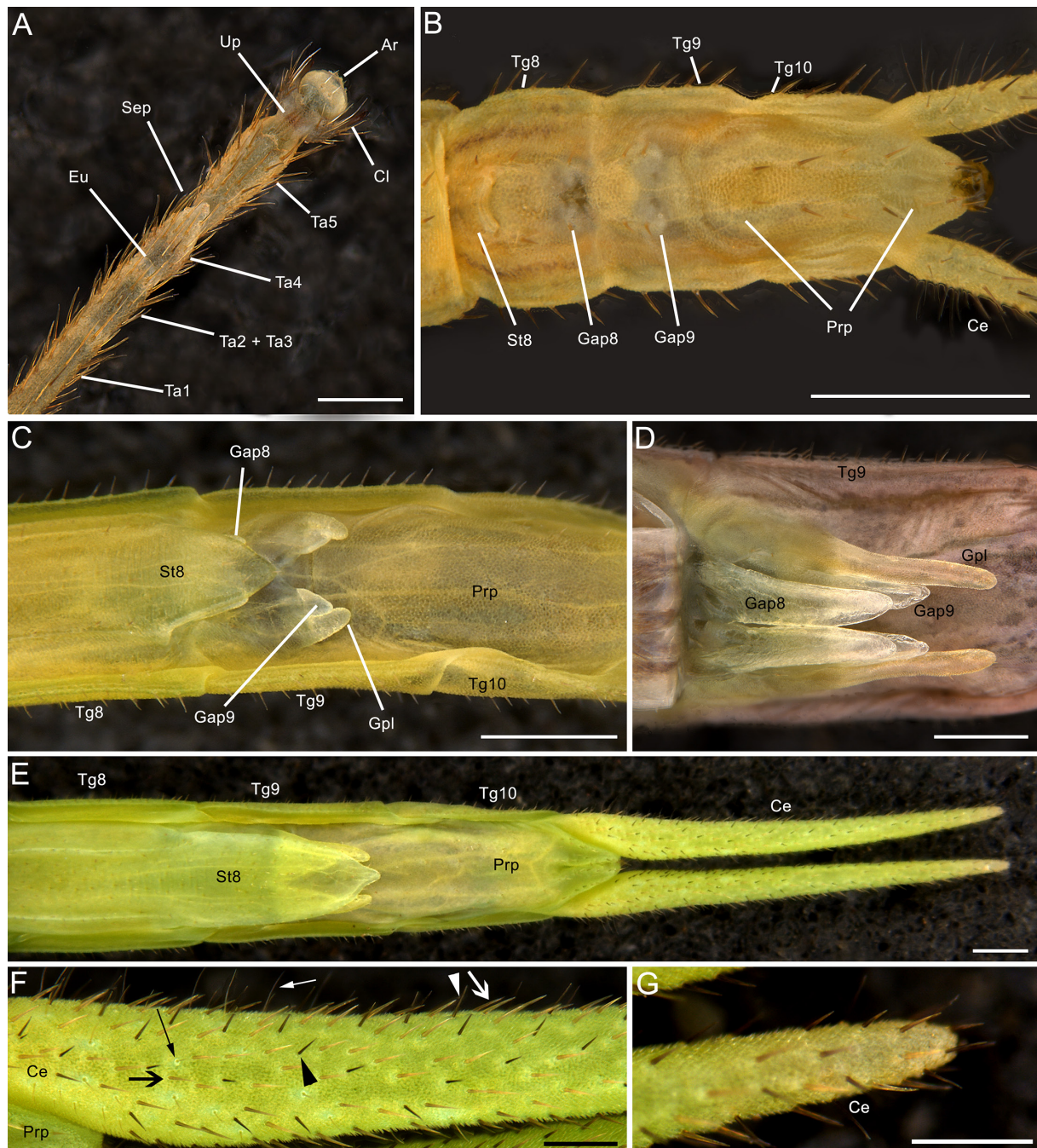


**Nymphs** (Figs 2B, 9–11)

FIRST-INSTAR NYMPH (Figs 1, 9–10, 11A–B). Entirely green with black blurred longitudinal lateral line running along head behind eyes, further crossing prothorax and extending to anterior portion of mesothorax. Dorsally green but lighter than lateral and ventral areas delimited by lateral black line. Body with sparse setae and surface with smooth and flat scaly texture. Head and eyes large. Head globose, just slightly elongate (Fig. 9). Gula not sclerotized, visually absent, cervix more than half length of head, slightly wider than that of adults. Subgena similar in shape to that of adults. Labrum notched and asymmetric, similar to that of adults but right lobe only slightly larger than left one. Lacinia similar to that of adults but with more blunt teeth and few, ca 3 setae on mesal edge (Fig. 10A–B). Galea similar to that of adults but narrower and with ca 8 circular granules, microtrichia present but diminutive and discrete (Fig. 10B). Galealobulus present, similar but slightly smaller than in adults (Fig. 10A–B). Left mandible with sharp dorsal cutting edge with two dentations ventrally, ventralmost one continuous with less sharp and slightly blunt ventral edge, mesal surface without protuberances but with sclerotization in centre away from edges (Fig. 10C). Right mandible with sharp dorsal cutting edge presenting two broad dentations, ventralmost one larger and continuous, with less sharp and slightly blunt ventral cutting edge, basally presenting level blunter surface corresponding to projections of molariform right ventral edge in adults, mesal surface without protuberance but with broad central sclerotization almost reaching edges (Fig. 10C). Antennae longer than body, filiform, with seven flagellomeres, each one very long and of similar length. Legs very elongate, proportionally much longer than those of adults. Profemoral



**Fig. 10.** Mouthparts of first instar female nymph of *Arumatia dubia* (Caudell, 1904) gen. et comb. nov. hatched from ♀ (MZUSP V0547) from Araguari, Minas Gerais, Brazil. **A.** Right maxilla, ventral (external) view. **B.** Left maxilla, dorsal (internal) view. **C.** Both mandibles, internal view. Abbreviations: Dce=dorsal cutting edge; Ga=galea; Galo=galealobulus; Gra=granules; Lase=lacinial setae; Lat=lacinial teeth; Mtr=microtrichia; Pmx=maxillary palpus; Se=setae; Vce=ventral cutting edge. Scale bars: 0.2 mm.

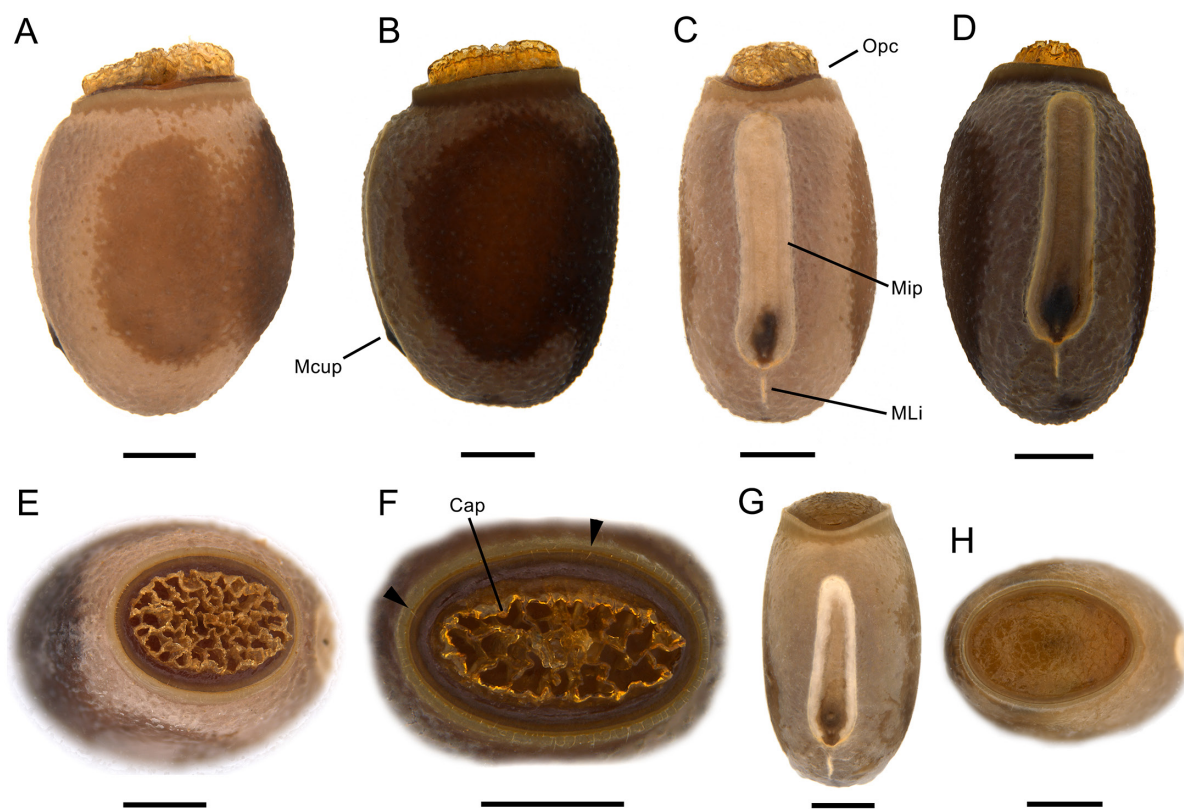


**Fig. 11.** Nymph morphology of *Arumatia dubia* (Caudell, 1904) gen. et comb. nov., female juveniles from stock from Ibaté, São Paulo, Brazil. **A.** Left fore tarsus of first instar, ventral view. **B.** Terminalia of first instar, ventral view. **C.** Terminalia of fourth instar, ventral view. **D–E.** Terminalia of fifth instar, ventral view, detail of external genitalia with tilted subgenital plate to permit visualization (D) and wider view of other individual (E). **F–G.** Detail of cercus of individual in E, showing sensory hairs (long arrow), stiff and straight setae (arrowhead) and inclined lighter setae (broad arrow) (F) and tip of cercus (G). Abbreviations: Ar=arolium; Ce=cercus; Cl=claw; Eu=euplantula; Gap=gonapophysis; Gpl=gonoplac; Prp=paraproct; Sep=setae of ventral patch; St=sternum; Ta=tarsomere; Tg=tergum; Up=unguitractor plate. Scale bars: A–E=0.5 mm; F–G=0.2 mm.



basal curvature very discrete (Fig. 9). Carinae of legs similar to those of adults, distinct and bearing row of somewhat straight and long setae, also on basitarsi. Stouter setae absent. All basitarsi extremely elongate, more than half length of corresponding tibia (Fig. 9). Tarsomeres with indistinct to discretely budded euplantulae on posterior margin of tarsomeres III and IV, with stiff setae instead (Fig. 11A). Unguitractor plate broad. Median segment distinct but not separated from thorax and about as long as metanotum (Fig. 9). Upon hatching, abdominal segments somewhat ovoid, none significantly longer than wide but most becoming longer with development of first instar. Anal segment emarginate, with broader posterior margin than in adults. Epiproct large, round, bearing setae and visible in dorsal view. Cerci longer than tergum X but not longer than IX and X combined (Fig. 9), on basal third presenting only long sensory hairs at all sides, and on remaining length presenting only black, thicker and fairly straight setae. Paraprocts fused, broad and elongate, with posterior margin emarginate and blunter than in adults, bearing setae (Fig. 11B). Sternum VIII budded, short, visible as central, forwardly curved lobe near anterior margin of segment VIII (Fig. 11A). Both gonapophyses absent but round light outline of budded gonapophyses noticeable, becoming more evident as first instar nymph develops (Fig. 11A).

SECOND-INSTAR NYMPH. Similar to first instar, except for: labrum distinctly asymmetric. Mesal surface of mandibles more sclerotized, reaching edges. Around 18 antennomeres, barely distinct, antennae reaching abdominal segment VII. Profemoral basal curvature slightly more prominent. Carinae of meso-

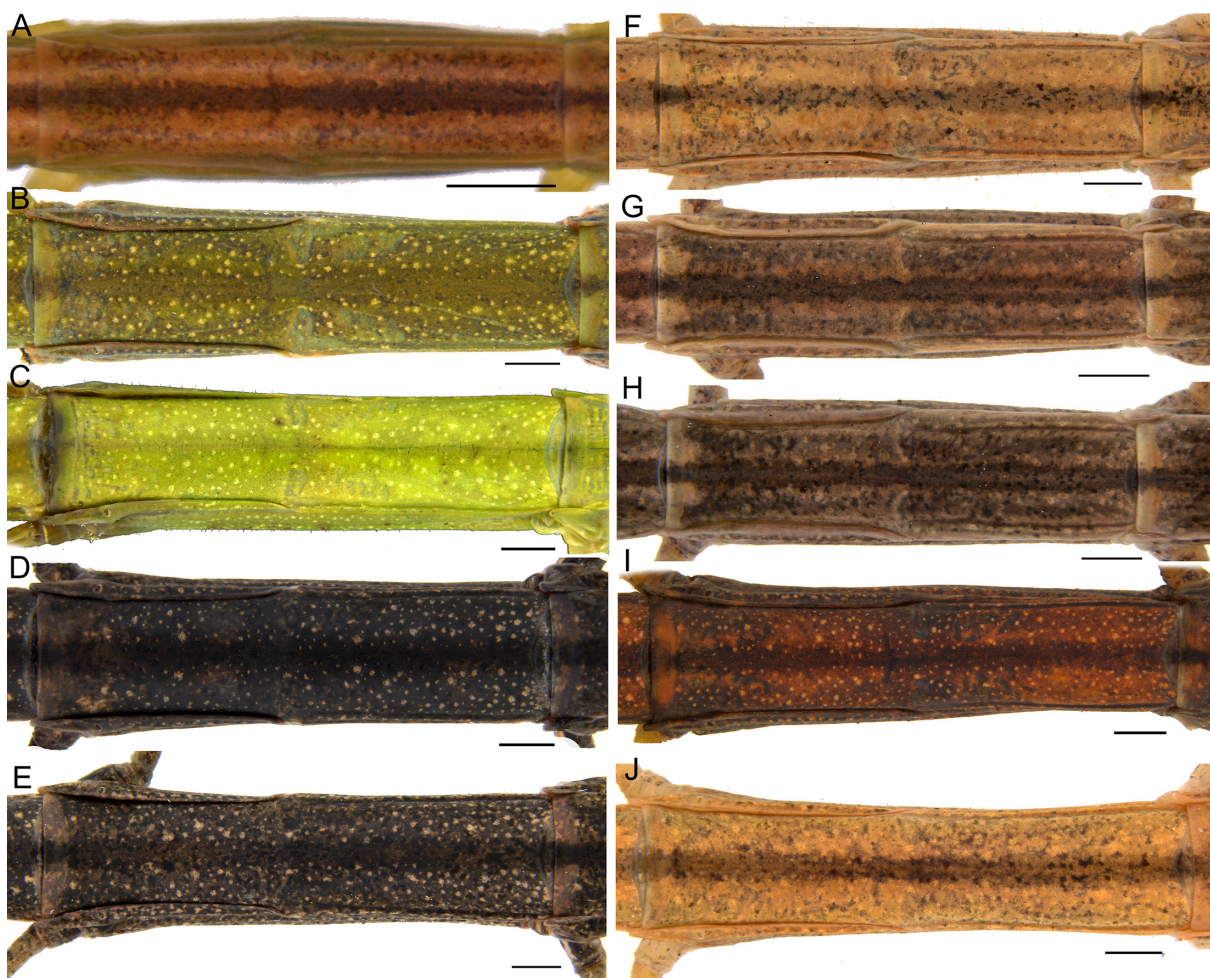


**Fig. 12.** Egg morphology of *Arumatia dubia* (Caudell, 1904) gen. et comb. nov. **A, C, E, G, H.** ♀ (MZUSP V0534) from Chapadão do Sul, Mato Grosso do Sul, Brazil. **B, D, F.** ♀ (MZUSP V0547) from Araguari, Minas Gerais, Brazil. **A–B.** Lateral view. **C–D.** Dorsal view. **E–F.** Anterior view, arrowheads pointing at bristles on opercular collar (F). **G–H.** Egg with flat operculum, dorsal (G) and anterior (H) views. Abbreviations: Cap=capitulum; Mcup=micropylar cup; Mip=micropylar plate; MLi=median line; Opc=operculum. Scale bars: 0.5 mm.

and metatibiae with one or two larger apicalmost setae. Basitarsi significantly longer than following tarsomeres but shorter than half length of corresponding tibia. Subgenital plate small and lobed. Gonapophyses budded, distinctly visible as bean-shaped protuberances with paler colour.

**THIRD-INSTAR NYMPH.** Similar to second instar, except for: head and body slightly more elongate and more similar to those of adults. Meso- and metatibiae with two apicalmost larger setae on each carina. Thorax relatively wider than in adults (similar to later instar nymphs, see Fig. 13A in comparison with adults in Fig. 13B–E). Meso- and metabasitarsi bear stouter spiniform setae on ventral carinae. Euplantulae developed but small. Subgenital plate and gonapophyses budded, subgenital plate not covering gonapophyses VIII (smaller than those of Fig. 11C). Cerci shorter than terga IX and X combined.

**FOURTH-INSTAR NYMPH.** Similar to third instar, except for: head very similar to that of adults. Colouration pattern more similar to that of adults, as dorsal and lateral areas of body acquiring same colour tone. Basitarsi significantly longer than following tarsomeres. Gonapophyses very short, only VIII covered by subgenital plate. Subgenital plate short, only reaching slightly anterior to or just to base of gonapophyses IX, gonoplac larger and exceeding gonapophyses IX (Fig. 11C).



**Fig. 13.** Colour variation of *Arumatia dubia* (Caudell, 1904) gen. et comb. nov., showing metathorax and median segment of females. **A–B.** ♀ (MZUSP V0561) from Ibaté when nymph (A) or adult (B); **C–E.** Adult ♀♀ from Ibaté (C: MZUSP V0542, D: MZUSP V0558, E: MZUSP V0560). **F–H.** Adult (F) and subadult (G–H) ♀♀ from Chapadão do Sul (F: MZUSP V0563, G: MZUSP V0564, H: MZUSP V0565). **I–J.** Adult ♀♀ from Araguari (I: MZUSP V0547, J: MZUSP V0676). Scale bars: 1 mm.



FIFTH-INSTAR NYMPH. Subadult. Generally more similar to adults. Similar to fourth instar, except for: thorax slightly wider than in adults (Fig. 13G–H, compare with adults in Fig. 13B–E). Gonapophyses and gonoplac slightly longer. Subgenital plate exceeding base of gonapophyses IX, from not totally covering them nor gonoplacs to covering all valves except apex of gonoplac (Fig. 11D–E).

#### **Distribution** (Fig. 52)

*Arumatia dubia* gen. et comb. nov. occurs in different biomes of South America: savannah formations (Fig. 53C–D) and seasonal deciduous forests (Fig. 53A–B) of the Cerrado domain (Batalha 2011) in the Southeast and Central-West regions of Brazil and the Humid Chaco of Paraguay. All these biomes share significant characteristics and are part of the South American Dry Diagonal (Vanzolini 1963; Prado & Gibbs 1993; Collevatti *et al.* 2020) with markedly dry seasons and deciduous vegetation. It also occurs in Cerrado seasonal forests in contact areas with the Atlantic Forest. In Brazil, *A. dubia* is known from Paraná, São Paulo, Minas Gerais, Mato Grosso do Sul and Goiás States, and in Paraguay from Paraguari Department (Fig. 52). One examined specimen is recorded from Londrina (Paraná), where the Atlantic Forest dominates, but there are savannic and deciduous seasonal forest (Cerrado) enclaves in the region (Estevan *et al.* 2016), meaning that this record does not exclude the hypothesis that *A. dubia* is endemic to savannah, shrubland and deciduous seasonal forest ecoregions in the Brazilian Cerrado and Paraguayan Chaco. The currently known distribution is very likely to increase with further sampling effort. We disregard previous records of the species from Australia agreeing with Brock & Hasenpusch (2009) (see Remarks).

#### **Sexuality of the species**

All specimens of *Arumatia dubia* gen. et comb. nov. reared by us from different localities are parthenogenetic and no males are known so far. Additionally, we did not find any specimen that could represent a male of *A. dubia* in the visited collections matching the known or an expected distribution of the species. This is also true for iNaturalist photographic records. It is quite likely that *Arumatia* gen. nov. presents exclusively natural parthenogenetic populations or even entire species, which is a possible and previously recorded condition for phasmids such as is known for most or some species in the genera *Acanthoxyla* in New Zealand (Uvarov 1944; Myers *et al.* 2013) or *Bacillus* Berthold, 1827 in Europe (Berthold 1827; Scali *et al.* 2003). All sightings of *A. dubia* in nature consisted of females even when found in abundance. A factor that could be related to the evolution of parthenogenesis in this lineage is the short egg incubation period observed for *A. dubia* (2–3 months). The eggs of facultative parthenogenetic individuals or populations of sexual phasmid species take considerably longer to hatch (Bedford 1978; VMG, PWE & PABAN pers. obs.). Another possible factor is the absence of a praeopercular organ, contrasting with its presence in *A. aramatia* gen. et sp. nov. and *A. motenata* gen. et sp. nov., both species with known males. This organ serves as an attachment for the male vomer so a historical absence of males could have led to the loss of such a structure. *Arumatia anyami* gen. et sp. nov., *A. diamante* gen. et sp. nov. and *A. crassicercata* gen. et sp. nov. are also known by females only, the former also lacking a praeopercular organ. This might suggest parthenogenesis to be present in other species of *Arumatia* gen. nov. as well.

#### **Biology**

In Chapadão do Sul (MT), Assis (SP) and Araguari (MG), specimens were found in natural areas feeding on plants of the subfamily Mimosoideae (Fabaceae). In captivity, they also fed on the Fabaceae plants *Anadenanthera* Speg. spp. and *Parapiptadenia rigida* (Benth.) Brenan (angico trees), *Chamaecrista flexuosa* (L.) Greene (sensitive pea), the Myrtaceae plants *Psidium guajava* L. (guava) and *Eugenia uniflora* L. (Brazilian cherry), and the Sapindaceae plant *Serjania* Mill. sp., all native to Brazil and occurring in the Cerrado and adjacent biomes.

Several reared specimens were observed to drastically change colour between green, orange or brown. This change was observed both gradually during moults and in adult specimens that changed colour in

a few days. The female V0561 from Ibaté (SP) was orangish when pre-subadult (Fig. 13A) and turned green when adult (Figs 2D–E, 13B). The female V0547 from Araguari (MG) was light green when found already as an adult (Fig. 2C) and later turned greenish brown (Fig. 1A, adult individual) and to orangish brown before dying (Figs 6A, 7A–C, 13I).

The female V0561 was kept in an open area from the fifth instar until adult from 16 April 2021 to 17 August 2021 with access to ca 10 plant vases, including the host plant species *C. flexuosa* and *P. guajava*. The insect was observed every day and night. It hid in typical camouflage posture during the day (Fig. 2D–E) and foraged at night, never going further than one meter from the host plants. At night, even if not walking away from the spot where it stayed by day, it kept its body away from the resting surface and held the antennae up and apart (similar to specimens in Fig. 2A, C). During daytime, it usually hid in different spots, among leaves and branches either atop, on the side or under branches, near the surface of cactuses (Fig. 2E) or large leaves, on the side of vases and less frequently on a thin branch with all legs close to the body (Fig. 2D). The guava plant was strongly preferred, as the phasmid totally ignored the sensitive pea most of the nights. The insect fed on parts of random leaves of the guava plant, and a few times on some leaves and flowers of the sensitive pea.

When handled, both nymphs and adults of *Arumatia dubia* gen. et comb. nov. display agitated behaviour, quickly walking frenetically away without stopping, which also happens frequently when the rearing cage is opened.

Eggs of this species have a somewhat short incubation period with most eggs hatching within 50–70 days and having a high hatching rate (> 70%). Eggs require infrequent watering to hatch with higher rates resulting from spraying 2–3 × to 0.5–1 × a week, which configures a lesser humidity requirement in comparison with many other phasmids from Southeast Brazil (pers. obs.). Some eggs were tracked for development: seven of a few dozen eggs laid in 18–30 January 2021 by female V0547 from Araguari hatched 6–10 April 2021; only four nymphs survived and moulted from first to second instar from 2 to 5 May 2021; from second to third in the period 23–25 May 2021; from third to fourth on 18 June 2021; from fourth to fifth in the period 10–14 July 2021; and from fifth to sixth in the period 9–12 August 2021, when they became adults. Three nymphs that hatched around 10 December 2021 from the stock from Ibaté were also tracked, presenting a quicker development probably due to the warmer season in which they developed: they moulted to second instar from 28 December to 4 October; to third instar in the period 9–16 October; to fourth from 16 to 30 October; to fifth from 30 October to 12 November; and to sixth from 11 to 25 November.

*Arumatia fulgens* (Zompro, 2004) gen. et comb. nov.

*Echetlus fulgens* Zompro, 2004: 137.

*Echetlus fulgens* – Zompro & Domenico 2005: 257. — Otte & Brock 2005: 132. — Zompro *et al.* 2006: 131. — Araujo & Garraffoni 2012: 235.

**Remarks**

The holotype was deposited in the Museu Paraense Emílio Goeldi but has been on loan since 2004 (O.T. Silveira, pers. comm., 2022). Therefore, we could not examine the holotype except for the low-resolution picture available in Zompro (2004b). According to Zompro (2004b), this species is very similar to *Arumatia dubia* gen. et comb. nov. with which it shares the median segment as long as the metanotum, and the very elongate cerci and basitarsi, traits that can be confirmed from the holotype picture. According to Zompro's (2004b) description and diagnosis, *A. fulgens* gen. et comb. nov. differs from *A. dubia* by the stouter body and the longer subgenital plate reaching the end of tergum X, features that are not visible in the picture. However, both in the description and in the picture, a striking feature



is the much longer cerci than that of other species of *Arumatia* Ghiorotto gen. nov. in comparison with the last terga. Zompro (2004b) also pointed out the black longitudinal dorsal line on the body as a diagnostic feature of *A. fulgens*, but the female holotype of *A. aramatia* gen. et sp. nov. and some specimens of *A. dubia* also present such a line or similar longitudinal markings (Figs 13A, F, 25). *Arumatia fulgens* is recorded from the seasonal forest of the Cerrado in Estação Ecológica Serra das Araras near Barra do Bugres, Mato Grosso state, Brazil (Fig. 52).

*Arumatia anyami* Ghiorotto, Crispino & Neves gen. et sp. nov.

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Figs 14–18, 52

## Diagnosis

### Females

From *Arumatia fulgens* gen. et comb. nov. it differs by a shorter median segment ca  $\frac{3}{4}$  the length of the metanotum, the slightly shorter cerci and the lack of a black dorsal line. From *A. dubia* gen. et comb. nov. it differs by the presence of a black spot on the ventral region of the prothorax, a shorter median segment ca  $\frac{3}{4}$  the length of the metanotum, the more homogeneous and less spiniform setae at the apex of the carinae of the tibiae, the longer subgenital plate, the smaller epiproct, the more emarginate posterior margin of the anal segment, shorter and less tapering cerci, tergum VII with posterior margin just gently widened, longer gonapophyses VIII and a thicker gonoplac. Some mouthparts differ between the two species, as *A. anyami* gen. et sp. nov. has a different microtrichia pattern as a circle on the galea and not a band and has slightly more setae on the lacinia, a thicker galea and thicker labial palp segments than *A. dubia*. From *A. crassicerca* gen. et sp. nov. it differs by the lack of a praeopercular organ, longer cerci and slightly thinner legs. *Arumatia anyami* gen. et sp. nov. also has a thicker galea and thicker labial palp segments than those of *A. crassicerca*. From *A. aramatia* gen. et sp. nov. it differs by a shorter and less elongate head, a shorter median segment ca  $\frac{3}{4}$  the length of the metanotum, the more homogeneous and less spiniform setae at the apex of the carinae of the tibiae, the emarginate posterior margin of tergum X, the slightly longer subgenital plate, the lack of praeopercular organ, the shorter gonoplac and gonapophyses IX and longer gonapophyses VIII. From *A. motenata* gen. et sp. nov. and *A. diamante* gen. et sp. nov. it differs by the shorter, less elongate head, the wider galea, the absence of an apical sessile spine on the apex of the ventral, antero- and posteroventral carinae of the tibiae, the more emarginate posterior margin of tergum X, the shorter epiproct, the longer subgenital plate and the absence of praeopercular organ.

### Eggs

The eggs of *Arumatia anyami* gen. et sp. nov. have a ridged capsule differing from those of all other species of *Arumatia* gen. nov.

## Etymology

As a science communication initiative, several possible epithets for the species were put forward for voting by students and teachers at a Brazilian school in São Paulo, São Paulo State. The winning epithet was ‘*anyami*’, composed of the words ‘*an*’, meaning ‘ghost’ or ‘shadow’, and ‘*yami*’, meaning ‘night’, both from Tupi-Guarani, a South American indigenous language. The name is to be treated as a noun in apposition and refers to the nocturnal and cryptic habit of stick insects, which also inspired the ordinal name Phasmatodea.

## Material examined

### Holotype

BRAZIL • ♀; Rondônia, Costa Marques, Forte Príncipe da Beira; 12°25'40.8" S, 64°25'23.4" W; 26 Nov. 1967; G.R. Kloss leg.; E040; MZUSP 1091.

### Paratypes

BRAZIL • 4 ♀♀; same collection data as for holotype; MZUSP 1090, MZUSP 1319, MZUSP 1320, MZUSP 1321 • eggs; same collection data as for holotype; MZUSP.

## Description

### Female (holotype, MZUSP 1091)

MEASUREMENTS (in mm). Body (without cerci) 91.9, head 4.0, antennae at least 45, pronotum 3.2, mesonotum 20.7, metanotum 8.3, median segment 5.5, abdomen (excluding median segment) 50.2, cercus 5.4, profemur 22.6, protibia 22.7, mesofemur 15.5, mesotibia 14.8, metafemur 19.5, metatibia 20.6.

COLOUR (Fig. 14). Known only from aged preserved specimens. Entirely green to pale yellow, eyes dark brown, profurcasternum dark.

HEAD (Fig. 15). Elongate, smooth and with sparse setae mostly on dorsal region. Vertex flat but very gently convex at posterior margin to fit underneath pronotum, frontal convexity developed, frontal suture round. Eyes small, slightly elongate, approximately  $0.2 \times$  length of head. Cervix covering about half length of head, cervical sclerites developed. Gula slightly tapering posteriorly, bearing setae and covering ca more than half of cervix. Subgena narrow with posterior projection at ca height of middle of eye. Submentum narrow and curved towards posterior, mentum simple and prementum somewhat wide. Glossa elongate and rounded, paraglossa larger, roundly falcate, almost reaching labrum. Lacinia with three distal teeth, one large medially and two smaller laterally, mesal edge bearing bundles of ca 20 large setae from base to sclerotized portion. Galea broad, roundly elliptical, bearing long setae, apically with dense round tuft of hairy and large microtrichia with few distinct circular granules present dorsally and posteriad to this patch (Fig. 15D). Galealobulus present, small, widely round and basally fused to galea (Fig. 15D). Maxillary palpal segments cylindrical, labial slightly widened. Clypeus wide, approximately elliptical. Labrum strongly notched anteromedially. Left mandible with two smooth and straight edges, dorsal cutting edge sharp, ventral edge blunt, mesal surface with convex globose protuberance near ventral cutting edge and sinuous furrow between both edges. Right mandible with sharp dorsal cutting edge, straight but interrupted at border with ventral edge by round edge, ventral edge irregular, level and molariform with two projections, without protuberances on mesal surface. Both mandibles with dense row of long setae at base of dorsal margin. Antennae filiform with at least 45 segments, reaching or exceeding posterior margin of median segment (Fig. 15A–C). Scapus ca  $1.7 \times$  as long as wide, basally constricted in dorsal view, slightly compressed dorsoventrally. Pedicellus subglobose, large, slightly longer than half length of scapus. Antennal bump very discrete dorsally on posterior region of 12<sup>th</sup> antennomere.

THORAX (Figs 14, 15A–C, 16A). Smooth with scattered dispersed setae inserted in paler small dots. Pronotum longer than wide, slightly constricted pre-medially and slightly wider from transverse sulcus towards anterior margin, fairly flat in lateral view. Transverse sulcus of pronotum conspicuous and forwardly curved towards anterior, longitudinal sulcus conspicuous and distinct. Paranota curved, slightly narrower medially and ca  $3 \times$  as long as wide, procoxopleurite apically round and ventrally concave (Fig. 15A–C). Probasisternum strongly tapering towards anterior, with two thin apices on anterior margin, profurcasternum round (Fig. 15C). Mesothorax  $6.5 \times$  as long as prothorax and as wide as prothorax, anteriorly slightly widening towards posterior region. Mesonotum with pair of distinct lateral

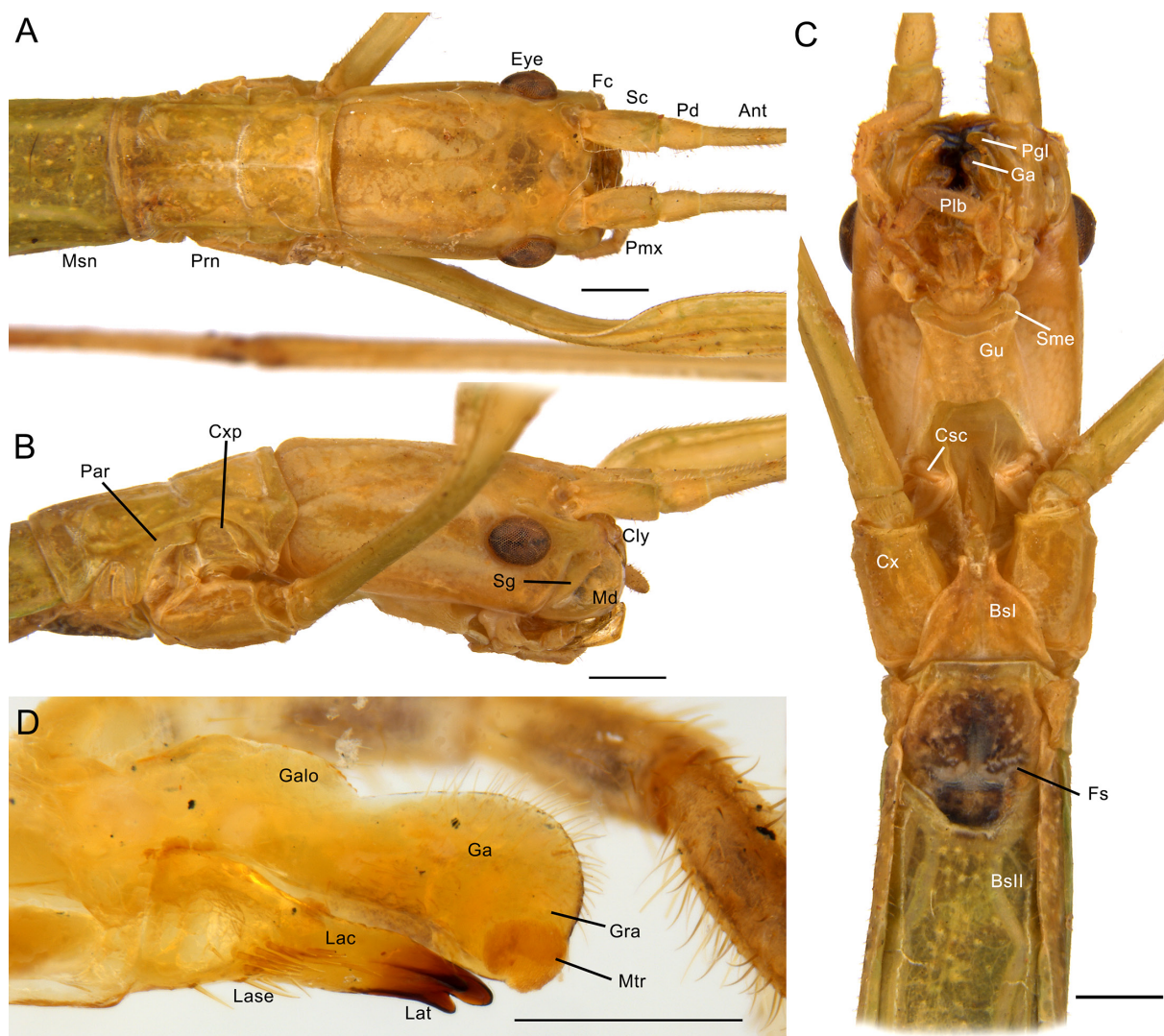
carinae, mesepisternum lanceolate and regularly widening posteriorly. Mesepimeron slightly elongate, pointing towards posterior and slightly exceeding posterior region of mesothorax, mesocoxopleurite indistinct, mesofurca Y-shaped (Fig. 14). Metathorax continuing the pair of lateral carinae of mesonotum, metepisternum long, similar to mesepisternum, metepimeron extremely elongate, extending across entire length of median segment, posteriorly pointing and slightly exceeding end of median segment. Metacoxopleurite very discrete but elongate, metafurca Y-shaped (Fig. 14). Metanotum  $1.5\times$  as long as median segment (Fig. 16A). Median segment anteriorly marked by two lateral short and slender transversal dark markings (Fig. 16A) and continuing the pair of thoracic lateral carinae.

LEGS (Figs 14, 15A–C, 16). Slender. Hindlegs slightly extending beyond epiproct but not cerci, anterior legs slightly longer than hindlegs, midlegs distinctly shorter. Coxae slightly elongate and smooth (Fig. 15B–C). Profemora slightly longer than mesothorax, mesofemora about  $0.7\times$  as long as profemora, metafemora slightly shorter than mesothorax. Protibia slightly longer than profemur, mesotibia slightly shorter than mesofemur, metatibia slightly longer than metafemur (Fig. 14). Profemur presenting distinct basal curvature (Figs 14, 15A–B). Femora and tibiae with five carinae without setae among them. Carinae of femora and tibiae distinctly keeled. Antero- and posteroventral carinae of femora with distinct apical toothed prominence. Carinae of all femora, tibiae and basitarsi bearing row of short setae



**Fig. 14.** *Arumatia anyami* Ghiorotto, Crispino & Neves gen. et sp. nov., holotype, ♀ (MZUSP 1091). A. Dorsal view. B. Lateral view. C. Ventral view. Scale bar: 10 mm.

slightly stouter on posterior region of meso- and metatibiae, stronger on mesotibiae (Figs 14, 16B–D). All basitarsi very elongate, with pro- and metabasitarsi significantly longer than respective following tarsomeres combined and mesobasitarsi almost longer than respective following tarsomeres combined, with hairy setae restricted to apical portion in ventral patches (Fig. 16B–D). Remaining tarsomeres with setae on ventro-lateral patches in all portions not covered by euplantulae. Tarsomeres I–III with discrete dorsal round apical projection. Arolium round and broad, dorsally bearing setae. Pretarsal claws symmetrical, dorsally and outwardly with setae. Euplantulae well developed in all tarsomeres, composed of two symmetrical pads separated by median groove in tarsomeres I–III, of single pointing domed pad

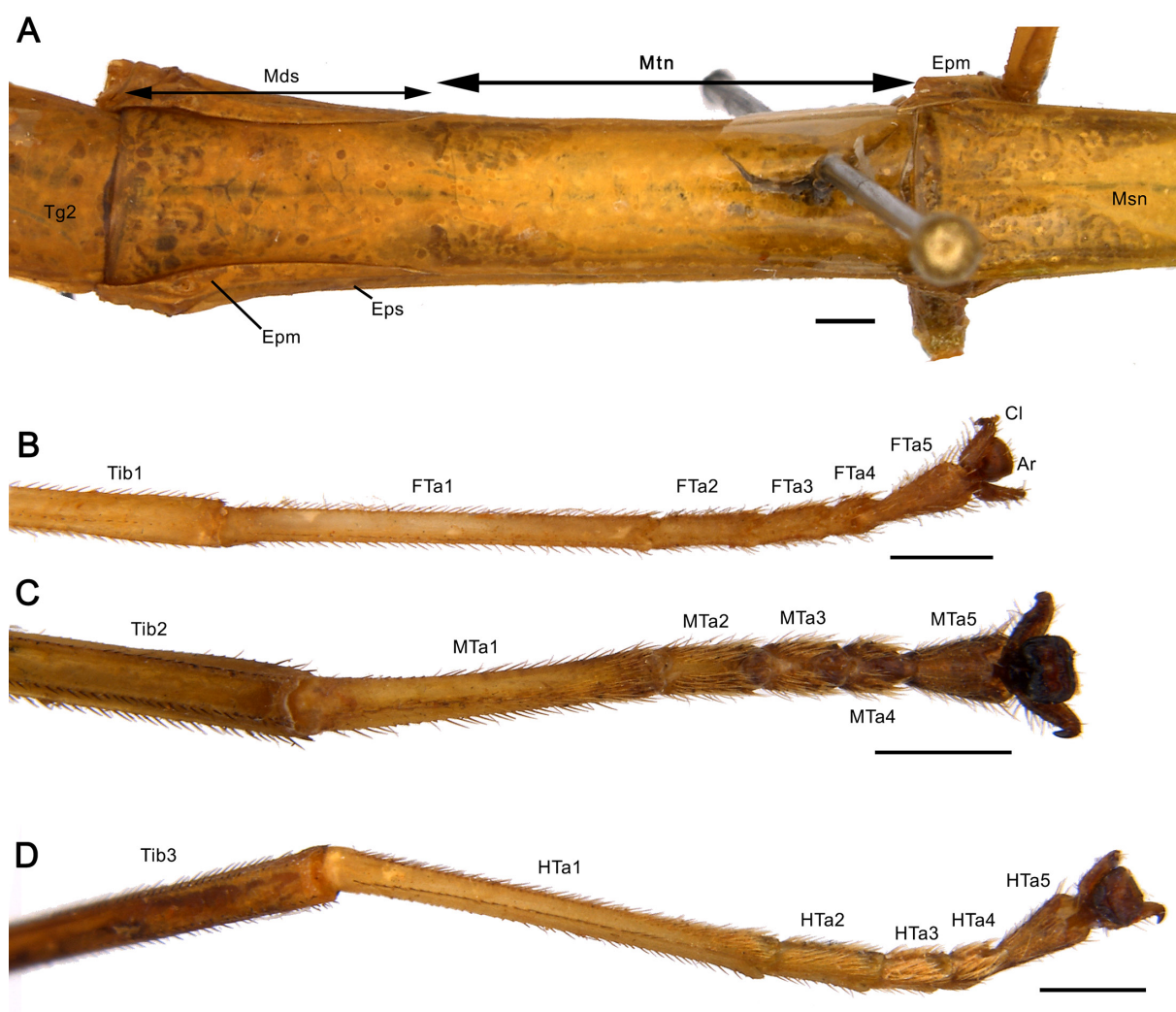


**Fig. 15.** *Arumatia anyami* Ghirotto, Crispino & Neves gen. et sp. nov., head and prothorax morphology. A–C. Holotype, ♀ (MZUSP 1091). D. Paratype (MZUSP 1320). A. Head and prothorax in dorsal view. B. Head and prothorax in lateral view. C. Head and prothorax in ventral view. D. Right maxilla, dorsal (internal) view. Abbreviations: Ant=antennomere; BsI-II=pro- and mesothoracic basisterna; Cly=clypeus; Csc=cervical sclerite; Cx=coxa; Cxp=coxopleurite; Eye=compound eye; Fc=frontal convexity; Fs=prothoracic furcasternite; Ga=galea; Galo=galealobulus; Gra=granules; Gu=gula; Lac=lacinia; Lase=lacinial setae; Lat=lacinial teeth; Md=mandible; Msn=mesonotum; Mtr=microtrichia; Par=paranota; Pd=pedicellus; Pgl=paraglossa; Plb=labial palpus; Pmx=maxillary palpus; Prn=pronotum; Sc=scapus; Sg=subgena; Sme=submentum. Scale bars: A–C=1 mm; D=0.5 mm.



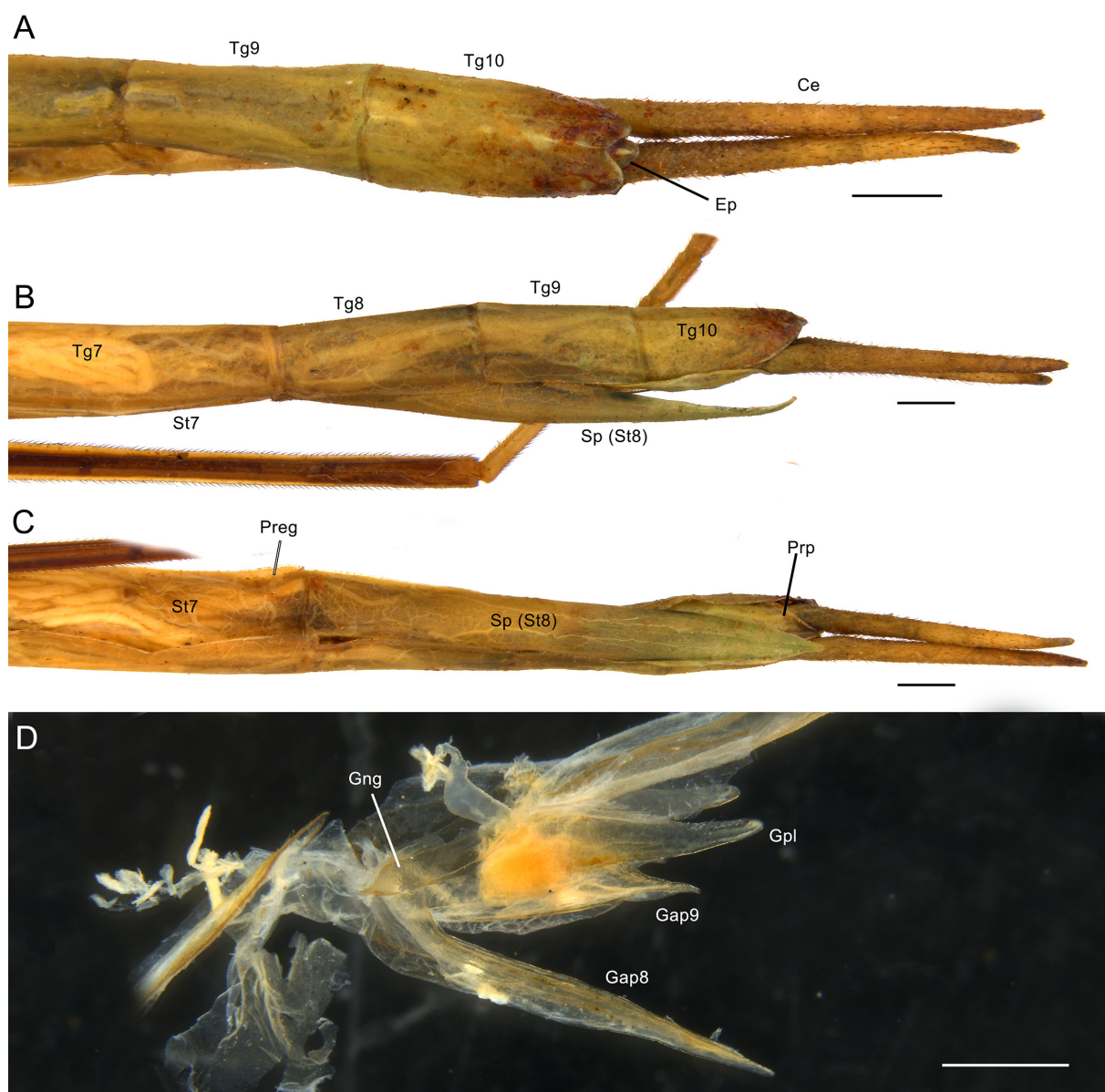
in tarsomeres IV and of single flattened lobed pad in tarsomeres V. Euplantulae present only apically at tarsomeres I–II, covering ca half or less the length of tarsomeres III, covering two thirds the length of tarsomeres IV and covering almost entire ventral surface of tarsomeres V (Fig. 16B–D).

ABDOMEN (Figs 14, 17). External surface as in thorax, bearing few setae across its entire length. Median segment shorter than metanotum (Fig. 16A). Combined length of segments II–X slightly longer than combined length of head, thorax and median segment. Terga II–VII and sterna II–VIII bear discrete lateral carinae near lateral margins. All segments longer than wide. Segments II and III as long as VI and slightly longer than VII, segments IV–V slightly longer than III, tergum VIII significantly shorter than preceding segment and slightly longer than IX, tergum IX ca as long as X. Lateral borders of tergum VII gently curving downwards and inwards near posterior margin. Tergum X just slightly narrower towards apex in dorsal view, posterior margin distinctly emarginate with right-angled indent showing



**Fig. 16.** *Arumatia anyami* Ghiorotto, Crispino & Neves gen. et sp. nov., holotype, ♀ (MZUSP 1091), thorax and leg morphology. **A.** Metathorax and median segment in dorsal view, arrows indicate the length of each segment. **B.** Right fore tarsus, dorsal view. **C.** Right mid tarsus, ventral view. **D.** Right hind tarsus, posteroventral view. Abbreviations: Ar=arolium; Cl=claw; Epm=epimeron; Eps=episternum; FTa=fore tarsomere; HTa=hind tarsomere; Mds=median segment; Msn=mesonotum; MTa=mid tarsomere; Mtn=metanotum; Tg=tergum; Tib=tibia. Scale bars: 1 mm.

epiproct (Fig. 17A–B). Epiproct small, domed in dorsal view, dorsoventrally flattened, prominent, slightly exceeding posteriormost margins of tergum X and visible dorsally, barely laterally (Fig. 17A–B). Paraprocts elongate, bearing setae, posteriorly acute and straight (Fig. 17B–C). Cerci extremely elongate, straight, basally narrower, fitting paraprocts, pointing to posterior, cylindrical and tapering only posteriorly and slightly shorter than terga IX and X combined (Fig. 17A–C). Praeopercular organ absent (Fig. 17C). Subgenital plate lanceolate, acute, reaching posterior margin of tergum X, gradually tapering towards posterior and totally covering gonapophyses and gonoplac (Fig. 17C). Gonapophyses and gonoplac flattened, dorsoventrally for gonapophyses VIII, lateroventrally for IX and laterally for gonoplac (Fig. 17D). Gonapophyses VIII longer than IX and slightly longer than gonoplac, slightly



**Fig. 17.** *Arumatia anyami* Ghirotto, Crispino & Neves gen. et sp. nov., terminalia morphology. A–C. Holotype, ♀ (MZUSP 1091). D. Paratype (MZUSP 1320). A. Dorsal view. B. Lateral view. C. Ventral view. D. Dissected genitalia treated with KOH, lateral view. Abbreviations: Ce=cercus; Ep=epiproct; Gap=gonapophysis; Gng=gonangulum; Gpl=gonoplac; Preg=praeopercular region; Prp=paraproct; Sp=subgenital plate; St=sternum; Tg=tergum. Scale bars: 1.0 mm.



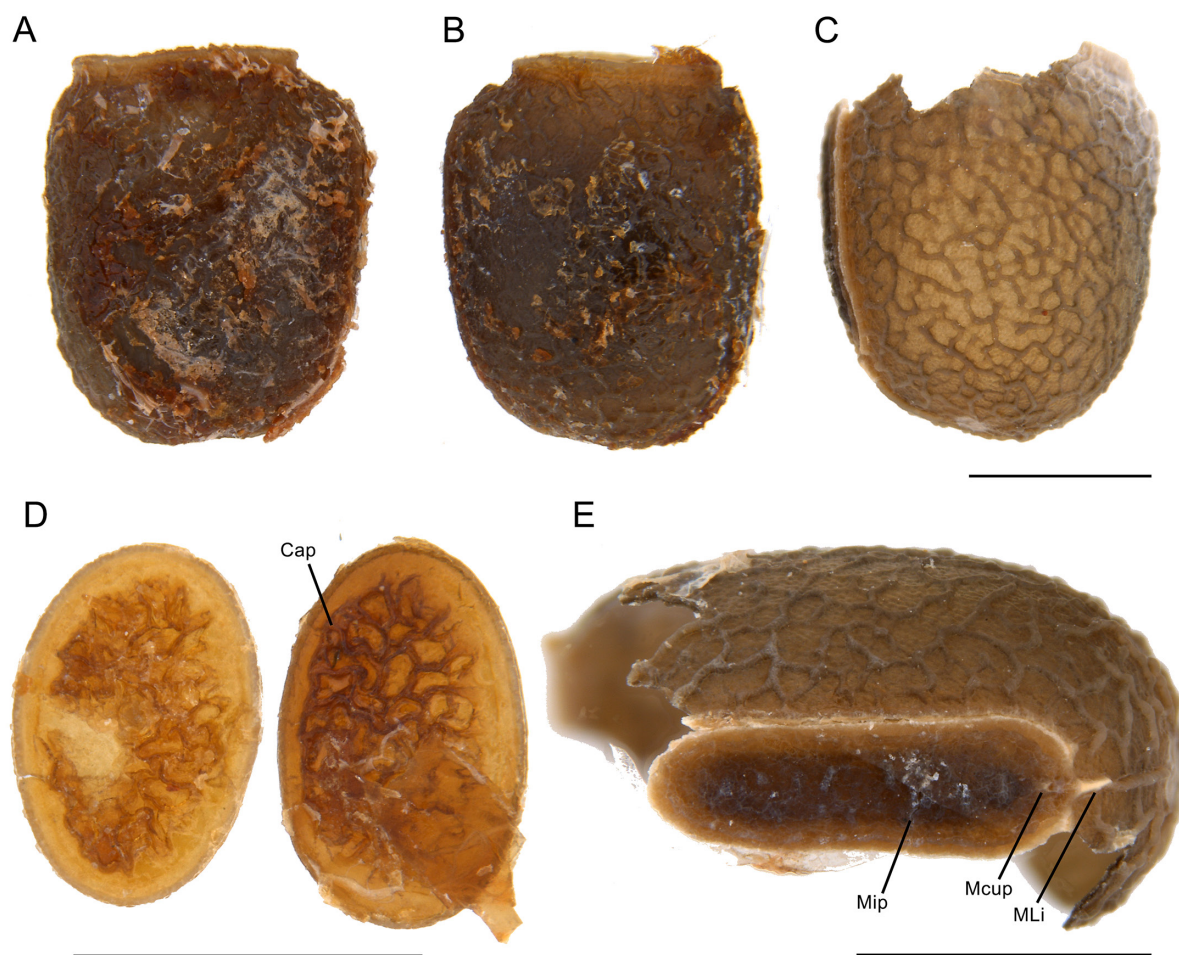
exceeding anterior margin of tergum X, gonapophyses IX reaching  $\frac{3}{4}$  the length of tergum IX. Gonapophyses VIII very elongate, somewhat narrow and linear, IX conical, short and abruptly tapering towards posterior (Fig. 17D). Gonapophyses IX ventrally folded to fit within gonapophyses VIII. Gonangulum distinctly reduced, flat. Gonoplac elongate, somewhat lorate, slightly tapering towards posterior, bearing setae, exceeding gonapophyses IX but not VIII and reaching ca anterior margin of tergum X (Fig. 17D).

#### Paratypes

Measurements (in mm, N = 3): body 88.1–90, head 4–4.8, antennae 40.5, pronotum 3–3.3, mesonotum 20.8–21.5, metanotum 7.4–7.8, median segment 5.2–5.6, abdomen (excluding median segment) 48.1–50.2, cercus 4.9–5.4, profemur 22.4–23.3, protibia 21.3–22.1, mesofemur 14.2–15, mesotibia 13.8–14.8, metafemur 18.9–19.7, metatibia 20–20.4.

#### Egg (Fig. 18)

Measurements (in mm, N = 2): length 2.3–2.4, height 1.7–1.8, width 1.5. Relatively small, capsule subrectangular to ovoid, constricted at opercular collar (Fig. 18A–B), gently compressed laterally



**Fig. 18.** *Arumatia anyami* Ghirotto, Crispino & Neves gen. et sp. nov., egg morphology. **A–B.** Lateral view. **C.** Posterolateral view of broken egg. **D.** Two detached operculi in anterior view. **E.** Dorsal view of broken egg. Abbreviations: Cap=capitulum; Mcup=micropylar cup; Mip=micropylar plate; MLi=median line. Scale bars: 1 mm.



(Fig. 18E) and ca  $1.8\times$  as long as wide and  $1.3\times$  as long as tall. Mid to dark brown. Capsule surface roughly textured with small irregular reticulate ridges (Fig. 18C, E). Micropylar plate elongate, occupying large area of dorsal region, elliptical with parallel sides and round margins (Fig. 18E). Micropylar plate with lighter elevated outer circle delimiting darker inner flat region confluent with micropylar cup. Micropylar cup small, rounded and only slightly elevated. Median line short, same colour and elevation as elevated margin of micropylar plate (Fig. 18E). Opercular collar narrower (constricted) than rest of capsule, with minute and delicate bristles surrounding edge. Operculum elliptical, with a short irregular reticulated elevation composing non-stalked capitulum (Fig. 18D).

#### **Distribution** (Fig. 52)

Known only from the type locality, Forte Príncipe da Beira, Costa Marques, Rondônia, Brazil, along the border with Bolivia along the Guaporé River in the Amazon Forest. Interestingly, the type locality is influenced by and in very close contact with the Beni savannahs of Bolivia (Fig. 52), which lie right at the other margin of the Guaporé River. There are also smaller patches of savannah formations in nearby areas at Costa Marques and it is uncertain whether individuals were collected in fully forested areas or in savannah formations.

*Arumatia crassicercata* Ghirotto, Crispino & Engelking gen. et sp. nov.

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Figs 19–24, 52, 53E

#### **Diagnosis**

##### **Females**

From *Arumatia fulgens* gen. et comb. nov. it differs by the thicker and prominently keeled legs, the shorter median segment, the slightly shorter subgenital plate, the shorter and thicker cerci, the presence of a praeopercular organ, the lack of a black dorsal line and the thinner body. From *A. anyami* gen. et sp. nov. it differs by the lack of a conspicuous black spot on the ventral region of the prothorax, slightly shorter subgenital plate, smaller epiproct, shorter cerci, the posterior margin of anal segment less emarginate, the presence of a praeopercular organ and shorter gonapophyses VIII and IX. Some mouthparts differ between the two species, as *A. crassicercata* gen. et sp. nov. has a narrower galea and narrower labial palp segments than those of *A. anyami*. From *A. dubia* gen. et comb. nov. it differs by the presence of a praeopercular organ, a shorter median segment, shorter and thicker cerci and thicker legs with more prominent keels. *Arumatia crassicercata* also has slightly more setae on the lacinia than *A. dubia*, and the microtrichia on the galea are arranged in a shorter patch and forming a circle, not a band. From *A. aramatia* gen. et sp. nov. it differs by the shorter, less elongate head, the more elongate galea, the longer median segment in relation to the metanotum, the emarginate posterior margin of tergum X, the shorter and thicker cerci, and the shorter gonapophyses IX. From *A. motenata* gen. et sp. nov. and *A. diamante* gen. et sp. nov. it differs by the shorter, less elongate head, the longer median segment as long as the metanotum, the presence of stronger spiniform setae on the carinae of the tarsi and on the apex of mid and hind tibiae, the absence of an apical sessile spine on the apex of ventral, antero- and posteroventral carinae of tibiae, the shorter and thicker cerci and the shorter epiproct, the longer subgenital plate, the narrower gonoplac and the shorter gonapophyses VIII and IX.

##### **Eggs**

The egg of *Arumatia crassicercata* gen. et sp. nov. has a smoother capsule than that of *A. anyami* gen. et sp. nov., shown as a finely punctuated texture, a more parallel-sided posteriormost region of the micropylar plate, and a micropylar plate more convex in lateral view than that of *A. dubia* gen. et comb. nov., a netted rather than radial capitulum present on the egg of *A. aramatia* gen. et sp. nov.,

*A. motenata* gen. et sp. nov. and *A. diamante* gen. et sp. nov., additionally to the more expanded whitish stain around the micropylar plate than that of *A. motenata*, from the polar region to the opercular collar.

### Etymology

This species is named after its thick and untapering cerci, which readily differentiate it from other species of the genus. The name is an adjective derived from the Latin words ‘*crassus*’ (= ‘thick’) and ‘*cercus*’.

### Material examined

#### Holotype

BRAZIL • ♀; Goiânia, Chapada dos Veadeiros, Alto Paraíso de Goiás, Trilha da Cachoeira do Segredo; 14°15'37" S, 47°52'11" W; 31 Dec. 2016–1 Jan. 2017; P.I. Chiquetto-Machado and A.Z. Ramin leg.; MZUSP 0812.

#### Paratypes

BRAZIL • 3 ♀♀; same collection data as for holotype; MZUSP 0813, 0814, 0871 • eggs; same collection data as for holotype; MZUSP.

### Description

#### Female (holotype, MZUSP 0812)

MEASUREMENTS (in mm). Body (without cerci) 66.65, head 3.75, antennae at least 38, pronotum 2.1, mesonotum 16.1, metanotum 6.0, median segment 3.7, abdomen (excluding median segment) 33.0, cercus 2.25, profemur 4.1, protibia 16.8, mesofemur 9.9, mesotibia 10.0, metafemur 12.1, metatibia 14.2.

COLOUR (Figs 19–20). Entirely green. Eyes yellowish to brown. Antennae darker ventrally. Apical segments of palp and other mouthparts brownish to beige.

HEAD (Fig. 21). Somewhat elongate, slightly bulky, smooth and with sparse setae mostly on dorsal region. Vertex flat but gently convex at posterior margin to fit underneath the pronotum, frontal convexity developed and frontal suture pyramidal (Fig. 21A–B). Eyes small and slightly elongate, approximately 0.17 × as long as head (Fig. 21B). Cervix covering more than half length of head, cervical sclerites weakly sclerotized, gula somewhat spatulate, bearing setae and covering ca more than half of cervix (Fig. 21C). Subgena narrow with posterior projection ca height of middle of eye. Submentum narrow, only slightly curved backwards, mentum simple, prementum somewhat wide (Fig. 21C). Glossa elongate, rounded, paraglossa larger, roundly falcate, almost reaching labrum. Lacinia with three distal teeth, one large medially and two smaller laterally, with mesal edge bearing bundles of ca 22 large setae from base to sclerotized portion (Fig. 21D). Lobe over base of lacinia almost indistinct. Galea elliptical and bearing long setae, apically with dense tuft of hairy, large microtrichia in round shape, dorsally and posteriorly to this patch ca 25 distinct circular granules of same diameter as setae base (Fig. 21D). Galealobulus present, widely round but gently protruding and basally fused to galea (Fig. 21D). Palpal segments cylindrical. Clypeus wide. Labrum strongly notched anteromedially. Antennae filiform, composed of at least 45 segments exceeding posterior margin of median segment (Fig. 21A–B). Scapus longer than wide, basally constricted in dorsal view, slightly compressed dorsoventrally, pedicellus subglobose and more than half length of scapus. Antennal bump very discrete dorsally on posterior region of 12<sup>th</sup> antennomere.

THORAX (Figs 19–20, 21A–C, 22A). Smooth with scattered setae. Pronotum very slightly longer than wide and slightly constricted pre-medially, fairly flat in lateral view, transverse sulcus conspicuous and

gently curved, longitudinal median sulcus distinct. Paranota curved, medially constricted, ca  $3\times$  as long as wide, procoxopleurite apically round (Fig. 21A–B). Probasisternum tapering towards anterior with two round apices on anterior margin, profurcasternum round (Fig. 21C). Mesothorax  $6\text{--}7\times$  as long as prothorax, as wide as prothorax anteriorly and slightly widening towards posterior region (Fig. 19). Mesonotum with pair of distinct lateral carinae, mesepisternum lanceolate and regularly widening posteriorly. Mesepimeron slightly elongate, pointing towards posterior and slightly exceeding end of mesothorax, mesocoxopleurite indistinct, mesofurca Y-shaped (Fig. 19). Metathorax continuing pair of lateral carinae of mesonotum, metepisternum long, similar to mesepisternum, metepimeron extremely elongate, extending across entire length of median segment, posteriorly pointing and slightly exceeding posterior margin of median segment (Fig. 22A). Metacoxopleurite very discrete, elongate, metafurca Y-shaped (Fig. 19). Metanotum  $1.6\times$  as long as median segment (Fig. 22A). Median segment anteriorly marked by two small ovoid parasagittal stains. Posterior margin of metanotum and anterior margin of median segment slightly widened (Fig. 20).

LEGS (Figs 20, 22). Slender. Hindlegs not extending beyond apex of abdomen, slightly longer than forelegs, midlegs distinctly shorter. Coxae smooth (Fig. 21A–C). Profemora ca as long as mesothorax,



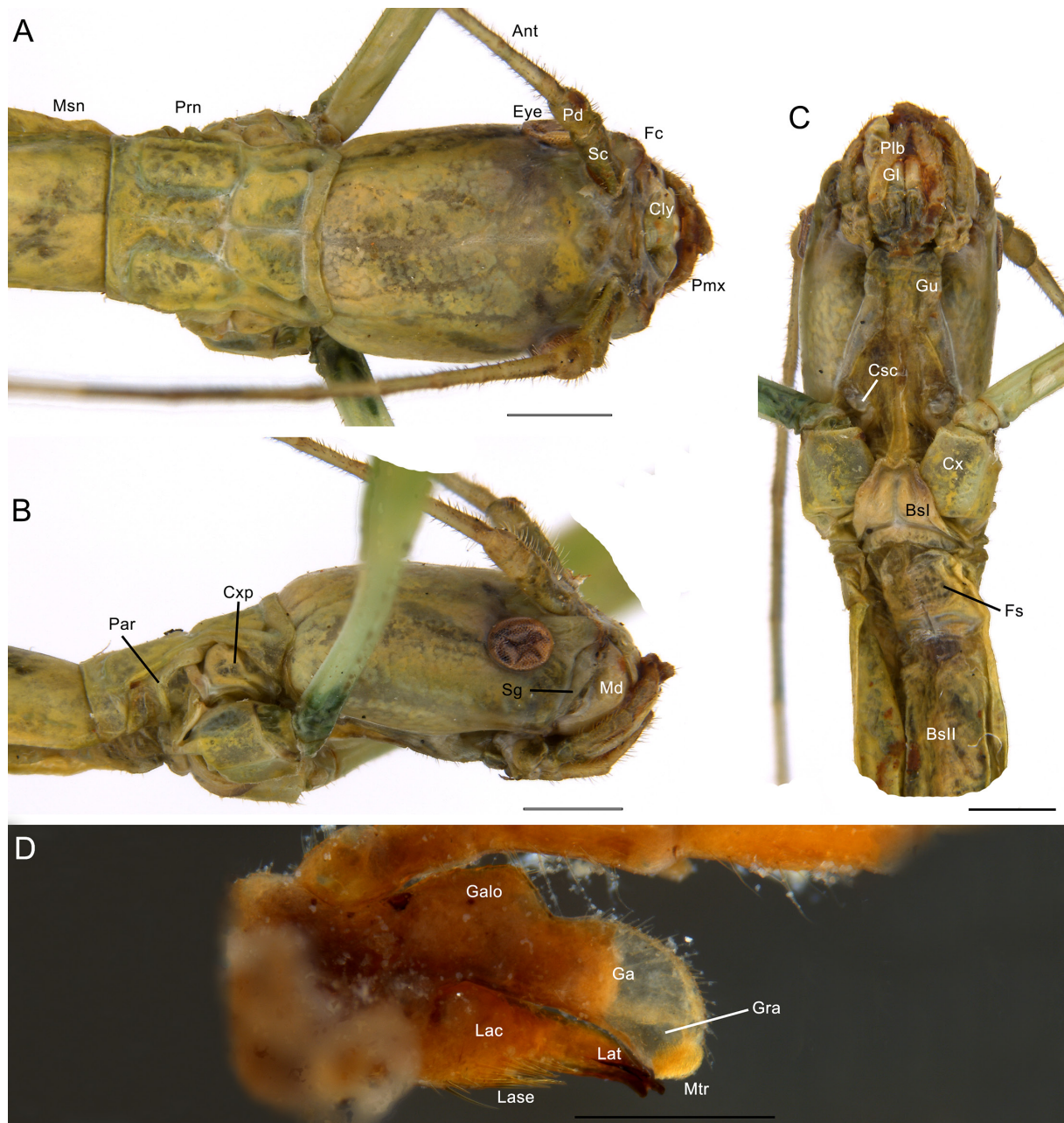
**Fig. 19.** *Arumatia crassicercata* Ghirotto, Crispino & Engelking gen. et sp. nov., holotype, ♀ (MZUSP 0812). **A.** Dorsal view. **B.** Lateral view. **C.** Ventral view. Scale bar: 10 mm.



mesofemora about  $0.6\times$  as long as profemora, metafemora shorter than mesothorax. Protibia slightly longer than profemur, mesotibia barely longer than mesofemur, metatibia slightly longer than metafemur. Profemur with distinct basal curvature (Figs 19–20, 21A–B). Femora and tibiae with five carinae without setae among them (Fig. 22B–E). Carinae of femora and tibiae prominently keeled (Figs 19–21). Antero- and posteroventral carinae of femora with round apical prominence. Carinae of all femora, tibiae and tarsi bearing row of short, somewhat stout setae, last two to three setae of all five carinae of meso- and metatibiae thicker and spiniform (Fig. 22B–E). In tarsi, setae present on ventral, antero- and posteroventral carinae distributed across entire length but apex. Tarsi setae on all carinae of probasitarsi short. Tarsi setae present on ventral, antero- and posteroventral carinae of meso- and metabasitarsi stouter while on mesobasitarsi, setae stronger and spiniform on these same carinae. All basitarsi very elongate, pro- and metabasitarsi significantly longer than respective following tarsomeres combined, mesobasitarsi as long as following tarsomeres combined (Fig. 22B–E), with setae restricted to apical portion on ventro-lateral patches. Remaining tarsomeres with setae on ventro-lateral patches in portions not covered by euplantulae. Arolium round and broad, bearing setae dorsally. Pretarsal claws symmetrical, dorsally and outwardly bearing setae. Euplantulae well developed in all tarsomeres, composed of two symmetrical pads separated by median groove in tarsomeres I–III, of single pointing domed pad in tarsomeres IV and of single flattened lobed pad in tarsomeres V. Euplantulae present only apically on tarsomeres I–II, covering ca half length of tarsomeres III, covering two thirds length of tarsomeres IV and covering almost entire ventral surface of tarsomeres V (Fig. 22B, C, E).



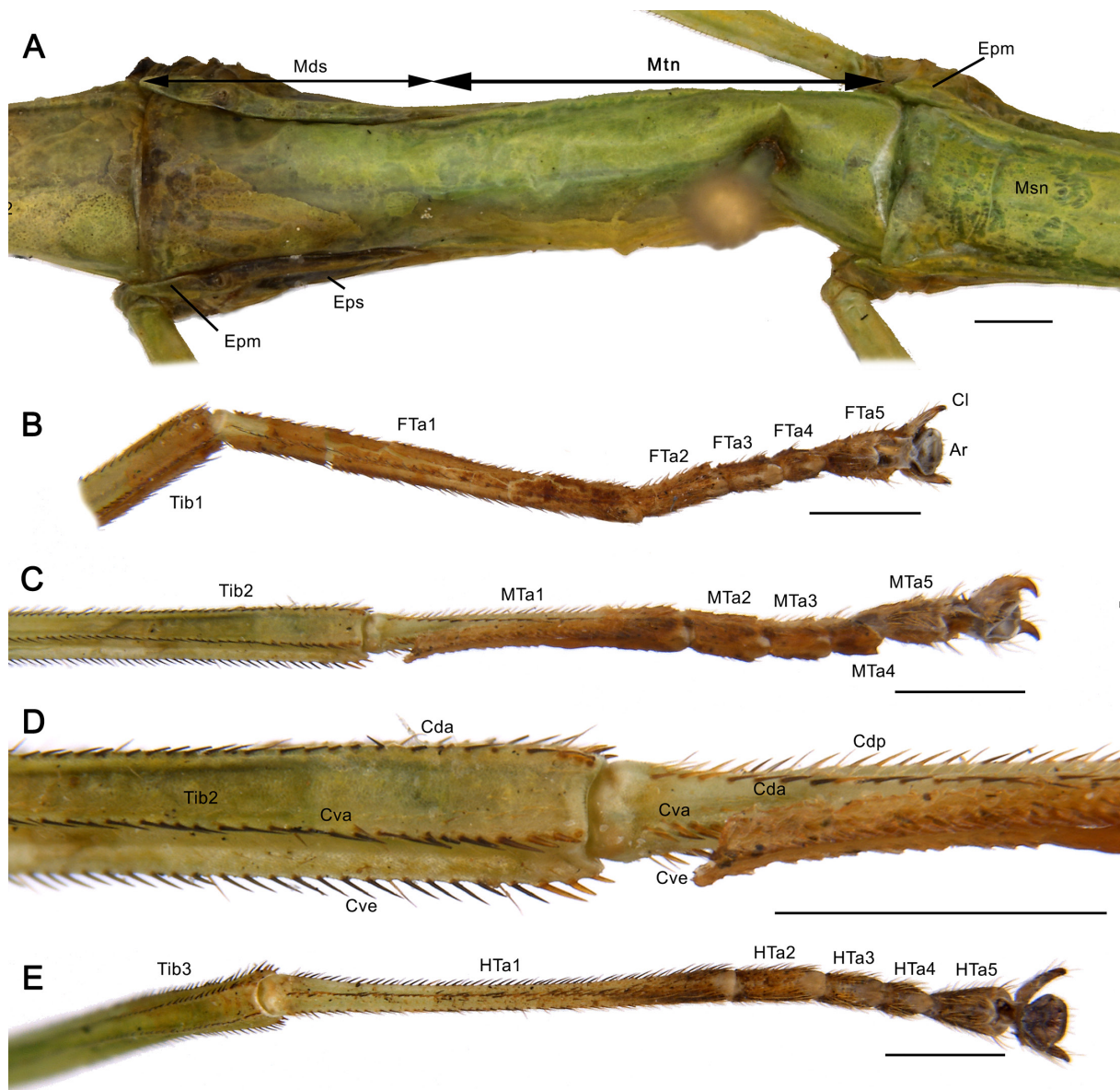
**Fig. 20.** *Arumatia crassicercata* Ghirotto, Crispino & Engelking gen. et sp. nov., live habitus of adult ♀ from Chapada dos Veadeiros, Goiás, Brazil.



**Fig. 21.** *Arumatia crassicercata* Ghirotto, Crispino & Engelking gen. et sp. nov., head and prothorax morphology. **A–C.** Holotype, ♀ (MZUSP 0812). **D.** Paratype (MZUSP 0871). **A.** Head and prothorax in dorsal view. **B.** Head and prothorax in lateral view. **C.** Head and prothorax in ventral view. **D.** Right maxilla, dorsal (internal) view. Abbreviations: Ant=antennomere; Bsl-I-II=pro- and mesothoracic basisterna; Cly=clypeus; Csc=cervical sclerite; Cx=coxa; Cxp=coxopleurite; Eye=compound eye; Fc=frontal convexity; Fs=prothoracic furcasternite; Ga=galea; Galo=galealobulus; Gl=glossa; Gra=granules; Gu=gula; Lac=lacinia; Lase=lacinial setae; Lat=lacinial teeth; Md=mandible; Msn=mesonotum; Mtr=microtrichia; Par=paranota; Pd=pedicellus; Plb=labial palpus; Pmx=maxillary palpus; Prn=pronotum; Sc=scapus; Sg=subgena. Scale bars: A–C=1 mm; D=0.5 mm.



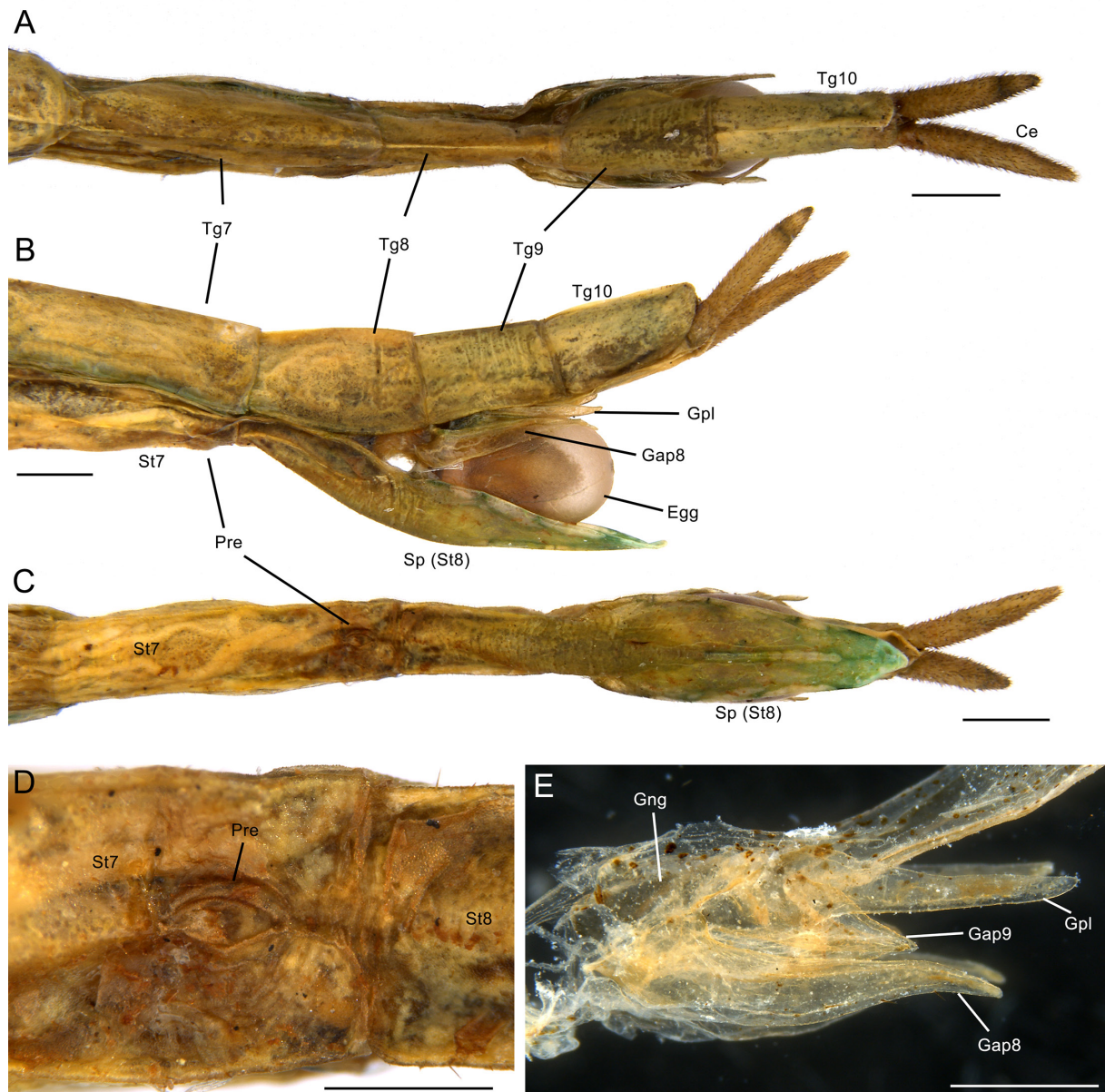
ABDOMEN (Figs 19–20, 23). External surface as in thorax bearing few setae across entire length. Median segment shorter than metanotum (Fig. 22A). Combined length of segments II–X slightly longer than combined length of head, thorax and median segment. Terga II–VII and sterna II–VIII bearing discrete lateral carinae near lateral margins. All segments longer than wide (Figs 19–20). Segment II as long as VII and slightly shorter than III, segments III and IV of ca same length, IV slightly shorter than V, V and VI of ca same length, tergum VIII significantly shorter than preceding segment, and barely longer than IX, tergum X slightly longer than IX and ca as long as VIII. Lateral borders of tergum



**Fig. 22.** *Arumatia crassicercata* Ghirotto, Crispino & Engelking gen. et sp. nov., holotype, ♀ (MZUSP 0812), thorax and leg morphology. **A.** Metathorax and median segment in dorsal view, arrows indicate the length of each segment. **B.** Right fore tarsus (mirrored), ventral view. **C–D.** Left mid tarsus, anteroventral view, detail in **D.** **E.** Right hind tarsus, ventral view. Abbreviations: Ar=arolium; Cda=dorsal anterior carina; Cdp=dorsal posterior carina; Cl=claw; Cva=ventral anterior carina; Cve=ventral carina; Epm=epimeron; Eps=episternum; FTa=fore tarsomere; HTa=hind tarsomere; Mds=median segment; Msn=mesonotum; MTa=mid tarsomere; Mtn=metanotum; Tib=tibia. Scale bars: 1 mm.



VII gently curving downwards and inwards near posterior margin. Tergum X dorsally just slightly narrower towards apex, with posterior margin gently emarginate (Fig. 23A). Epiproct barely visible, wide and short. Paraprocts elongate, posteriorly acute, straight, bearing setae on posterior margin. Cerci elongate, straight, pointing to posterior, cylindrical, tapering near apex and slightly longer than tergum X (Fig. 23A–C). Praeopercular organ small, elliptical with longitudinal keel, anteriorly with small yellow convex rugosity, slightly away from posterior margin of sternum VII and only slightly prominent in lateral view (Fig. 23B–D). Subgenital plate lanceolate, acute, almost reaching posterior margin of tergum X, bearing median and two parasagittal carinae beginning on anterior margin and running half

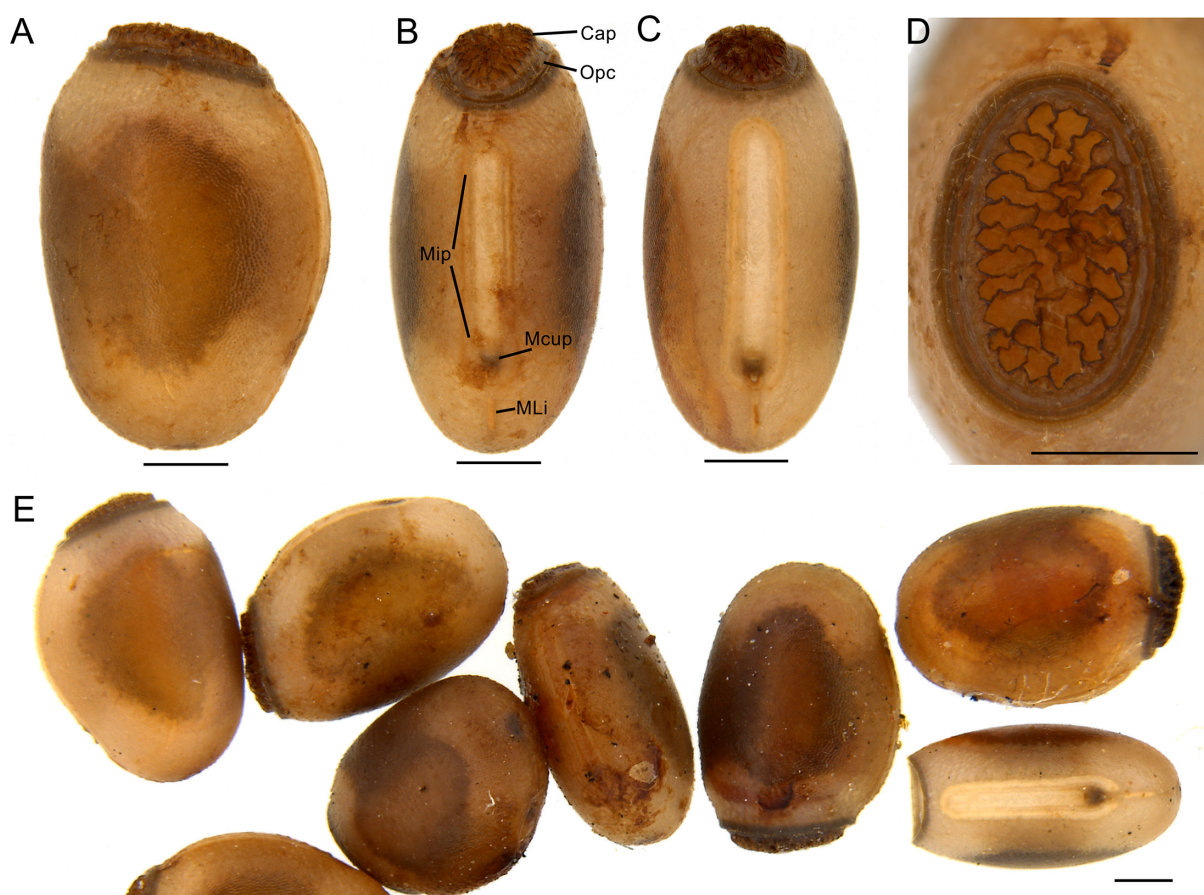


**Fig. 23.** *Arumatia crassicercata* Ghirotto, Crispino & Engelking gen. et sp. nov., terminalia morphology. A–D. Holotype, ♀ (MZUSP 0812). E. Paratype (MZUSP 0871). A. Dorsal view. B. Lateral view. C. Ventral view. D. Detail of praeopercular organ, ventral view. E. Dissected genitalia treated with KOH, lateral view. Abbreviations: Ce=cercus; Gap=gonapophysis; Gng=gonangulum; Gpl=gonoplac; Pre=praeopercular organ; Sp=subgenital plate; St=sternum; Tg=tergum. Scale bars: A–C=1 mm; D–E=0.5 mm.

length of segment before becoming flatter and more setose, gradually tapering towards posterior and totally covering gonapophyses and gonoplac (Fig. 23B–C). Gonapophyses and gonoplac flattened, dorsoventrally for gonapophyses VIII, lateroventrally for IX and laterally for gonoplac (Fig. 23B). Gonapophyses VIII longer than IX, slightly exceeding posterior margin of tergum IX, gonapophyses IX reaching about  $\frac{3}{4}$  length of tergum IX, gonapophyses VIII elongate, somewhat falcate, slightly sinuous, tapering towards posterior and gonapophyses IX conical, short and abruptly tapering towards posterior (Fig. 23E). Gonapophyses IX ventrally folded to fit within gonapophyses VIII. Gonangulum distinctly reduced and flat (Fig. 23E). Gonoplac elongate and lorate, bearing setae, exceeding both gonapophyses and posterior margin of tergum IX (Fig. 23E).

**Egg (Fig. 24)**

Measurements in mm (N = 10): length 2.4–2.5, height 1.7–1.8, width 1.3–1.4. Relatively small, capsule ovoid, constricted at the opercular collar and taller at the region of micropylar plate, laterally compressed and ca  $2 \times$  as long as wide and  $1.5 \times$  as long as tall (Fig. 24A–C, E). Capsule surface smooth but with finely punctuated appearance. Colour varying in shades of orangish or reddish brown with creamy, lighter band on dorsal, anterior and posterior regions, surrounding operculum and polar region (Fig. 24). Micropylar plate convex, very elongate, occupying large area of dorsal region, elliptical with round apical margins and almost parallel sides with posteriormost portion not widened or just very slightly widened



**Fig. 24.** *Arumatia crassicercata* Ghirotto, Crispino & Engelking gen. et sp. nov., egg morphology from female paratypes. **A.** Lateral view. **B–C.** Dorsal view. **D.** Detail of operculum, anterior view. **E.** Several eggs together. Abbreviations: Cap=capitulum; Mcup=micropylar cup; Mip=micropylar plate; MLI=median line; Opc=operculum. Scale bars: 0.5 mm.

(Fig. 24B–C, E). Micropylar plate with lighter elevated outer circle delimiting darker inner flat region confluent with micropylar cup (Fig. 24B–C). Micropylar cup small, rounded and only slightly elevated, dark. Median line short, in same colour and elevation as elevated margin of micropylar plate and almost reaching polar area (Fig. 24B–C). Opercular collar narrower (constricted) than rest of capsule, smooth, whitish and with minute and delicate bristles surrounding edge (Fig. 24B–D). Operculum elliptical, with irregular, somewhat radial to reticular, sinuous elevations of amber texture composing non-stalked capitulum (Fig. 24B, D).

#### **Distribution** (Fig. 52)

Known only from the type locality. The types were collected at the margins of a river in a gallery forest (Fig. 53E) of the Cerrado domain, in the Central-West region of Brazil, in the Chapada dos Veadeiros plateau, municipality of Alto Paraíso de Goiás, Goiás State, Brazil.

*Arumatia aramatia* Ghirotto gen. et sp. nov.

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Figs 25–33, 43, 52, 53F

#### **Diagnosis**

##### **Females**

From *Arumatia dubia* gen. et comb. nov. and *A. fulgens* gen. et comb. nov. it differs by the more elongate head, the shorter median segment in relation to the metanotum, the longer terga VIII–X, the round posterior margin of tergum X, the slightly longer subgenital plate, the presence of a praeopercular organ and additionally from *A. dubia* the longer gonapophyses VIII. From *A. anyami* gen. et sp. nov. it differs by the more elongate head, the longer median segment in relation to the metanotum, the presence of stouter and spiniform setae at the apex of the carinae of the tibiae, the round posterior margin of tergum X, the slightly shorter subgenital plate, the presence of a praeopercular organ, the longer gonoplac and gonapophyses IX and shorter gonapophyses VIII. From *A. crassicercata* gen. et sp. nov. it differs by the more elongate head, the shorter median segment in relation to the metanotum, round posterior margin of tergum X, the longer cerci, and the longer gonapophyses IX. From *A. motenata* gen. et sp. nov. and *A. diamante* gen. et sp. nov. it differs by the less elongate head, the longer median segment in relation to the metanotum, the presence of stronger spiniform setae on the carinae of tarsi and on the apex of mid tibiae, the absence of an apical sessile spine on the apex of the ventral, antero- and posteroventral carinae of the tibiae, the longer cerci and subgenital plate and shorter gonapophyses VIII.

##### **Males**

From *Arumatia motenata* gen. et sp. nov., the only other species with a known male, it differs by the head with convex sides in dorsal view rather than parallel to concave, the presence of one to few stouter spiniform setae at the end of all carinae, the absence of an apical sessile spine on the apex of ventral, antero- and posteroventral carinae of the tibiae, tergum IX longer than X, poculum elongate and conical, pointed in lateral view, tergum X without lateral expansions, and thorn pads restricted to the ventral area of the posterior margin of tergum X.

##### **Eggs**

Eggs of *Arumatia aramatia* gen. et sp. nov. can be differentiated from known eggs of all other species by the fewer distinct, slightly sinuous ridges of the capitulum forming a shape resembling a turtle shell as well as the large and not constricted opercular collar which is shared only with the eggs of *A. diamante* gen. et sp. nov.



### Etymology

This species is named in reference to *Aramatiá*, a variant of the indigenous name for stick insects in Brazil, *Arumatiá*, which inspired the name of the new genus of which this is the type-species. To be treated as a noun in apposition.

### Material examined

#### Holotype

BRAZIL • ♀; Tocantins, Porto Nacional, Luzimangues district, at margins of Ribeirão Santa Luzia; 10°03'40.1" S, 48°25'10.1" W; 15 Aug. 2002; D. Pavan and J.P. Silva leg.; “vegetação fechada” [dense vegetation]; campanha VII; gride C; MZUSP 1352.

#### Paratype

BRAZIL • 1 ♂; same collection data as for holotype; 6–14 Dec. 2002; campanha IX; MZUSP 1322.

### Remarks

Eggs were obtained from inside the abdomen of the only known female and might differ in some details from laid eggs. For comparison, analysis of eggs of *Arumatia dubia* gen. et comb. nov. extracted from the same region of the abdomen revealed that in this species the capitulum and micropylar plate were already formed but the whitish dorsal stains were not present and the texture of the capsule was sometimes smooth, still not formed.

### Description

#### Female (holotype, MZUSP 1352)

MEASUREMENTS (in mm). Body (without cerci) 86.1, head 5.0, antennae at least 12.0, pronotum 3.3, mesonotum 22.6, metanotum 7.0, median segment 5.2, abdomen (excluding median segment) 43.0, cercus 5.8, profemur 21.8, protibia 23.3, mesofemur 15.0, mesotibia 15.8, metafemur 20.0, metatibia at least 22.2.

COLOUR (Fig. 25). Known only from aged specimens preserved in alcohol. Entirely brown to yellowish beige, lighter in the legs. Body with scattered dark sprinkled stains and dorsal longitudinal medial dark line running across mesonotum, metanotum, median segment and sternum II.

HEAD (Fig. 26). Fairly elongate, smooth with sparse setae mostly on dorsal region, vertex flat but very gently convex at posterior margin to fit underneath the pronotum, frontal convexity developed, frontal suture round (Fig. 26A–B). Eyes small, slightly elongate, approximately  $0.2\times$  as long as head. Cervix covering significantly more than half of head, cervical sclerites developed, gula bearing setae and covering less than half of cervix (Fig. 26C). Subgena fairly narrow with posterior projection ca height of middle of eye. Submentum narrow and slightly curved towards posterior, mentum simple and prementum somewhat wide. Glossa elongate and rounded, paraglossa larger, roundly falcate and reaching labrum. Lacinia with three distal teeth, one large medially and two smaller laterally, mesal edge bearing around 6 large setae. Galea slightly elongate, roundly elliptical, bearing long setae, apically with dense semicircular band of hairy and large microtrichia. Galealobulus present, small, widely round and basally fused to galea. Maxillary palpal segments cylindrical, labial slightly widened. Clypeus wide, approximately trapezoidal. Labrum strongly notched anteromedially, asymmetric. Antennae filiform, broken. Scapus ca  $1.8\times$  as long as wide, basally and apically slightly constricted in dorsal view, slightly compressed dorsoventrally. Pedicellus subglobose, large and more than half length of scapus (Fig. 26A).

THORAX (Figs 25–26, 27A). Smooth with scattered setae. Pronotum longer than wide, slightly constricted pre-medially and slightly wider from transverse sulcus towards anterior margin, fairly flat in lateral view,

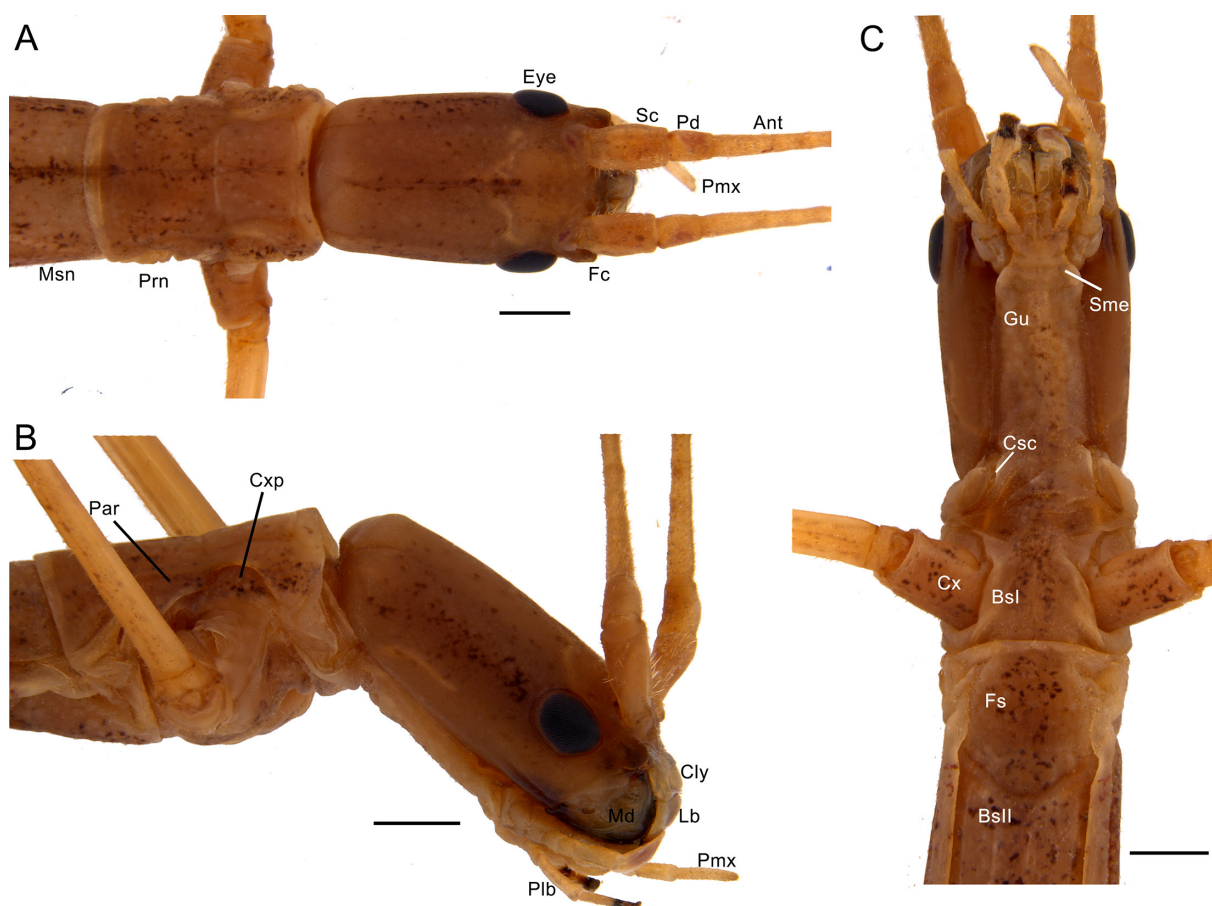
transverse sulcus conspicuous and almost straight, longitudinal sulcus conspicuous and distinct. Paranota curved, slightly widened medially and longer than wide, procoxopleurite apically round and ventrally gently concave (Fig. 26). Probasisternum tapering towards anterior, profurcasternum round (Fig. 26C). Mesothorax  $4.8\times$  as long as prothorax. Mesonotum with pair of weak lateral carinae, mesepisternum lanceolate and regularly widening posteriorly. Mesepimeron slightly elongate, pointing towards posterior and slightly exceeding end of mesothorax, mesocoxopleurite indistinct, mesofurca Y-shaped. Metathorax continuing pair of lateral carinae of mesonotum, metepisternum long and similar to mesepisternum, metepimeron extremely elongate, extending through the entire length of median segment, posteriorly



**Fig. 25.** *Arumatia aramatia* Ghirotto gen. et sp. nov., holotype, ♀ (MZUSP 1352). **A.** Dorsal view. **B.** Lateral view. Scale bar: 10 mm.

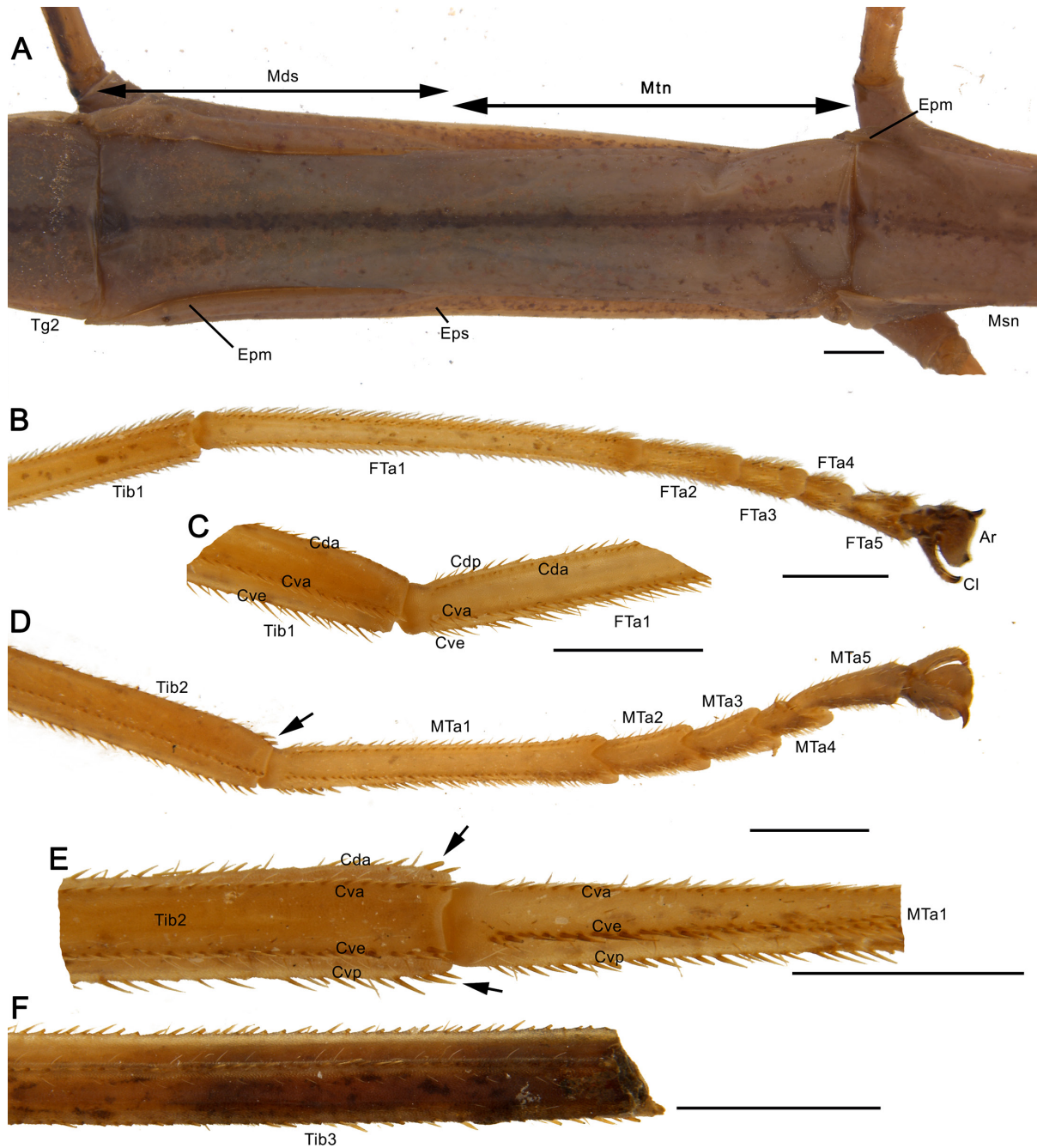
pointing and slightly exceeding end of median segment (Fig. 27A). Metacoxopleurite very discrete, elongate, metafurca Y-shaped. Metanotum  $1.2\times$  as long as median segment (Fig. 27A).

LEGS (Figs 25, 27B–F). Slender. Hindlegs extending beyond epiproct, at least slightly shorter than anterior legs, midlegs distinctly shorter. Coxae smooth. Profemur with distinct basal curvature. Femora and tibiae with five carinae with few sparse setae among them (Fig. 27B–F). Carinae of profemora and protibiae distinctly keeled, mid and hind femora and tibiae with slightly less prominent keels. Antero- and posteroventral carinae of femora with round apical prominence. Carinae of all femora, tibiae and tarsi bearing row of short, stout setae. Last few setae of all carinae of protibiae and last five setae of ventral carinae, last three of antero- and posteroventral carinae and last two of antero- and postero-dorsal carinae of mesotibiae stouter and spiniform (Fig. 27B–E). Metatibia apex broken off (Fig. 27F). In tarsi, setae on carinae distributed across about three quarters to four fifths of length and on ventral and posteroventral carinae of probasitarsi longer and only slightly stouter while setae on ventral, antero- and posteroventral carinae of mesobasitarsi stouter (only slightly on anteroventral carinae) (Fig. 27B–E). Probasitarsi very elongate and significantly longer than respective following tarsomeres combined,



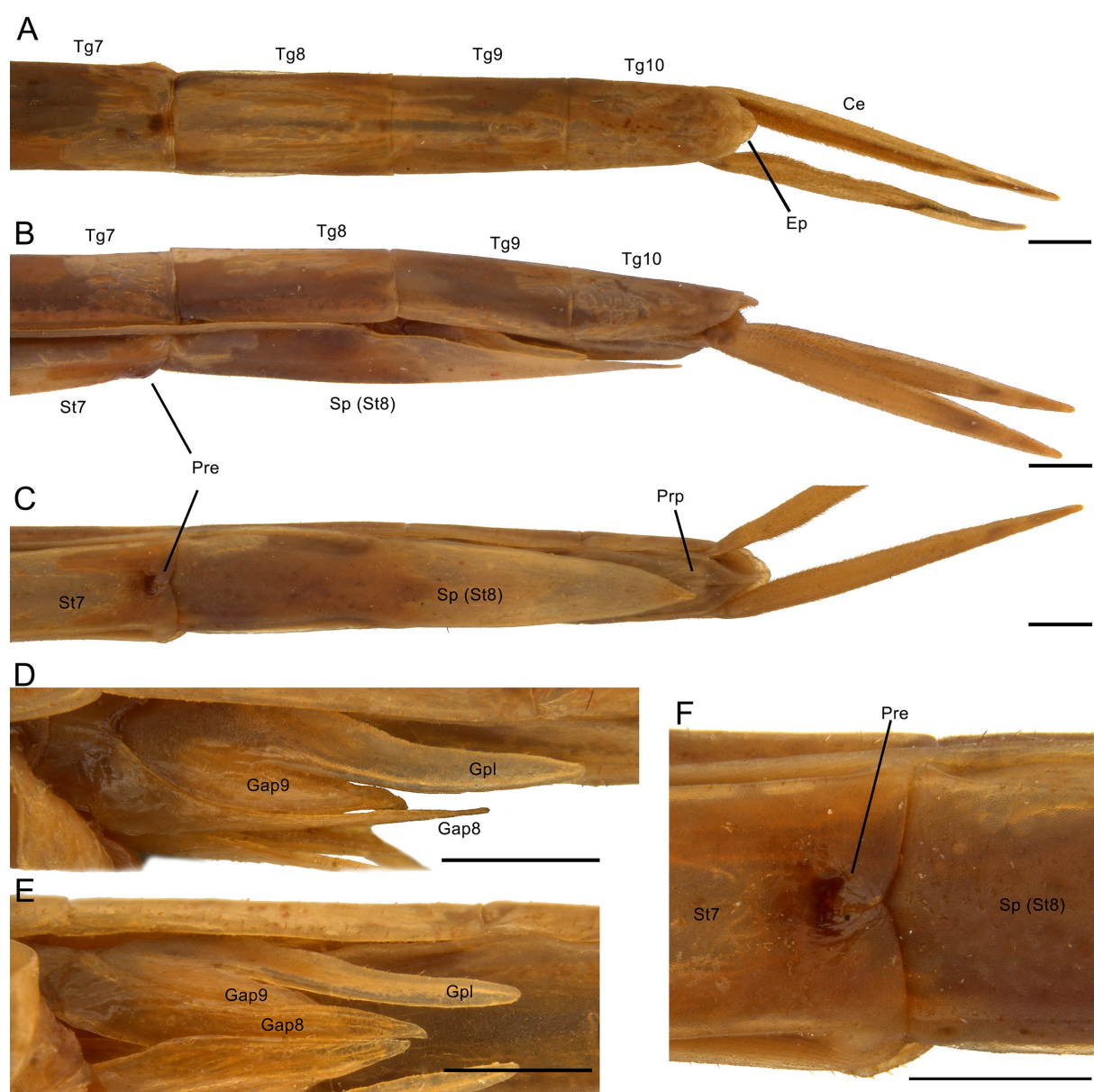
**Fig. 26.** *Arumatia aramatia* Ghirotto gen. et sp. nov., holotype, ♀ (MZUSP 1352), head and prothorax morphology. **A.** Dorsal view. **B.** Lateral view. **C.** Ventral view. Abbreviations: Ant=antennomere; Bsl-I=pro- and mesothoracic basisterna; Cly=clypeus; Csc=cervical sclerite; Cx=coxa; Cxp=coxopleurite; Eye=compound eye; Fc=frontal convexity; Fs=prothoracic furcasternite; Gu=gula; Lb=labrum; Md=mandible; Msn=mesonotum; Par=paranota; Pd=pedicellus; Plb=labial palpus; Pmx=maxillary palpus; Prn=pronotum; Sc=scapus; Sme=submentum. Scale bars: 1 mm.





**Fig. 27.** *Arumatia aramatia* Ghirotto gen. et sp. nov., holotype, ♀ (MZUSP 1352), thorax and leg morphology. **A.** Metathorax and median segment in dorsal view, arrows indicate the length of each segment. **B.** Left fore tarsus, ventral view. **C.** Detail of right fore tibia and tarsus (mirrored), prolateral view. **D.** Right mid tarsus (mirrored), prolateral view, arrows showing stronger apical spines. **E.** Detail of left mid tibia and tarsus, ventral view, arrow showing stronger apical spines. **F.** Detail of broken apex of left tibia, dorsal view. Abbreviations: Ar=arolium; Cda=dorsal anterior carina; Cdp=dorsal posterior carina; Cl=claw; Cva=ventral anterior carina; Cve=ventral carina; Cvp; ventral posterior carina; Epm=epimeron; Eps=episternum; FTa=fore tarsomere; Mds=median segment; Msn=mesonotum; MTa=mid tarsomere; Mtn=metanotum; Tg=tergum; Tib=tibia. Scale bars: 1 mm.

mesobasitarsi as long as respective following tarsomeres combined (Fig. 27B–E), with hairy setae restricted to apical portion on ventrolateral patches (Fig. 27B, D). Remaining tarsomeres with setae on ventrolateral patches in portions not covered by euplantulae. Tarsomeres I–III with a discrete dorsal round apical projection. Arolium round and broad, bearing setae dorsally. Pretarsal claws symmetrical, dorsally and outwardly bearing setae. Euplantulae well developed in all tarsomeres, composed of two symmetrical pads separated by median groove in tarsomeres I–III, of single pointing domed pad in tarsomeres IV, and of single flattened lobed pad in tarsomeres V. Euplantulae present only apically at



**Fig. 28.** *Arumatia aramatia* Ghiorotto gen. et sp. nov., holotype, ♀ (MZUSP 1352), terminalia morphology. **A.** Dorsal view. **B.** Lateral view. **C.** Ventral view. **D–E.** Detail of external genitalia, lateral view (D), ventral view (E). **F.** Detail of praeopercular organ, ventral view. Abbreviations: Ce = cercus; Ep = epiproct; Gap = gonapophysis; Gpl = gonoplac; Pre = praeopercular organ; Prp = paraproct; Sp = subgenital plate; St = sternum; Tg = tergum. Scale bars: 1 mm.

tarsomeres I–II, covering ca half length of tarsomeres III, covering two thirds length of tarsomeres IV and covering almost entire ventral surface of tarsomeres V (Fig. 27B).

**ABDOMEN** (Figs 25, 27A, 28). External surface as in thorax, bearing few setae across entire length. Median segment slightly shorter than metanotum (Fig. 27A). Combined length of segments II–X as long as combined length of head, thorax and median segment. Terga II–VII and sterna II–VIII bearing discrete lateral carinae near lateral margins. All segments longer than wide (Fig. 25). Segment II ca as long as III and VII, segments III–V slightly increasing in size in relation to anterior segment, segment VI ca as long as V, tergum VII shorter than on preceding segment, and longer than VIII, terga X and IX same size, slightly shorter than VIII. Terga II–V around same width, wider than following terga, VI wider than following terga, VIII–X around same width (Fig. 28A). Tergum X somewhat conical in lateral view (Fig. 28B), in dorsal view almost parallel-sided but gently tapering towards posterior, posterior margin straight with round lateral margins (Fig. 28A). Epiproct domed in dorsal view, dorsoventrally flattened, distinctly prominent visible dorsally and laterally (Fig. 28A–B). Paraprocts elongate, posteriorly acute, straight and bearing setae on posterior margin, laterally bearing cerci, not concealing them from ventral or lateral view (Fig. 28B–C). Cerci extremely elongate, straight, gently laterally compressed, basally narrower fitting paraprocts, pointing to posterior, gradually tapering, slightly longer than terga IX, X and epiproct combined (Fig. 28A–C). Cerci bear four types of setae, shorter setae very discrete, round and not protruding. Praeopercular organ small, round, brownish and posteriorly with short longitudinal sulcus continuing across posterior margin of sternum VII (Fig. 28B–C, F). Subgenital plate lanceolate, fairly acute, reaching  $\frac{2}{3}$  of length of tergum X, bearing two parasagittal carinae beginning on anterior margin and running half length of segment before becoming flatter and more setose, gradually tapering towards posterior and totally covering gonapophyses and gonoplac (Fig. 28B–C). Gonapophyses and gonoplac flattened, dorsoventrally for gonapophyses VIII, lateroventrally for IX and laterally for



**Fig. 29.** *Arumatia aramatia* Ghirotto gen. et sp. nov., paratype, ♂ (MZUSP 1322). A. Dorsal view. B. Ventral view. Scale bar: 10 mm.

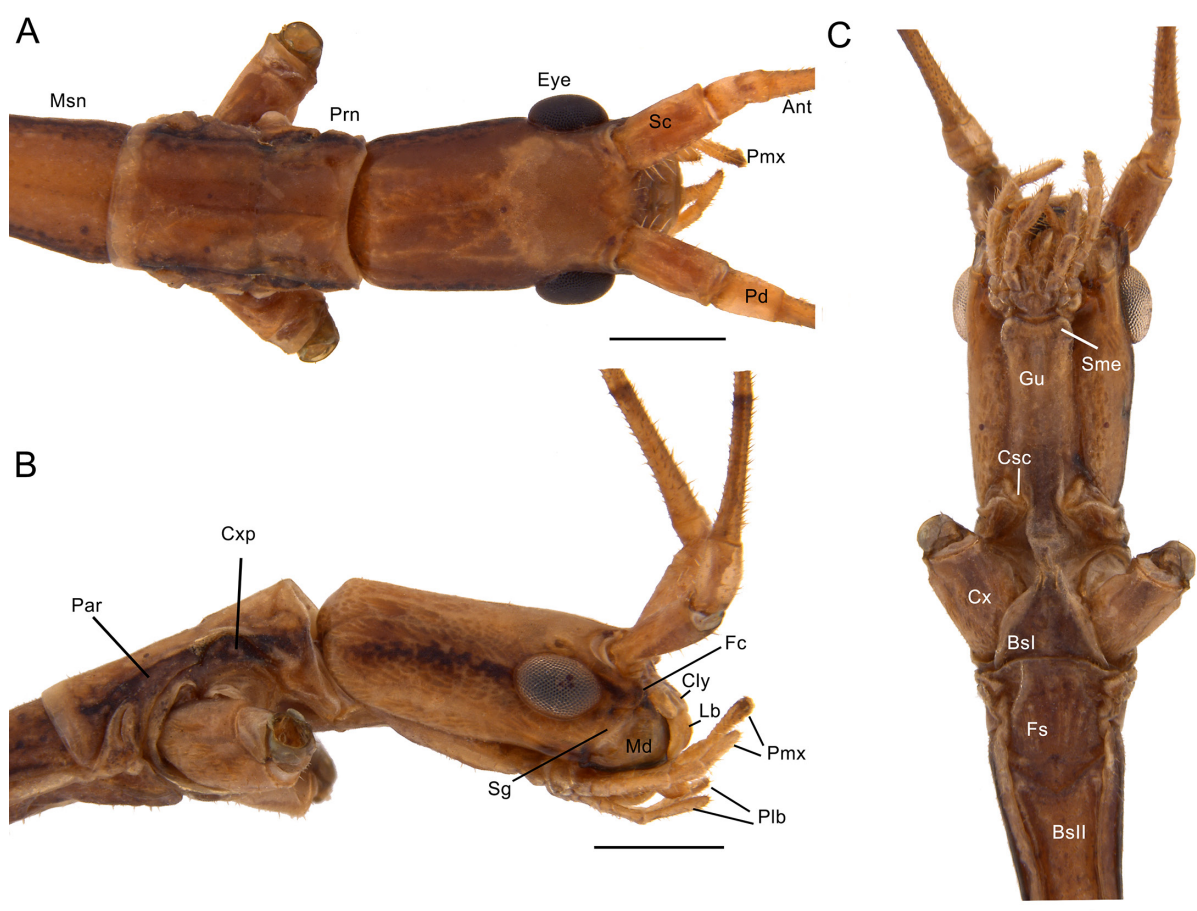


gonoplac (Fig. 28D–E). Gonapophyses VIII longer than IX, VIII almost reaching tergum X, IX reaching ca  $\frac{3}{4}$  of length of tergum IX, VIII linear to lorate, IX conical, tapering towards posterior (Fig. 28D–E). Gonapophyses IX ventrally folded to fit within gonapophyses VIII. Gonangulum distinctly reduced, flat, not lobed. Gonoplac significantly elongate, widened basally, subsequently lorate, bearing setae, exceeding both gonapophyses and exceeding anterior margin of tergum X (Fig. 28D–E).

**Male paratype (MZUSP 1322)**

MEASUREMENTS (in mm). Body 56.7, head 2.7, antennae at least 15.0, pronotum 2.2, mesonotum 13.8, metanotum 5.4, median segment 4.1, abdomen (excluding median segment) 28.5, cercus 1.0, profemur -, protibia -, mesofemur 11.8, mesotibia 13.1, metafemur 16.7, metatibia 19.8.

COLOUR (Fig. 29). Known only from aged specimen preserved in alcohol. Entirely dark brown to yellowish beige, lighter in legs, darker than female. Head, pronotum and mesonotum with two lateral dark lines (Fig. 30B).

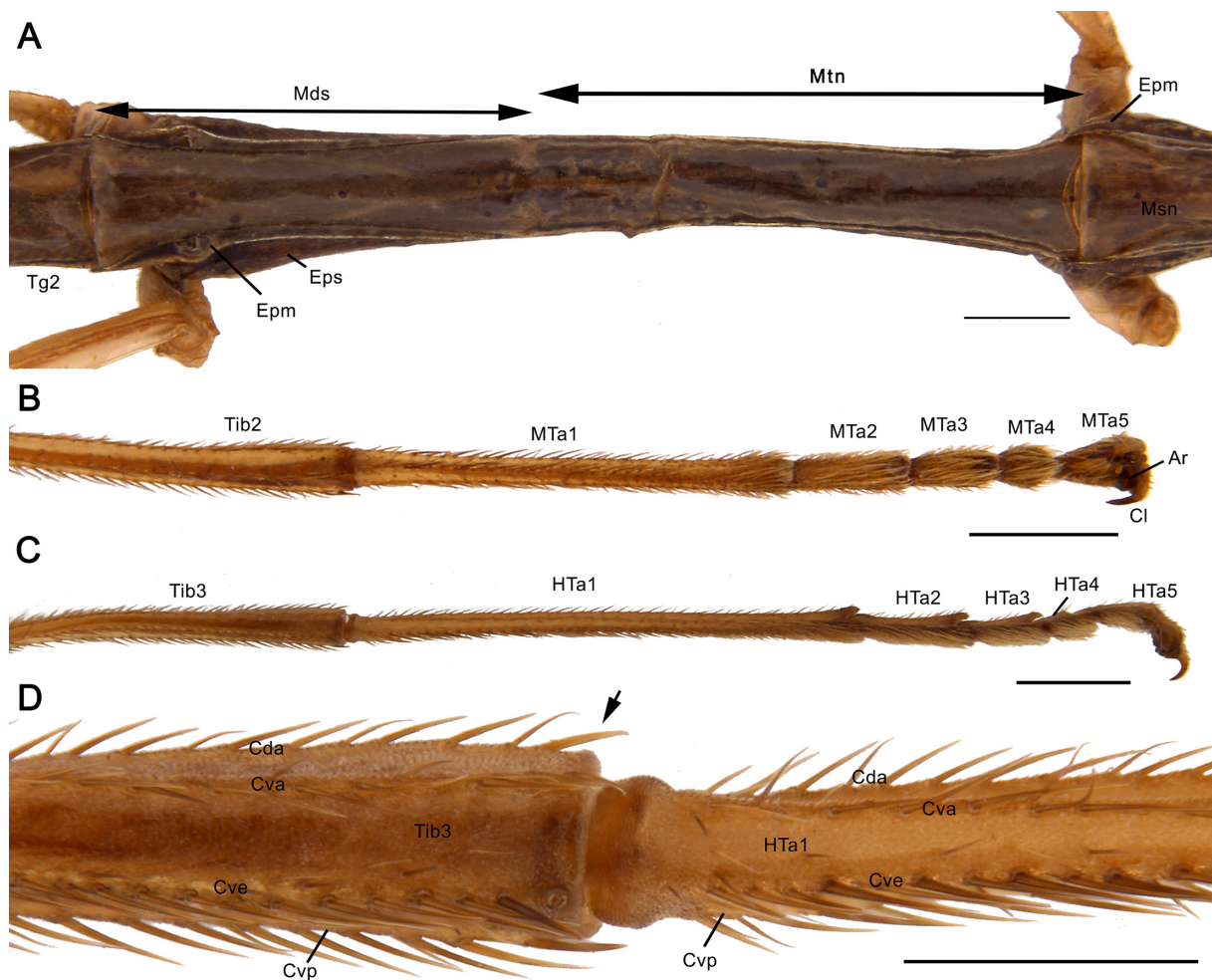


**Fig. 30.** *Arumatia aramatia* Ghirotto gen. et sp. nov., paratype, ♂ (MZUSP 1322), head and prothorax morphology. **A.** Head and prothorax in dorsal view. **B.** Head and prothorax in lateral view. **C.** Head and prothorax in ventral view. Abbreviations: Ant=antennomere; Bsl-I=pro- and mesothoracic basisterna; Cly=clypeus; Csc=cervical sclerite; Cx=coxa; Cxp=coxopleurite; Eye=compound eye; Fc=frontal convexity; Fs=prothoracic furcasternite; Gu=gula; Lb=labrum; Md=mandible; Msn=mesonotum; Par=paranota; Pd=pedicellus; Plb=labial palpus; Pmx=maxillary palpus; Prn=pronotum; Sc=scapus; Sg=subgena; Sme=submentum. Scale bars: 1 mm.

HEAD (Fig. 30). Similar to female except: eyes, scapus and pedicel larger, head slightly widening from posterior margin to behind eyes in dorsal view (Fig. 30A). Palpal segments larger, labial less widened.

THORAX (Figs 29, 31A). Similar to female except: significantly thinner, more elongate than that of female. Mesothorax  $6.6\times$  as long as prothorax. Mesocoxopleurite larger and triangular.

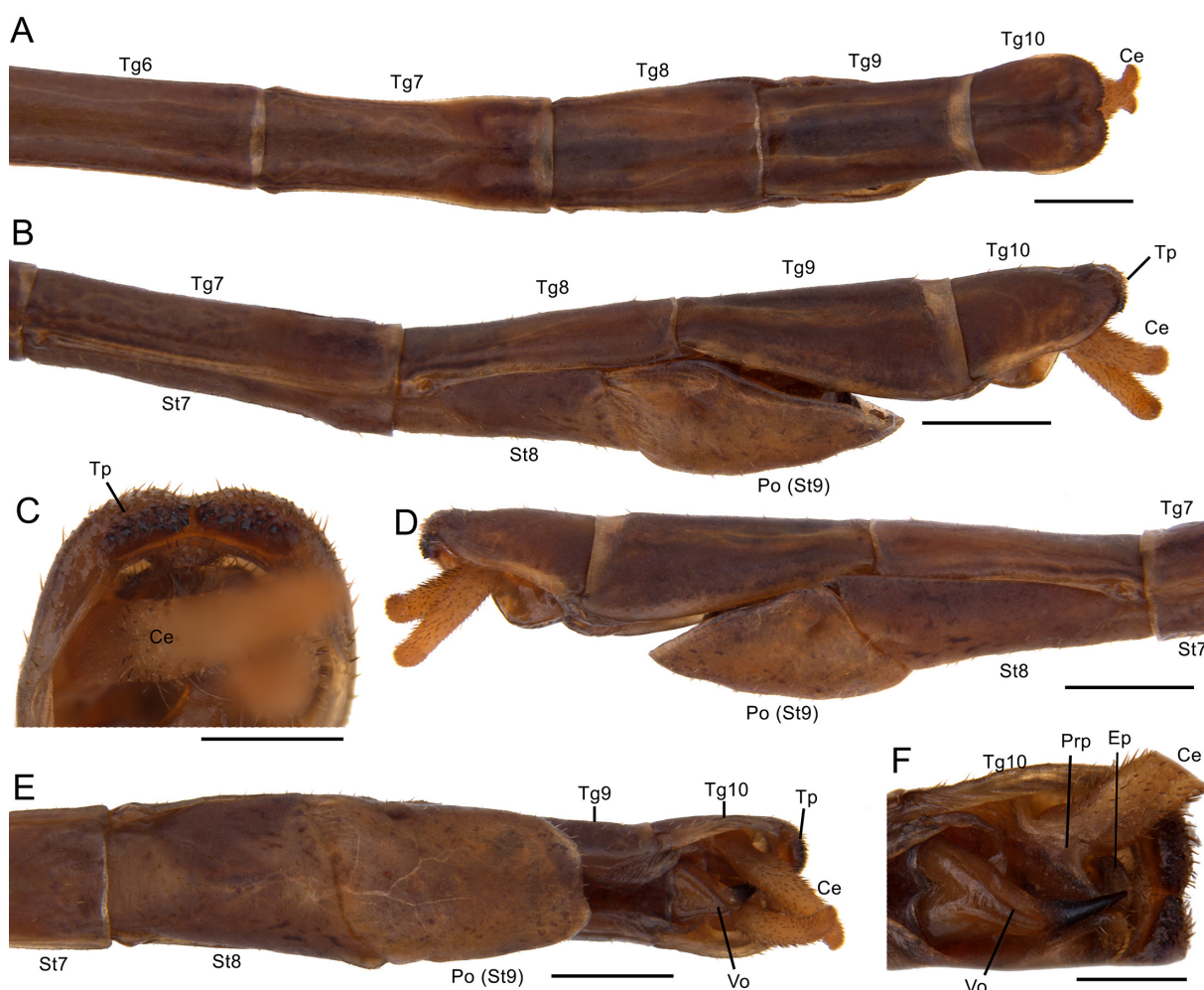
LEGS (Figs 29, 31B–D). Forelegs not present in paratype, the only known male of species. Similar to female except: legs longer and thinner than those of female (Fig. 29). All setae generally longer than those of female (Fig. 31B–D). Setae on carinae of meso- and metafemora slightly sparser, longer, on carinae of meso- and metatibiae slightly longer, stouter, and apical spiniform setae of carinae of tibiae only slightly stouter than remaining setae (Fig. 31D). Meso- and metabasitarsi longer than respective following tarsomeres combined (Fig. 31B–C). Metabasitarsi with stouter setae on ventral, antero- and



**Fig. 31.** *Arumatia aramatia* Ghirotto gen. et sp. nov., paratype, ♂ (MZUSP 1322), thorax and leg morphology. **A.** Metathorax and median segment in dorsal view, arrows indicate the length of each segment. **B.** Right mid tarsus, ventral view. **C.** Right hind tarsus (mirrored), prolateral view. **D.** Detail of right hind tibia and tarsus (mirrored), latero-ventral view, arrow showing stronger apical spines. Abbreviations: Ar=arolium; Cda=dorsal anterior carina; Cl=claw; Cva=ventral anterior carina; Cve=ventral carina; Cvp; ventral posterior carina; Epm=epimeron; Eps=episternum; HTa=hind tarsomere; Mds=median segment; Msn=mesonotum; MTa=mid tarsomere; Mtn=metanotum; Tg=tergum; Tib, tibia. Scale bars: A–C=1 mm; D=0.5 mm.

posteroventral carinae, stronger on ventral carinae. Ventrolateral hairy setae of tarsomeres denser. Euplantulae shorter.

ABDOMEN (Figs 29, 31A, 32). Thinner and more elongate than that of female. Median segment anteriorly with two parasagittal ovoid stains (Fig. 31A), lateral carinae absent. Terga II and VI about same length, both slightly shorter than III–V, tergum VI shorter than VII, tergum VII longer than VIII, terga VIII and IX about same length, X shorter. Terga II–V about same width, tergum VI slightly shorter, tergum VII anteriorly as wide as VI and slightly widened posteriorly, tergum VIII slightly wider than VII and IX (Fig. 32A). Tergum X wider than IX, about as long as wide, slightly widened towards posterior, sides convex in dorsal view and with posterior margin emarginate forming two round edges (Fig. 32A). Thorn pads at ventral area of posterior margin of tergum X bearing ca 32 small to large inwardly curved short, sclerotized teeth (Fig. 32C). Tergum VIII and sternum VIII separated, not fused (Fig. 32B, D). Sternum VIII partly fused with sternum IX, border between both sterna shown as asymmetric sulcus curving towards posterior on right side (Fig. 32E). Sternum IX reduced with anterior portion indistinct; only shown as poculum. Poculum reaching around  $\frac{3}{4}$  length of tergum IX, due to asymmetry of sulcus poculum



**Fig. 32.** *Arumatia aramatia* Ghirrotto gen. et sp. nov., paratype, ♂ (MZUSP 1322), terminalia morphology. **A.** Dorsal view. **B.** Left side lateral view. **C.** Detail of thorn pads, ventro-posterior view. **D.** Right side lateral view. **E.** Ventral view. **F.** Detail of vomer, ventral view. Abbreviations: Ce=cercus; Ep=epiproct; Po=poculum; Prp=paraproct; St=s sternum; Tg=tergum; Tp=thorn pads; Vo=vomer. Scale bars: A–B, D–E=1 mm; C, F=0.5 mm.

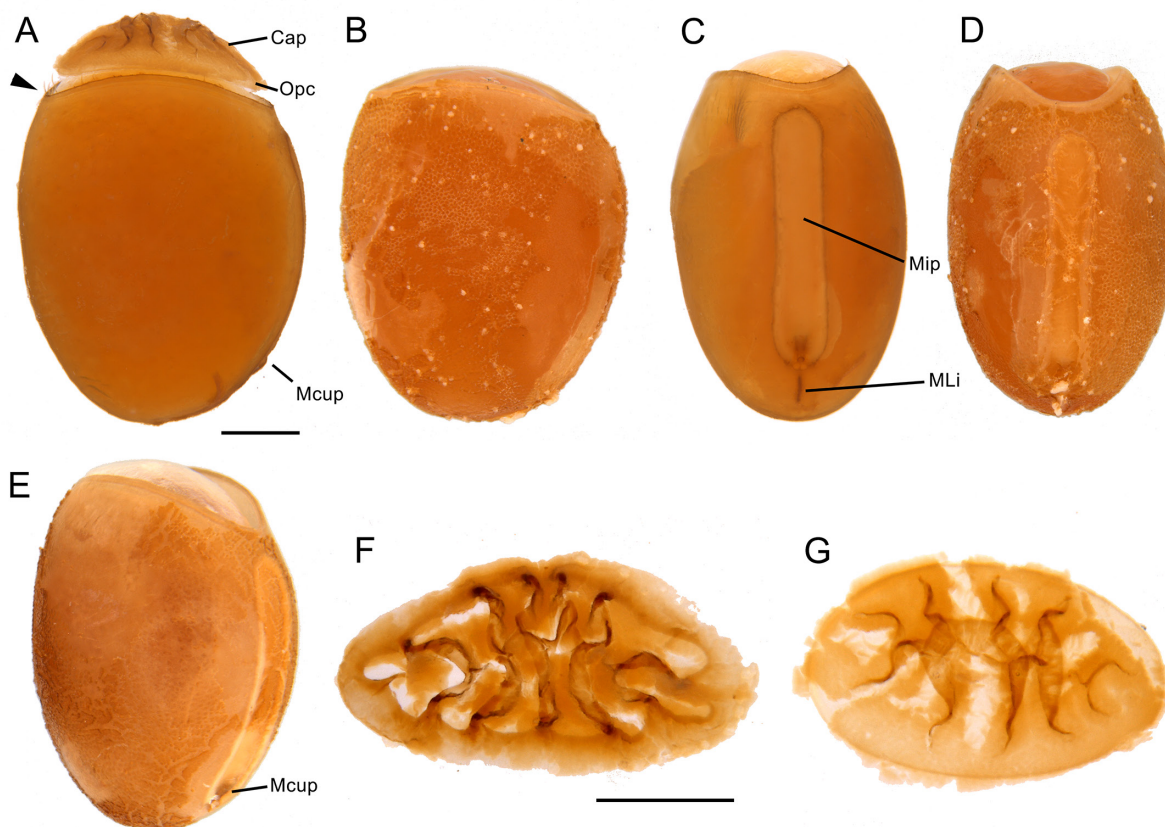


shorter at right side than left side (Fig. 32B, D). Poculum slightly elongate, conical in lateral view, round in ventral view, posterior margin medially with wide emarginate short curvature towards anterior (Fig. 32B, D–E). Cerci slightly shorter than tergum X, inwardly curved, with round apex (Fig. 32B, D–E). Epiproct small, hidden from dorsal and lateral view (Fig 32F). Vomer elongate, convex, terminal hook elongate and strongly sclerotized, acute, conical, single pointed and curving upwards (Fig. 32F).

**MALE GENITALIA** (Fig. 43, left side). Male genitalia or phallic organ composed of dorsalmost sclerite (dorsal sclerite), wide lobe with fine granulation originating ventrally from dorsal sclerite (longitudinal lobe), and smaller and shorter lobe basally, slightly ventrally, on right side, the (right) basal lobe. Dorsal sclerite very elongate, somewhat hook-shaped, curved to left in dorsal view and penetrating body cavity. Anterior portion penetrating body narrower. Posterior portion wider, connecting to rest of genitalia, and apically further bending ventrally while continuing left curve of whole structure, basally near anterior portion very short, round projection pointing anteriorly. Longitudinal lobe bends accompanying dorsal sclerite, and forming apicalmost round lobe, small elongate and thin lobe at right side and central foldings. Longitudinal lobe basally bearing round weak internal sclerotization near dorsal sclerite (Fig. 43E–H). Basal lobe conical, flattened and densely granulated.

**Egg** (Fig. 33)

Egg not fully formed, retrieved from inside female holotype. Measurements in mm (N = 3): length 2.5–2.6, height 1.9, width 1.5. Relatively small, ovoid in lateral view, not constricted at opercular



**Fig. 33.** *Arumatia aramatia* Ghirotto gen. et sp. nov., egg morphology from the holotype female. **A–B.** Lateral view, arrowhead pointing at bristles on opercular collar (**A**). **C–D.** Dorsal view. **E.** Lateral view, slightly tilted towards dorsal. **F–G.** Detail of operculum, anterior view. Abbreviations: Cap=capitulum; Mcup=micropylar cup; Mip=micropylar plate; MLi=median line; Opc=operculum. Scale bars: 0.5 mm.

collar, gently compressed laterally and ca  $1.6 \times$  as long as wide and  $1.4 \times$  as long as tall (Fig. 33A–D). Capsule surface smooth but with finely punctuated appearance (Fig. 33B, D). Colour yellowish orange. Micropylar plate very elongate, occupying large area of dorsal region, with round margins and almost parallel-sided (Fig. 33C–D). Micropylar cup small, rounded and only slightly elevated. Median line short and of same colour and elevation as elevated margin of micropylar plate, almost reaching polar area (Fig. 33C–D). Opercular collar very wide, as wide as surrounding capsule, smooth with minute and delicate long bristles along edge (Fig. 33A). Operculum elliptical, with sinuous and somewhat radial elevations with amber texture, in shape resembling a turtle shell (Fig. 33A, F–G).

#### **Distribution** (Fig. 52)

Known only from the type locality, Luzimangues District, along Santa Luzia River, in Porto Nacional, Tocantins, Brazil. This area is in the Cerrado domain and the types were found in savannah formations (Fig. 53F).

*Arumatia motenata* Ghiorotto gen. et sp. nov.

[urn:lsid:zoobank.org:act:935C1661-AF01-473F-A0B3-884C968257DF](https://zoobank.org/act:935C1661-AF01-473F-A0B3-884C968257DF)

Figs 34–46, 53G–H

#### **Diagnosis**

##### **Females**

Differs from all other known females of *Arumatia* Ghiorotto gen. nov., except those of *A. diamante* gen. et sp. nov., by the very elongate and subrectangular head, larger microtrichia on the galea, the presence of an apical sessile spine on the apex of ventral, antero- and posteroventral carinae of the tibiae, the very elongate epiproct, the shorter subgenital plate and the wider gonoplac in lateral view and from all other known species of the genus by the lobed, well-developed praeopercular organ. It also differs from all other species of the genus except *A. diamante* and *A. anyami* gen. et sp. nov. by the absence of stronger spiniform setae on the carinae of the tarsi and on the apex of the mid and hind tibiae. It further differs from *A. dubia* gen. et comb. nov. and *A. fulgens* gen. et comb. nov. by the shorter median segment in relation to the metanotum, the longer segment VII in relation to VIII, the slightly shorter cerci and the longer gonapophyses VIII. From *A. anyami* it further differs by the less emarginate posterior margin of tergum X. From *A. crassicerca* gen. et sp. nov. it further differs by the shorter median segment in relation to the metanotum and the longer cerci. From *A. aramatia* gen. et sp. nov. it further differs by the shorter median segment in relation to the metanotum, the shorter cerci and the longer gonapophyses VIII. From *A. diamante* it further differs by the less elongate head, the relatively longer cerci, the shorter epiproct, and paraprocts and the lack of tubercles on tergum VI.

##### **Males**

From *Arumatia aramatia* gen. et sp. nov., the only other species with known male, it differs by the head with parallel to concave sides slightly widening towards the anterior in dorsal view rather than convex and not widening, the absence of stouter spiniform setae at the posterior region of all carinae of the tibiae, the presence of an apical sessile spine on the apex of the ventral, antero- and posteroventral carinae of the tibiae, tergum IX as long as X, the poculum shortened and round in lateral view, tergum X with lateral flat expansions with thorn pads further extending to the ventral area of the lateral expansions.

##### **Eggs**

The egg of *Arumatia motenata* gen. et sp. nov. differs from the eggs of all other *Arumatia* gen. nov. whose eggs are known by the not sinuous, somewhat radial elevations of the capitulum and from eggs of *A. diamante* gen. et sp. nov. it further differs by the constricted opercular collar, not enlarged.

### Etymology

This species is named after its unusual male-female attaching mechanism consisting of the posterior margin of the tergum X of the male bearing lateral expansions that fold around the well-developed and prominent female praeopercular organ. The name is a Latinized adjective formed by the old Tupi word ‘*motena*’ (= ‘to attach, to fit’) with the Latin suffix ‘-ata’ meaning ‘shaped to attach’. The old Tupi language was spoken by the indigenous Tupi people of Brazil and is now extinct. However, the word survives with the same meaning in the more recently developed Nheengatu language of the Tupi-Guarani family which is spoken by some peoples of the Amazon.

### Material examined

#### Holotype

BRAZIL • ♀; Minas Gerais, Santana do Riacho, side of highway MG-010, next to Sítio Velozias; 19°16′51.7″ S, 43°34′52.6″ W; 1100–1200 m a.s.l.; 31 Oct. 2021; V.M. Ghirotto leg.; Serra do Cipó plateau, in campo rupestre vegetation; MZUSP V0603.

#### Paratypes

BRAZIL • 5 ♀♀; same collection data as for holotype; MZUSP V0626, V0659, V0662, V0663, V0675 • 6 ♂♂; same collection data as for holotype; MZUSP V0620 to V0625 • eggs; same collection data as for holotype; MZUSP.

#### Other material

BRAZIL • 3 ♀♀; same collection data as for holotype; MZUSP V0660, V0661, V0664.

### Description

#### Female holotype (MZUSP V0603)

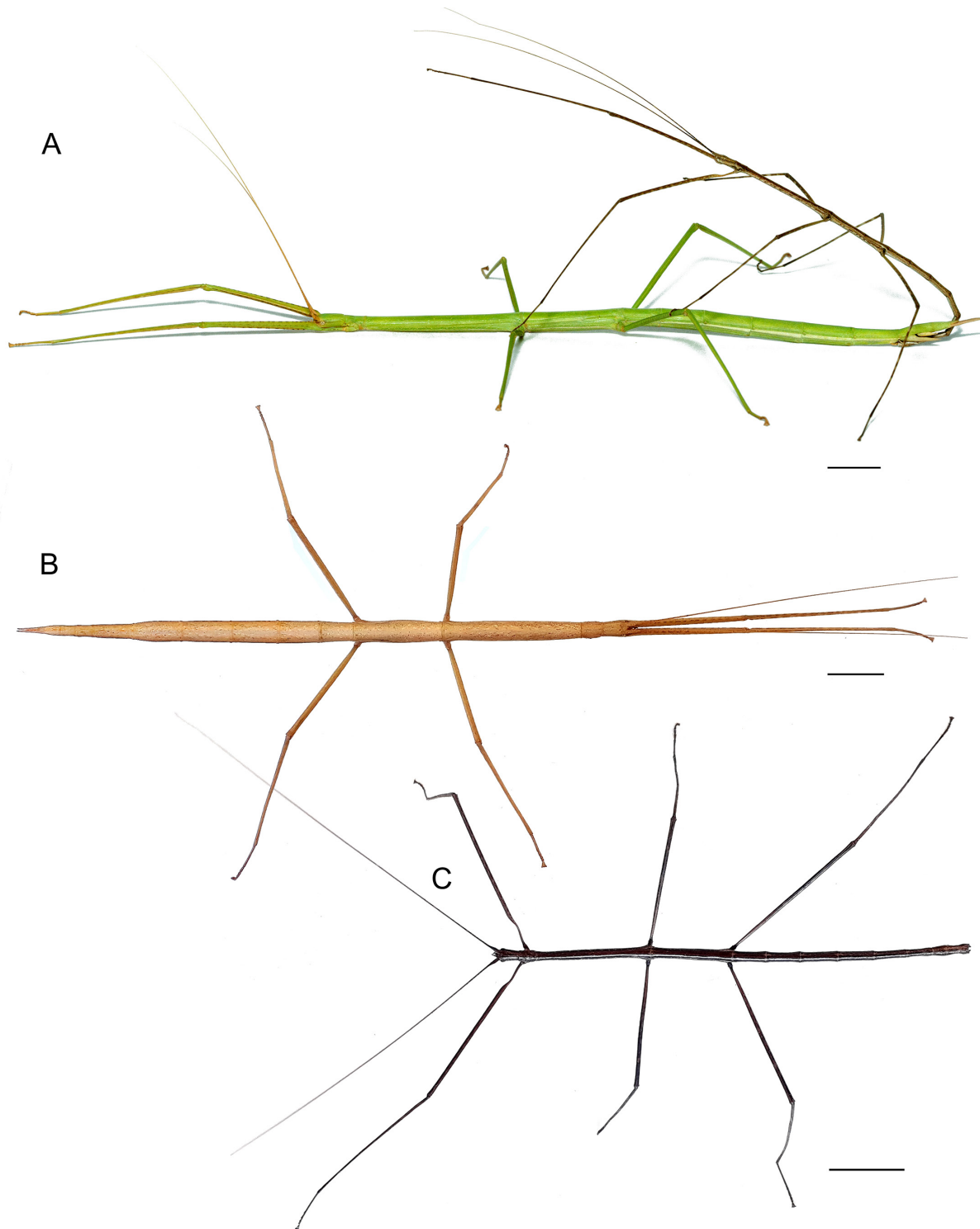
MEASUREMENTS (in mm). Body (without cerci) 100.1, head 6.5, antennae 57.0, pronotum 4.5, mesonotum 26.3, metanotum 10.0, median segment 6.7, abdomen (excluding median segment) 57.1, cercus 6.0, profemur 26.5, protibia 27.0, mesofemur 19.5, mesotibia 20.0, metafemur 24.0, metatibia 26.0.

COLOUR (Figs 35–37). Entirely yellowish beige with irregular stains of different tones.

HEAD (Fig. 35). Very elongate, smooth, with sparse small setae, vertex flat but very gently convex at posterior margin to fit underneath the pronotum. Frontal convexity developed, frontal suture round (Fig. 35A–B). Eyes small and slightly elongate, approximately  $0.15 \times$  as long as head. Cervix covering slightly more than half head, cervical sclerites developed, gula bearing setae and covering slightly less than half of cervix (Fig. 35C). Subgena fairly narrow, with posterior projection ca height of middle of eye. Submentum narrow and curved towards posterior, mentum simple, prementum somewhat wide. Glossa elongate, rounded, paraglossa roundly falcate, with round lateral margins and curved inner margins, reaching middle of labrum. Lacinia with three distal teeth, one large medially and two smaller laterally, all prominent, mesal edge bearing bundles of ca 11 large setae from base to sclerotized portion. Galea bearing long setae, slightly elongate, slightly widened before apical portion, apex round. Inner edge of galea apically with dense round tuft of hairy, long, large microtrichia and a few distinct circular granules dorsally and posteriad to this patch. Galealobulus present, small, round and basally fused to galea. Maxillary palpal segments cylindrical and labial slightly widened. Clypeus wide, subrectangular. Labrum strongly notched anteromedially, delimiting two round lobes, asymmetric with right lobe larger. Antennae filiform, reaching at least tergum IV. Scapus ca  $2 \times$  as long as wide, slightly compressed dorsoventrally. Pedicellus subglobose, large, slightly more than half as long as scapus (Fig. 35A–B). Antennomeres bear three types of setae as in *A. dubia*.

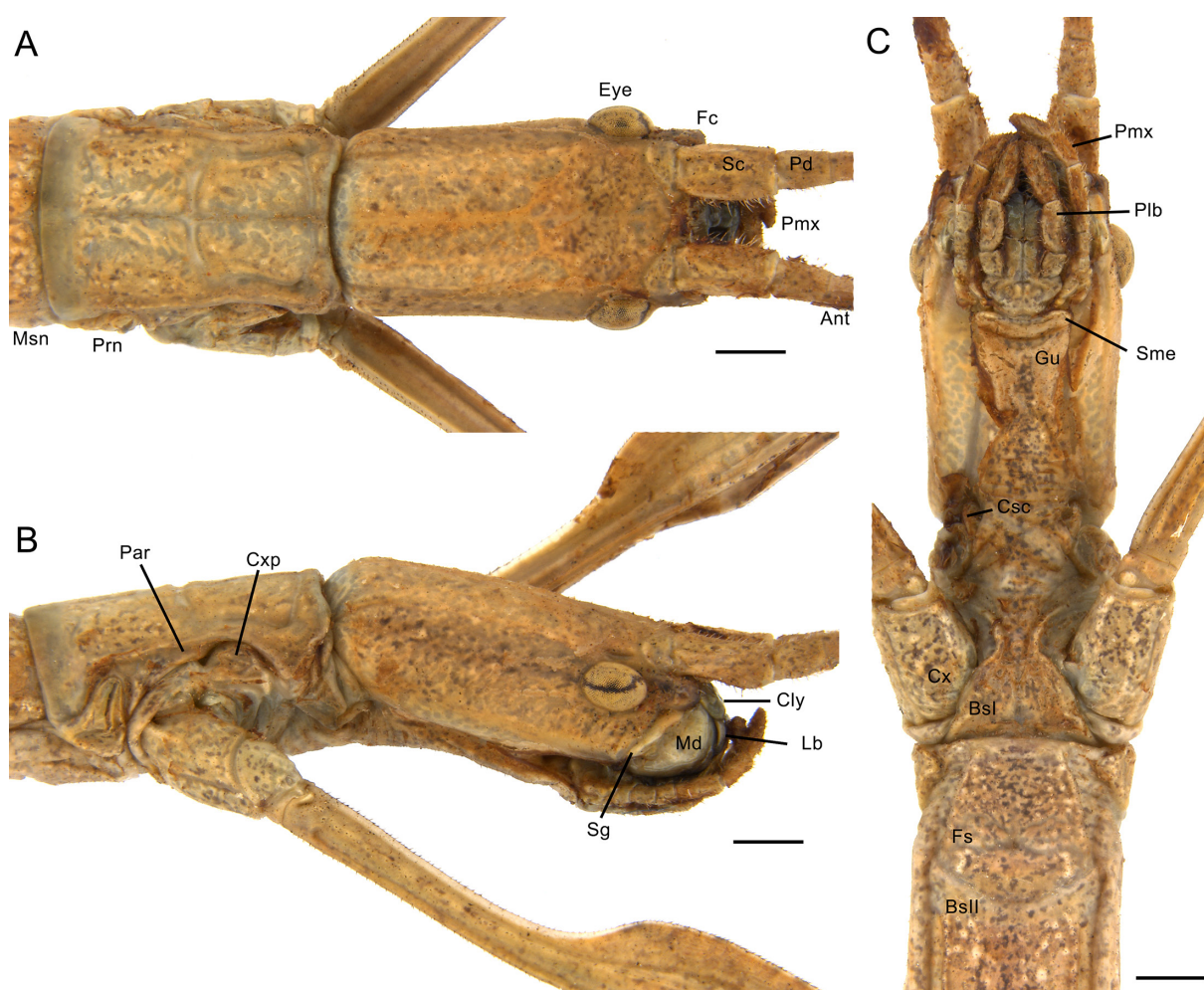


THORAX (Figs 34, 35A, 36A). Smooth with scattered small and short black setae. Pronotum longer than wide, slightly constricted pre-medially and slightly wider from transverse sulcus towards posterior margin, fairly flat in lateral view. Transverse sulcus of pronotum conspicuous and gently curved towards



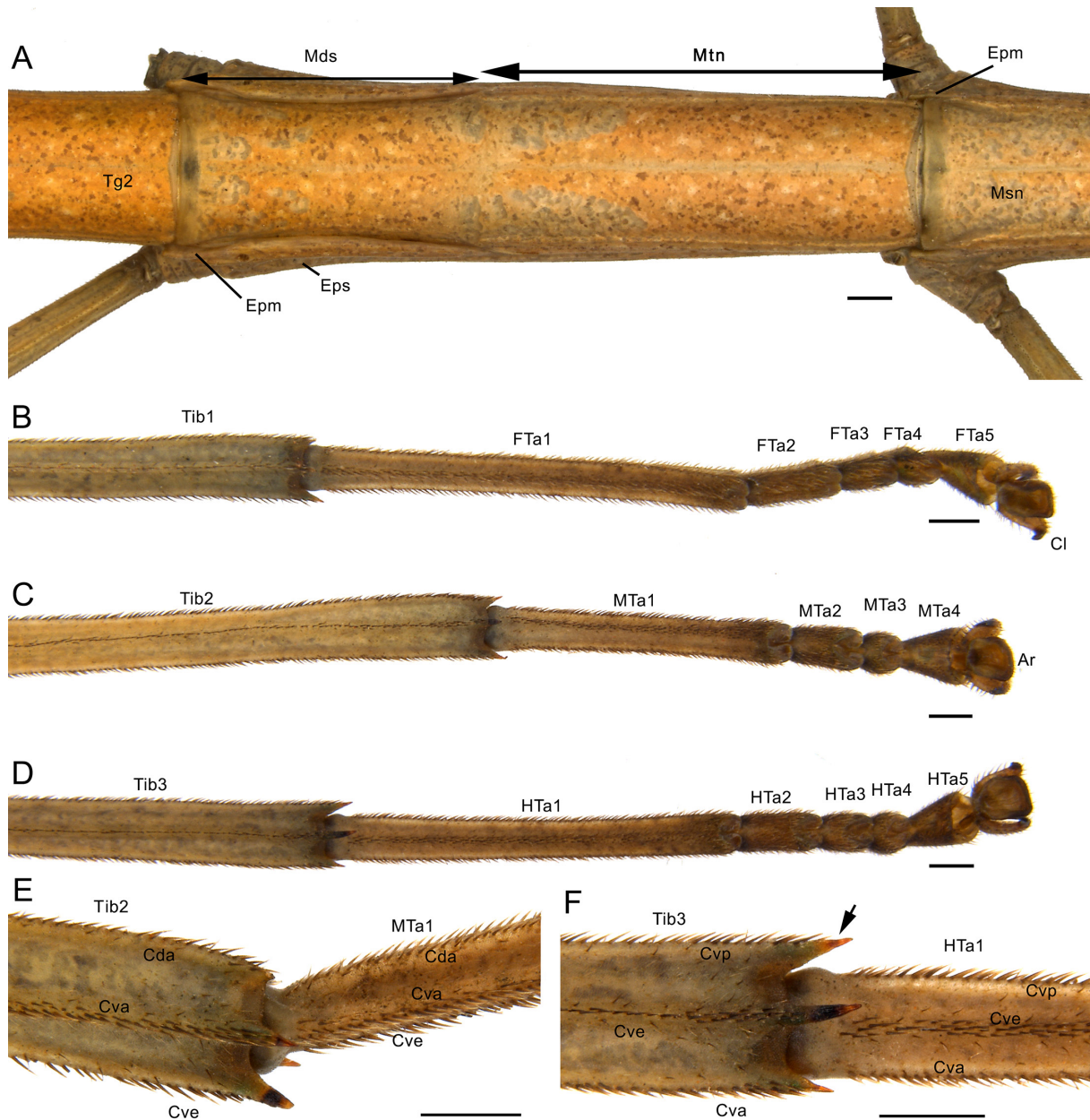
**Fig. 34.** Live habitus of *Arumatia motenata* Ghirotto gen. et sp. nov. from Serra do Cipó, Minas Gerais, Brazil. **A.** Mating pair. **B.** Adult ♀, holotype (MZUSP V0603). **C.** Adult ♂. Scale bars: 1 mm.

posterior, longitudinal sulcus conspicuous and distinct. Paranota curved, slightly widened medially, longer than wide, procoxopleurite apically round and ventrally straight (Fig. 35A–B). Probasisternum strongly tapering towards anterior, profurcasternum round (Fig. 35C). Mesothorax widened across all of length except near margins, gently convex in dorsal view (similar to paratype, Fig. 34B). Mesothorax 7 × as long as prothorax. Mesonotum with pair of lateral carinae, mesepisternum lanceolate and regularly widening posteriorly, mesepimeron slightly elongate, medially gently widened, pointing towards posterior and slightly exceeding end of mesothorax (Fig. 36A). Mesocoxopleurite small, elongate, mesofurca Y-shaped. Metathorax and median segment widened across all of length except near margins, gently convex in dorsal view (Fig. 36A). Metathorax continuing pair of lateral carinae of mesonotum, metepisternum long, similar to mesepisternum, metepimeron extremely elongate, extending across entire length of median segment, posteriorly pointing and slightly exceeding end of median segment



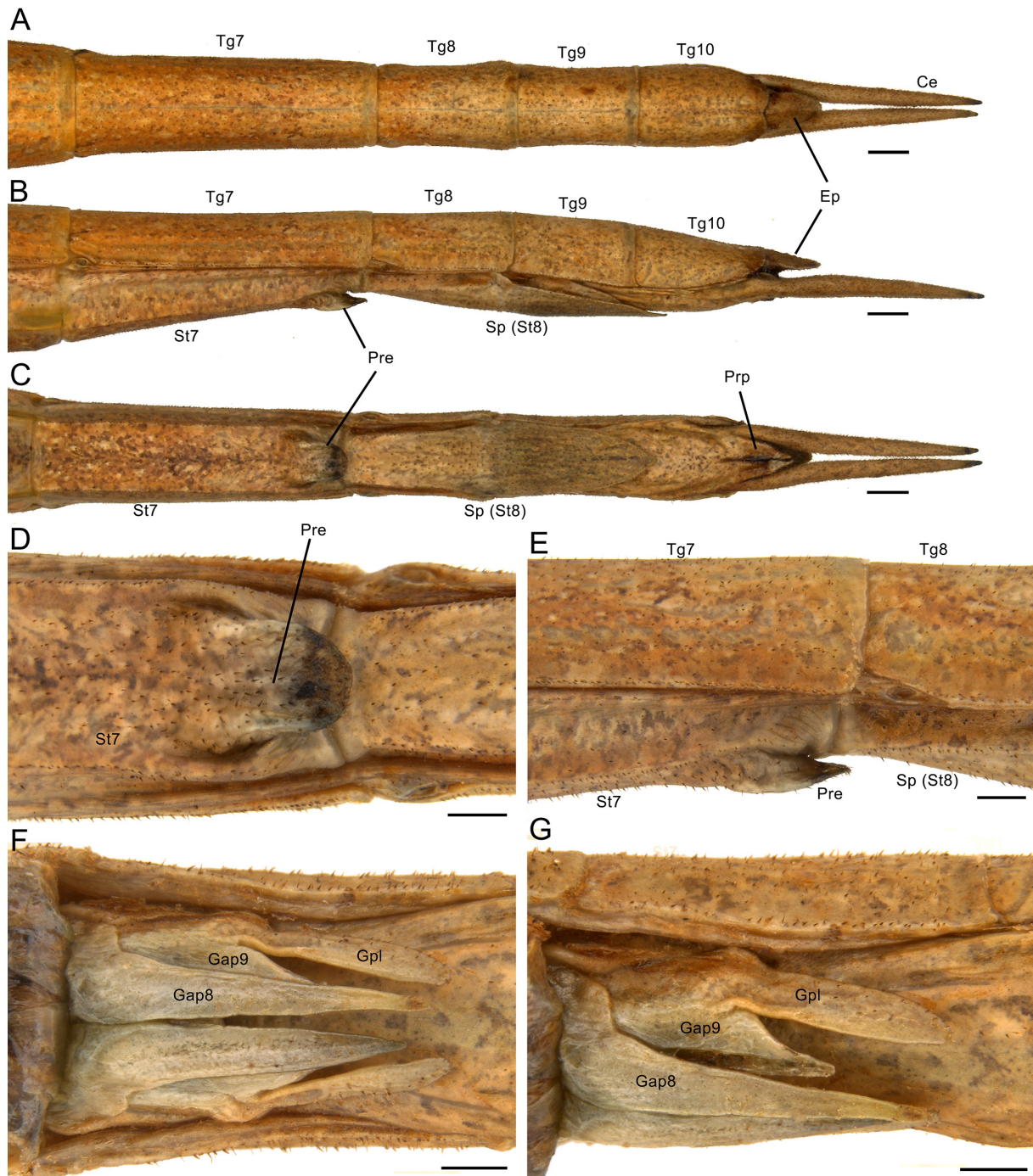
**Fig. 35.** *Arumatia motenata* Ghiorotto gen. et sp. nov., holotype, ♀ (MZUSP V0603), head and prothorax morphology. **A.** Head and prothorax in dorsal view. **B.** Head and prothorax in lateral view. **C.** Head and prothorax in ventral view. Abbreviations: Ant=antennomere; Bsl-II=pro- and mesothoracic basisterna; Cly=clypeus; Csc=cervical sclerite; Cx=coxa; Cxp=coxopleurite; Eye=compound eye; Fc=frontal convexity; Fs=prothoracic furcasternite; Gu=gula; Lb=labrum; Md=mandible; Msn=mesonotum; Par=paranota; Pd=pedicellus; Plb=labial palpus; Pmx=maxillary palpus; Prn=pronotum; Sc=scapus; Sg=subgena; Sme=submentum. Scale bars: 1 mm.

(Fig. 36A). Metacoxopleurite discrete, slightly elongate, medially gently widened, metafurca T-shaped. Metanotum 1.4 × as long as median segment (Fig. 36A). Median segment continuing pair of thoracic lateral carinae but weaker.



**Fig. 36.** *Arumatia motenata* Ghirotto gen. et sp. nov., holotype, ♀ (MZUSP V0603), thorax and leg morphology. **A.** Metathorax and median segment in dorsal view, arrows indicate the length of each segment. **B.** Left fore tarsus, ventro-prolateral view. **C.** Left mid tarsus, ventral view. **D.** Right hind tarsus, ventral view. **E.** Detail of right mid tibia and tarsus (mirrored), prolateral view. **F.** Detail of right hind tibia and tarsus, ventral view, arrow showing apical sessile spine. Abbreviations: Ar=arolium; Cda=dorsal anterior carina; Cl=claw; Cva=ventral anterior carina; Cve=ventral carina; Cvp; ventral posterior carina; Epm=epimeron; Eps=episternum; FTa=fore tarsomere; HTa=hind tarsomere; Mds=median segment; Msn=mesonotum; MTa=mid tarsomere; Mtn=metanotum; Tg=tergum; Tib=tibia. Scale bars: A=1 mm; B–F=0.5 mm.





**Fig. 37.** *Arumatia motenata* Ghirotto gen. et sp. nov., holotype, ♀ (MZUSP V0603), terminalia morphology. **A.** Dorsal view. **B.** Lateral view. **C.** Ventral view. **D–E.** Detail of praeopercular organ, ventral (D) and lateral view (E). **F–G.** Detail of external genitalia, ventral (F) and lateral view (G). Abbreviations: Ce=cercus; Ep=epiproct; Gap=gonapophysis; Gpl=gonoplac; Pre=praeopercular organ; Prp=paraproct; Sp=subgenital plate; St=sternum; Tg=tergum. Scale bars: A–C=1 mm; D–G=0.5 mm.

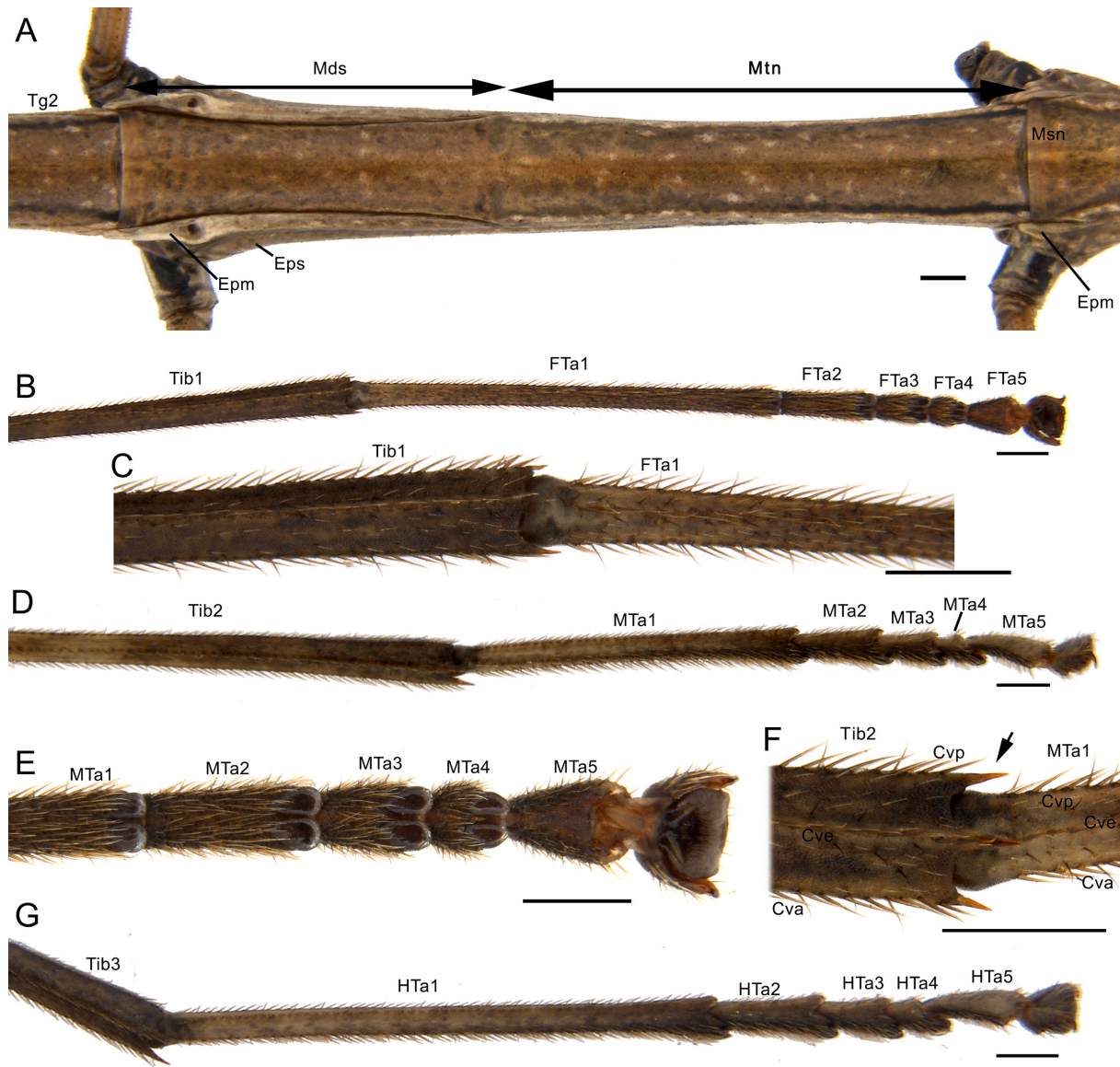
LEGS (Figs 34, 36B–F). Slender. Hindlegs extending beyond epiproct, anterior legs around same length as hindlegs, midlegs shorter. Coxae smooth. Profemur with distinct basal curvature. Femora and tibiae with five carinae with few sparse setae among them (Fig. 36B–F). Carinae of profemora and protibiae distinctly keeled, mid and hind femora and tibiae with slightly less prominent keels. Antero- and posteroventral carinae of femora with round apical prominence. Carinae of all femora, tibiae and tarsi bearing row of short stout setae, stouter and spiniform on tibiae. Along all basitarsi and near apex of meso- and metatibiae, ventral, antero- and posteroventral carinae bearing two to three rows of setae. Setae on ventral, antero- and posteroventral carinae of basitarsi stouter and spiniform. Ventral, antero-



**Fig. 38.** *Arumatia motenata* Ghirotto gen. et sp. nov., paratype, ♂ (MZUSP V0602), head and prothorax morphology. **A.** Head and prothorax in dorsal view. **B.** Head and prothorax in lateral view. **C.** Left maxilla in dorsal (internal) view. **D.** Detail of labrum, anterior view. **E.** Detail of paraglossa and glossa, antero-ventral view. **F.** Head and prothorax in ventral view. Abbreviations: Ant=antennomere; Bsl-II=pro- and mesothoracic basisterna; Cly=clypeus; Csc=cervical sclerite; Eye=compound eye; Fc=frontal convexity; Fs=prothoracic furcasternite; Ga=galea; Gao=galealobulus; Gl=glossa; Gra=granules; Gu=gula; Lac=lacinia; Lase=lacinal setae; Lb=labrum; Md=mandible; Msn=mesonotum; Mtr=microtrichia; Pd=pedicellus; Pgl=paraglossa; Plb=labial palpus; Pmx=maxillary palpus; Prn=pronotum; Sc=scapus; Sg=subgena; Sme=submentum. Scale bars: A–B, D–F=0.5 mm; C=0.2 mm.



and posteroventral carinae of tibiae ending as apical spiniform sessile projection parallel to tibiae, pointing towards tarsi (Fig. 36E–F). Pro- and metabasitarsi very elongate, significantly longer than respective following tarsomeres combined, mesobasitarsi as long as respective following tarsomeres combined (Fig. 36B–D). Basitarsi with hairy setae restricted to apical portion on ventro-lateral patches (Fig. 36B, D). Remaining tarsomeres with setae on ventrolateral patches in portions not covered by euplantulae. Tarsomeres I–III with dorsal apical projection. Arolium round and broad, bearing setae



**Fig. 39.** *Arumatia motenata* Ghirotto gen. et sp. nov., paratype, ♂ (MZUSP V0602), thorax and leg morphology. **A.** Metathorax and median segment in dorsal view, arrows indicate the length of each segment. **B.** Left fore tarsus, ventral view. **C.** Detail of left fore tibia and tarsus. **D.** Right mid tarsus, retrolateral view. **E.** Detail of right mid tarsus, ventral view. **F.** Detail of right mid tibia and tarsus, ventral view, arrow showing apical sessile spine. **G.** Right hind tarsus, retrolateral view. Abbreviations: Cva=ventral anterior carina; Cve=ventral carina; Cvp; ventral posterior carina; Epm=epimeron; Eps=episternum; FTa=fore tarsomere; HTa=hind tarsomere; Mds=median segment; Msn=mesonotum; MTa=mid tarsomere; Mtn=metanotum; Tg=tergum; Tib=tibia. Scale bars: 0.5 mm.



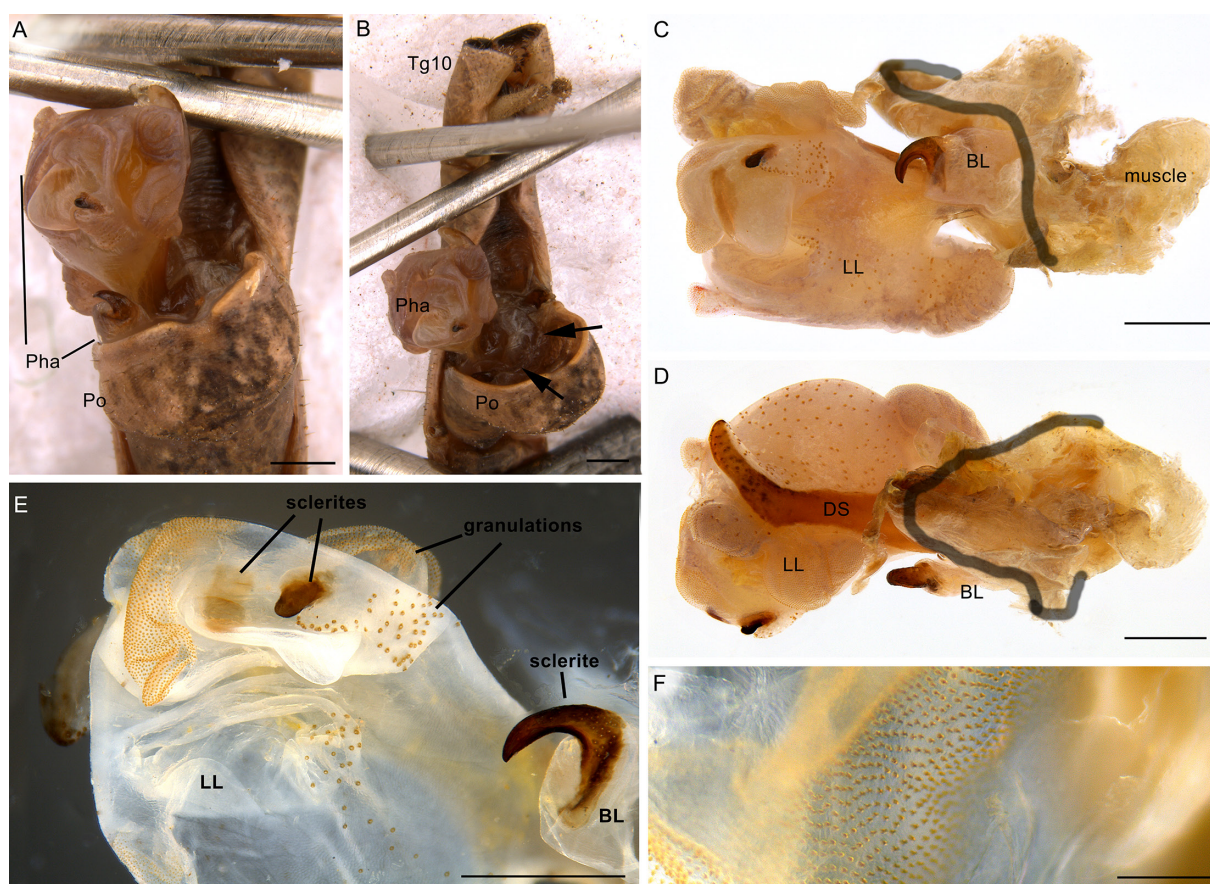
dorsally. Pretarsal claws symmetrical, dorsally and outwardly bearing setae. Euplantulae well developed in all tarsomeres, composed of two symmetrical pads separated by median groove in tarsomeres I–IV, and of single flattened lobed pad in tarsomeres V. Euplantulae present only apically at tarsomeres I–II, covering ca half length of tarsomeres III, covering two thirds length of tarsomeres IV and covering almost entire ventral surface of tarsomeres V (Fig. 36B–D).

ABDOMEN (Figs 34, 36A, 37). External surface as in thorax but bearing slightly more scattered short setae across entire length. Median segment shorter than metanotum, anteriorly with two parasagittal ovoid stains (Fig. 36A). Combined length of segments II–X as long as combined length of thorax



**Fig. 40.** *Arumatia motenata* Ghirotto gen. et sp. nov., paratype, ♂ (MZUSP V0602), terminalia morphology. **A.** Dorsal view. **B.** Left side lateral view. **C.** Posterior view, detail of tergum X. **D.** Left side latero-dorsal view. **E.** Right side lateral view. **F.** Posterodorsal view, detail of tergum X. **G.** Ventral view. **H.** Detail of vomer, ventral view. Abbreviations: Ce=cercus; Ep=epiproct; Pha=phallic organ; Po=poculum; Prp=paraproct; St=sternum; Tg=tergum; Tp=thorn pads; Vo=vomer. Scale bars: 0.5 mm.

and median segment. Terga II–VIII and sterna II–VII bearing lateral carinae near lateral margins. All segments longer than wide. Segment II shorter than III, segment III of same length as VII and shorter than IV, segments IV–VI of same length, tergum VIII significantly shorter than preceding segment and slightly longer than IX and X, tergum X slightly longer than IX. Tergum II widening towards posterior, tergum III widest, slightly wider than II and IV, terga IV and V about same width, tergum VI wider than preceding segment, with lateral margins convex in dorsal view, tergum VII narrower than all preceding segments, slightly wider than VIII, terga VIII–X around same width or very slightly tapering (Fig. 37A). Tergum X somewhat conical in lateral view (Fig. 37B) and in dorsal view almost parallel-sided but at  $\frac{3}{4}$  the length tapering towards posterior, posterior margin emarginate with round lateral margins (Fig. 37A). Epiproct very prominent, elongate, lingulate in dorsal view, dorsoventrally flattened, visible dorsally and laterally (Fig. 37A–B). Paraprocts elongate, posteriorly fairly acute, straight, bearing setae on posterior margin, laterally bearing cerci (Fig. 37B–C). Cerci extremely elongate, straight, basally narrower fitting paraprocts, pointing to posterior, gradually tapering and slightly shorter than terga IX and X combined (Fig. 37A–C), bearing four types of setae. Praeopercular organ very prominent, lobed,



**Fig. 41.** *Arumatia motenata* Ghiorotto gen. et sp. nov., ♂♂, genital morphology. **A–D.** Paratype (MZUSP V0620). **E–F.** Paratype (MZUSP V0621). **A–B.** Terminalia, ventral view. **A.** Poculum pushed anteriorly showing the phallic organ. **B.** Phallic organ tilted, arrows showing attachment area corresponding to the sulcus between sterna VIII and IX. **C–D.** Dissected untreated phallic organ, ventral (C) and dorsal view (D), grey line highlights area of attachment to the body. **E.** Detail of phallic organ treated with KOH, ventral view. **F.** Detail of granulations on the longitudinal lobe of phallic organ treated with KOH, lateral view. Abbreviations: BL=basal lobe; DS=dorsal sclerite; LL=longitudinal lobe; Pha=phallic organ; Po=poculum; Tg=tergum. Scale bars: A–E=0.5 mm; F=0.1 mm.



elevated and folded backwards, forming a round dorsoventrally flattened, centrally depressed projection (Fig. 37B–E). Subgenital plate roundly lanceolate, short, almost reaching  $\frac{1}{3}$  of length of tergum X. Subgenital plate bearing two parasagittal carinae beginning on anterior margin and running half length of segment before becoming flatter and more setose, tapering towards posterior and totally covering gonapophyses and gonoplac (Fig. 37B–C). Gonapophyses and gonoplac flattened, dorsoventrally for gonapophyses VIII, lateroventrally for IX and laterally for gonoplac (Fig. 37F–G). Gonapophyses VIII longer than IX, gonapophysis VIII reaching ca  $0.8 \times$  length of tergum IX, gonapophysis IX reaching ca  $0.6 \times$  length of tergum IX. Gonapophysis VIII linear and gradually tapering, IX conical, tapering towards posterior, with lateral margin concave and inner margin straight (Fig. 37F–G). Gonapophyses IX ventrally folded to fit within gonapophyses VIII. Gonangulum distinctly reduced, flat, not lobed. Gonoplac lorate, somewhat wide in lateral view, bearing setae and slightly longer than gonapophyses VIII (Fig. 37F–G).

#### Other females

MEASUREMENTS (in mm, N = 8). Body 92–113.5, head 5.0–5.8, antennae 48.0–58.0, pronotum 3.3–4.1, mesonotum 20.0–25.5, metanotum 7.5–9.9, median segment 4.9–7.3, abdomen (excluding median segment) 44.0–54.7, cercus 4.4–6.0, profemur 21.4–24.7, protibia 20.8–26.0, mesofemur 16.5–19.5, mesotibia 16.3–20.3, metafemur 20.0–23.6, metatibia 20.6–28.7.

VARIATION. Some few specimens may present shorter cerci due to regeneration from breaking in previous instars (e.g., Fig. 45C). Some specimens may present more elongate gonapophyses IX, longer than gonoplac (e.g., Fig. 45D).

COLOUR (Figs 34, 44–46A). Body generally light to mid green, beige, brown, grey or dark, with or without irregular stains of different tones.

#### Male paratype (MZUSP V0602)

MEASUREMENTS (in mm). Body 57.6, head 2.9, antennae at least 48.8, pronotum 2.3, mesonotum 14.0, metanotum 5.6, median segment 4.1, abdomen (excluding median segment) 28.7, cercus 1.1, profemur 19.2, protibia 21.9, mesofemur 15.3, mesotibia 17.0, metafemur 18.8, metatibia 22.1.

COLOUR (Figs 38–40, similar to paratype in Fig. 34C). Entirely light to mid brownish with irregular stains of different tones and scattered whitish to creamy granules.

HEAD (Fig. 38). Similar to female except: eyes, scapus and pedicel proportionally larger, head widening from posterior margin towards anterior in dorsal view, vertex very gently convex near anterior margin above eyes, frontal suture more acute (Fig. 38A). Paraglossa wider, inner margin straight (Fig. 38E). Galea thinner, more elongate, slightly constricted before apical portion, galealobulus wider, less prominent (Fig. 38C). Labial palpal segments slightly less widened (Fig. 38F). Antennae reaching at least tergum VI, scapus ca  $1.7 \times$  as long as wide (Fig. 38A).

THORAX (Figs 38A–B, F, 39A, similar to paratype in Fig. 34C). Similar to female except: significantly thinner and more elongate than that of female. Meso-, metathorax and median segment with straight lateral margins in dorsal view, not convex (Fig. 39A). Mesothorax ca  $6.5 \times$  as long as prothorax. Mesocoxopleurite larger, triangular. Metanotum  $1.3 \times$  as long as median segment (Fig. 39A). Metafurca Y-shaped.

LEGS (Fig. 39B–G, similar to paratype in Fig. 34C). Similar to female except: legs thinner than those of female, basitarsi relatively longer (Fig. 39B, D, G). All setae generally longer than those of female (Fig. 39B–F). Setae over carinae of femora slightly sparser, over carinae of tibiae longer (Fig. 39B, D, G). Carinae of femora, tibiae and tarsi with single row of setae except for ventral carinae of basitarsi



with two to three rows. Apical spine in ventral carinae of tibiae less developed, discrete. All basitarsi longer than respective following tarsomeres combined (Fig. 39B, D, G). Ventrolateral hairy setae of tarsomeres denser. Euplantulae slightly shorter, on tarsomeres V rougher (Fig. 39E).

**ABDOMEN** (Figs 39A, 40, 41A–B, similar to paratype in Fig. 34C). Thinner than that of female. Lateral carinae absent in median segment. Segments II–VII slightly constricted medially from anterior to posterior regions. Terga II, III and VI about same length, terga IV and V about same length and slightly longer than III, tergum VII shorter than VI, tergum VIII shorter than preceding segment and slightly longer than IX, terga IX and X about same length. Terga II–V about same width, tergum VI slightly narrower than preceding segment, tergum VII as wide as VI but slightly wider posteriorly, VIII wider than VII, slightly widening towards posterior, IX slightly narrower than VIII, tapering towards posterior, X narrower anteriorly, slightly widened medially with maximum width around as wide as maximum width of VIII and IX (Fig. 40A). Tergum X presenting lateral flat flexing expansions bent downwards from half length to posterior margin, with somewhat acute ventrolateral edges directed posteriad (Fig. 40A–G). Paraprocts totally covered by these expansions. Dorsal posterior margin of tergum X widely v-shaped emarginate (Fig. 40A, F). Ventral area of posterior dorsal margin of tergum X strongly sclerotized, black (Fig. 40C). Thorn pads composed of ca 28–35 strong, inwardly curved sclerotized conical teeth, variable in size, with very few in sclerotized area on ventral surface of posterior dorsal margin of tergum X, with teeth present also anteroventrally (near apex of vomer) and laterally at ventral surface of posterior margin of lateral expansions (Fig. 40C). Tergum VIII and sternum VIII separated, not fused (Fig. 40B, E). Sternum VIII partly fused with sternum IX, border between both sterna shown as asymmetric sulcus curving towards posterior on right side (Fig. 40G). Sternum IX reduced with anterior portion indistinct; only shown as poculum (Fig. 40B, E). Poculum reaching around  $\frac{3}{4}$  length of tergum IX. Due to asymmetry of sulcus, poculum shorter at right side than left side (Fig. 40B, E). Poculum fairly short, round in lateral view, about as long as tall or slightly longer than tall at left side, round in ventral view, posterior margin medially with wide emarginate short curvature towards anterior (Fig. 40G). Cerci slightly shorter than tergum X, inwardly curved and with round apex (Fig. 40A–F). Epiproct small, hidden in dorsal and lateral views (Fig. 40H). Vomer elongate, dorsoventrally flattened, terminal hook elongate and strongly sclerotized, symmetrically bifid near posterior margin with round apices gently curving upwards (Fig. 40C, G–H).

**GENITALIA** (Figs 41, 43, right side). Male genitalia or phallic organ attached ventrally at area corresponding to asymmetric sulcus between sterna VIII and IX (Fig. 41A–B) by large muscles connected to anterior portion of dorsal sclerite (Fig. 41C–D). Phallic organ composed of dorsalmost sclerite (dorsal sclerite), wide lobe with fine granulation originating ventrally from dorsal sclerite (longitudinal lobe), and smaller and shorter lobe basally, slightly ventrally, at right side, the (right) basal lobe. Dorsal sclerite very elongate and penetrating inside body cavity (Fig. 43). Anterior portion penetrating body, wider and medially constricted. Short truncate branch at right side pointing towards posterior, connecting dorsal sclerite to body wall at end of anterior portion (Fig. 43C–D). Posterior portion narrower, slender, slightly tapering towards apex and bent to left near apex (Figs 41D, 43A–D). Longitudinal lobe wide, anteriorly to left branching in round lobule pointing towards anterior, with densely finely granulated round lobule dorsally before apex, originating near dorsal sclerite. Longitudinal lobe posteriorly with several folding and smaller lobules, with dense fine granulations (Fig. 41F), larger and sparser circular granulations, ventrally with weakly sclerotized area near apex and more posteriorly with strong, projecting, small and round sclerite (Fig. 41C–F). Basal lobe short and apically bearing claw-like sclerite, strongly sclerotized, with few sparse granules and with wide base (Fig. 41E).

#### **Other males**

**MEASUREMENTS** (paratypes, range in mm, N = 6). Body 61–70.1, head 2.7–3.2, antennae 50.0–57.0, pronotum 2.0–2.6, mesonotum 15.8–17.4, metanotum 6.3–7.5, median segment 4.4–5.2, abdomen

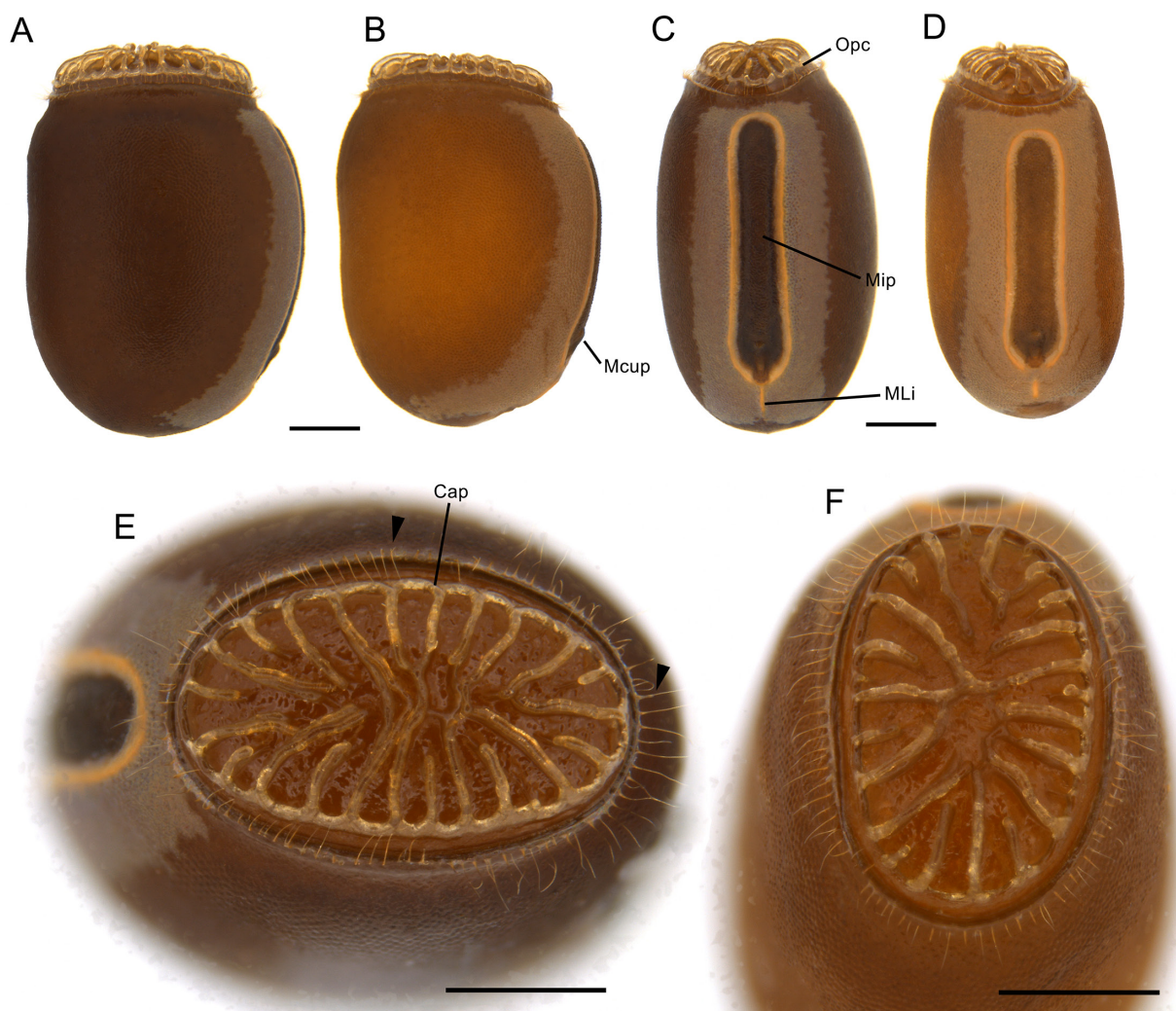
(excluding median segment) 29.8–34.2, cercus 0.9–1.2, profemur 20.5–22.7, protibia 22.4–24.8, mesofemur 16.0–17.8, mesotibia 17.9–19.1, metafemur 20.0–23.2, metatibia 22.4–25.2.

VARIATION. Thorn pad at ventral area of posterior dorsal margin of tergum X bearing 2–10 spines.

COLOUR (Figs 34A, C, 44–45). Entirely light to dark brownish, light greenish, grey or dark with irregular stains of different tones and with or without stains of beige, dark red, black with scattered whitish to creamy granules.

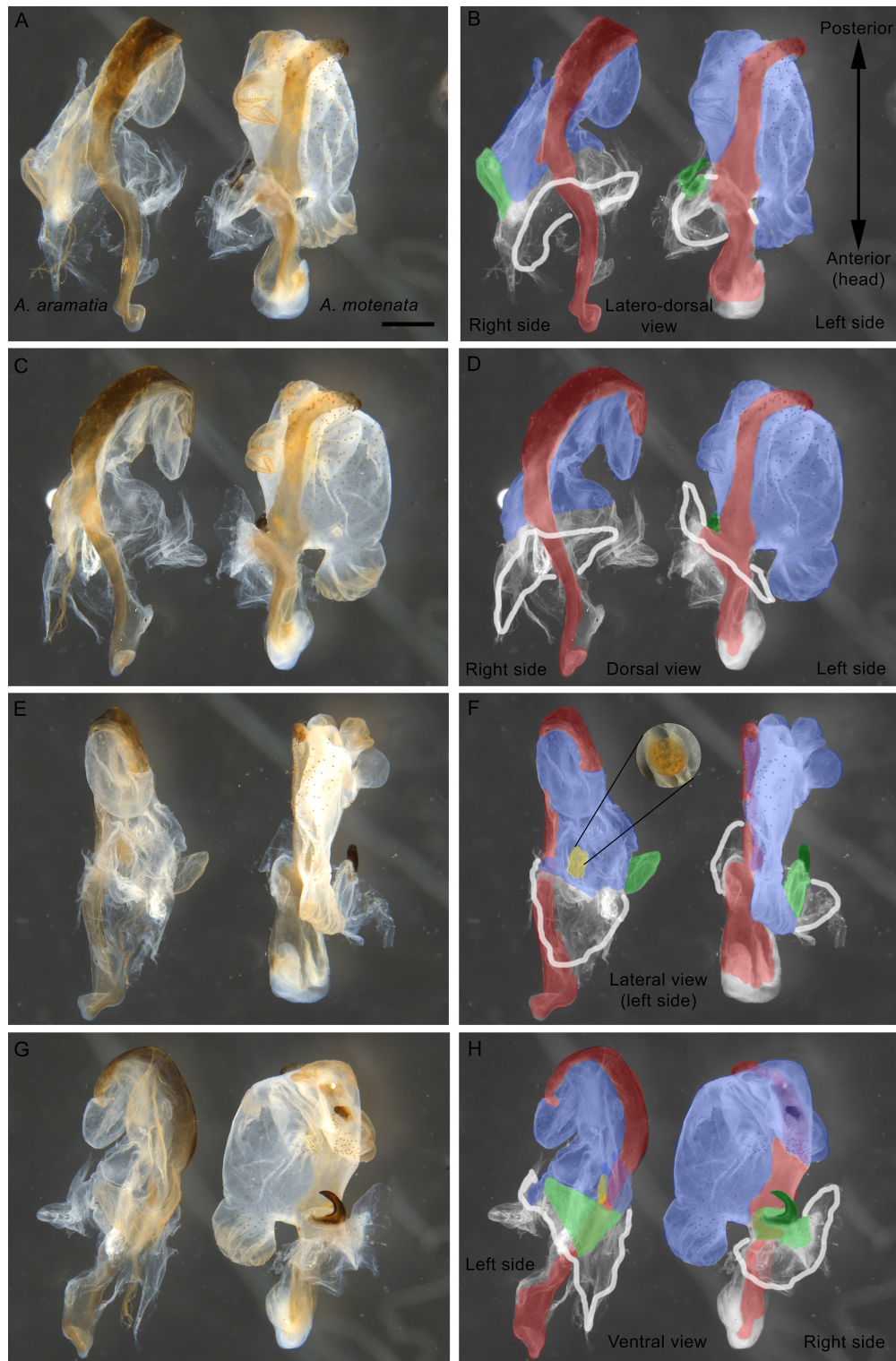
**Egg** (Fig. 42)

Measurements (in mm, N=10): length 2.7–2.8, height 1.9–2.0, width 1.4–1.5. Relatively small, somewhat subrectangular in lateral view, slightly constricted at opercular collar, laterally compressed and ca 1.8 × as long as wide and 1.4 × as long as tall (Fig. 42A–D). Capsule surface smooth but with finely punctuated appearance (Fig. 42A–B). Colour varying in shades of orangish or reddish brown with creamy lighter



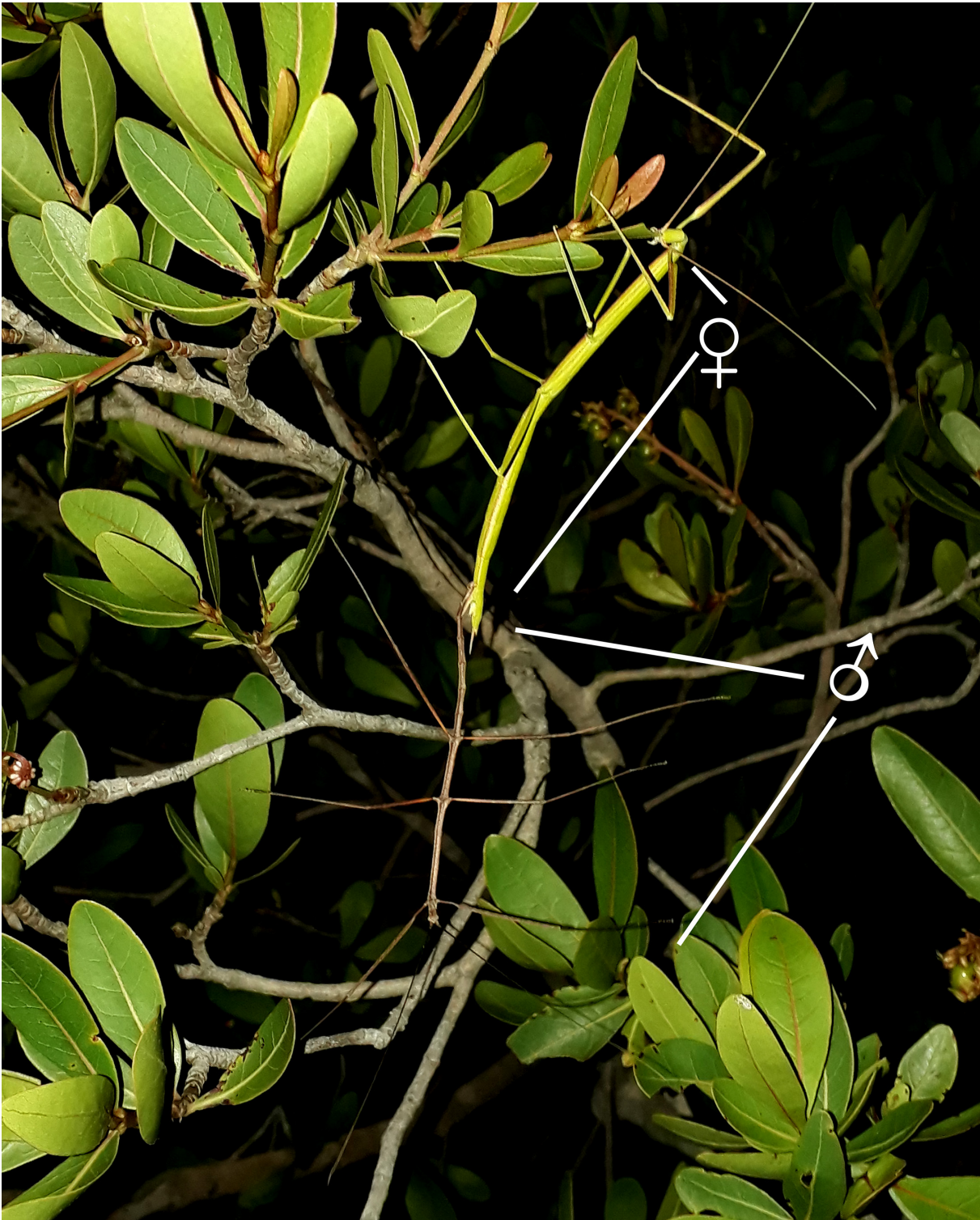
**Fig. 42.** *Arumatia motenata* Ghirotto gen. et sp. nov., egg morphology. **A–B.** Lateral view. **C–D.** Dorsal view. **E–F.** Detail of operculum, anterior view, arrowheads pointing to bristles on opercular collar (E). Abbreviations: Cap=capitulum; Mcup=micropylar cup; Mip=micropylar plate; MLI=median line; Opc=operculum. Scale bars: 0.5 mm.





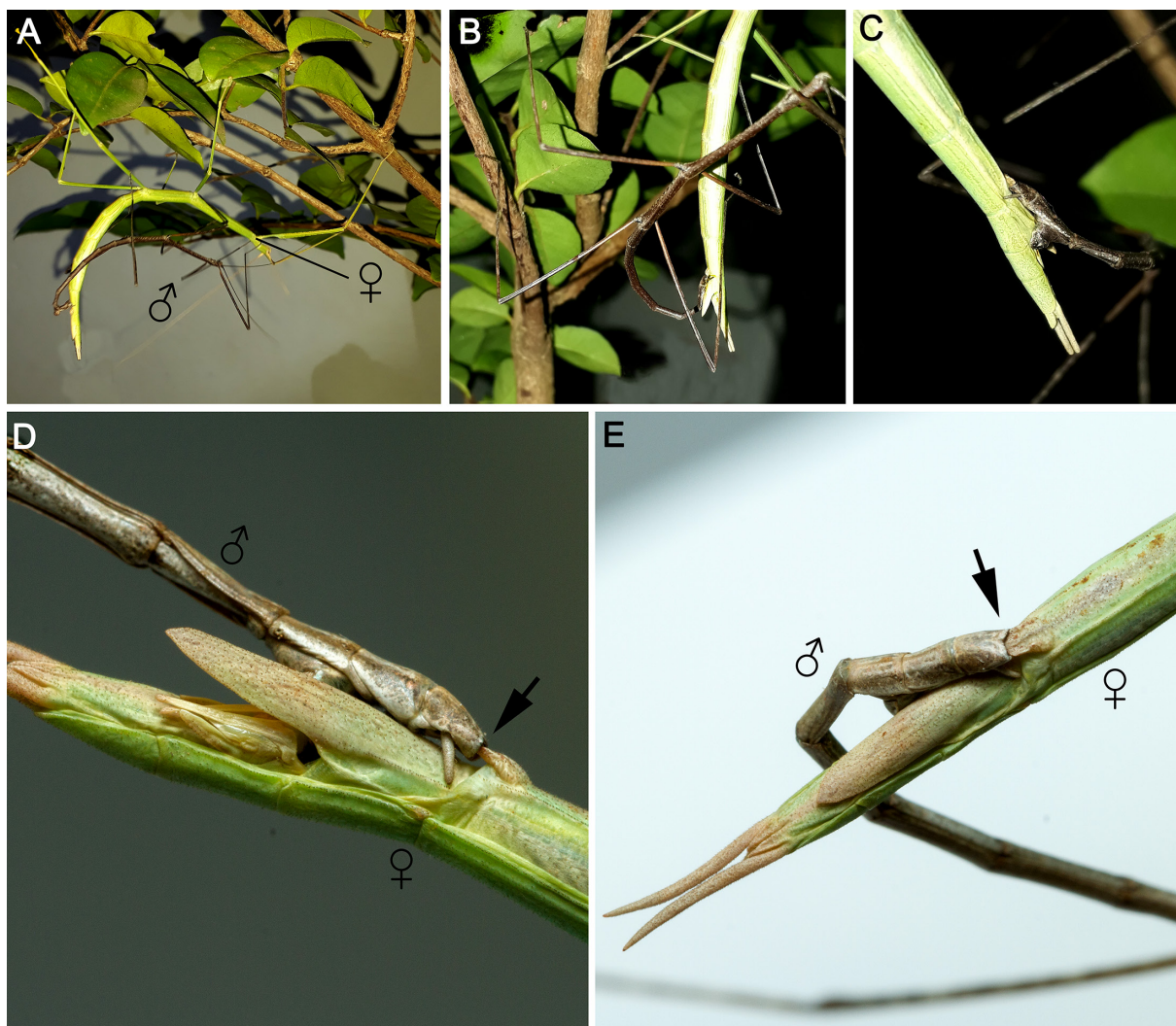
**Fig. 43.** Male genitalia of *Arumatia aramatia* Ghirotto gen. et sp. nov. and *Arumatia motenata* Ghirotto gen. et sp. nov., treated with KOH. **A, C, E, G.** Treated genitalia of *A. aramatia* (left side) and *A. motenata* (right side) in different views. **B, D, F, H.** Same pictures as respective preceding, structures coloured for visualisation: red=dorsal sclerite; blue=longitudinal lobe; green=basal lobe; yellow=internal sclerotization; white line=area of attachment to the body; inset (F)=detail of internal sclerotization, internal view. All pictures to the same scale. Scale bar: 0.5 mm.





**Fig. 44.** *Arumatia motenata* Ghiretto gen. et sp. nov., live habitus in situ at Serra do Cipó, Minas Gerais, Brazil. Adult pair, at night, on locustberry plant (*Byrsonima* sp.). Note female feeding on the plant and male hanging attached to the female by the terminalia. Image not to scale.

band on dorsal surface extending in short posterior lateral patches around polar area. Micropylar plate very elongate, occupying large area of dorsal region, with round margins, almost parallel-sided with posterior portion gently widened (Fig. 42C–D). Micropylar plate with lighter round elevation delimiting inner flat region confluent with micropylar cup (Fig. 42C–D). Micropylar cup small, rounded and only slightly elevated. Median line short and of same colour and elevation as elevated margin of micropylar plate, almost reaching polar area, sometimes disjunct with micropylar plate (Fig. 42C–D). Opercular collar very slightly narrower (constricted) than rest of capsule, smooth, whitish with several minute and delicate long bristles surrounding edge (Fig. 42E–F). Operculum elliptical with marginally radial elevations with amber texture, irregular and less elevated at centre with some elevations fused centrally (Fig. 42A–F).



**Fig. 45.** *Arumatia motenata* Ghirotto gen. et sp. nov., sexual behaviour and mating attachment mechanism, from Serra do Cipó, Minas Gerais, Brazil. **A–C.** Sequential copulatory behaviour. **D–E.** Attachment of male and female structures. **A.** Male (dark) on top of female (green) extends his terga VIII–X anteriorly and touches the ventral surface of the abdomen of the female trying to attach. **B.** Male attached to the female by the left side and inserting the phallic organ; note abdomen of male curved upwards. **C.** Male and female in copulation, male hanging from female; note abdomen of male extended. **D–E.** Male attached to the praeopercular organ of the female with the posterior margin of its tergum X (arrow), cerci pressing the subgenital plate of the female, lateral (D) and ventral view (E). Images not to scale.



**Distribution** (Fig. 52)

Known only from the type locality, in the Serra do Cipó District, Santana do Riacho, Minas Gerais, Brazil. Serra do Cipó is part of the Serra do Espinhaço (Espinhaço mountain range), which is a wide and long mountain range in Brazil typically dominated by campos rupestres (“rupestrian grasslands”), a grassland to savannic rocky formation (Fig. 53G–H). All individuals of the species were found in campos rupestres vegetation near a road running through the Serra do Cipó (Fig. 53G–H). Certainly, the species also occurs in a nearby protected area continuous with the type locality, also in the Serra do Cipó formation, the Parque Nacional da Serra do Cipó, although it has not yet been recorded for the Park.

**Biology**

At the type locality at Serra do Cipó specimens were found in the rainy season at several stages from early nymphs to mating adult pairs. In two nights of searching, more than 20 specimens were seen over a few kilometres. Specimens were observed feeding on native locust berries (*Byrsonima* Rich ex. Kunth, Malpighiaceae) (Fig. 44) and on guava trees alongside the road (native to Brazil but not to that particular environment; it is widely dispersed in urbanized areas). In captivity, they also fed on Brazilian cherry. Similar to *Arumatia dubia* gen. et comb. nov. both nymphs and adults are agitated when handled but in a somewhat lessened manner. Reared specimens were not observed to hide resting along a branch, but usually with mid and hindlegs keeping the body elevated. Eggs laid by adult females since collecting took 90–150 days to hatch but most of 10 controlled eggs hatched within 105 days. The first nymphs to hatch were adult males or pre-subadult females when totalling 60–73 days of development and females became adults at around 90–105 days of development.

In one of the mating attempts observed under captivity, the male repeatedly touched the female with his antennae while climbing on her, but the pair parted ways shortly after. Another two mating attempts resulted in a quick tapping of the antennae on the female while climbing on her and either only the male or the pair started to frenetically move their legs. The male quickly jumped on top of the female facing



**Fig. 46.** Comparison of live adult females. **A.** *Arumatia motenata* Ghirotto gen. et sp. nov. **B.** *Arumatia dubia* gen. et comb. nov. Scale bar: 10 mm.



the same direction with all tarsi touching her thorax. Then, while the female was shaking, the male positioned his abdomen beneath the abdomen of the female by the left side, tapped with the apex of his abdomen and then significantly bent his terga VIII to X anteriorly and slid the apex of his abdomen up and down the ventral surface of the abdomen of the female until the posterior margin of his tergum X attached to the female's praeopercular organ (Fig. 45A). Then, the male pushed his abdomen backwards so the poculum contacted the female's subgenital plate and copulation started (Fig. 45A–B). At this moment, the male's abdomen curved upwards so the ventral side of the apex of his abdomen contacted the ventro-lateral area of the tip of the female's abdomen (Fig. 45B). The poculum faced the right side of the female's subgenital plate and attached that way. Later on, the male was seen to hang attached to the female only by the abdomen and eventually mounted on the top of the female again but with the abdomen now curving to the right side so that his abdomen curved downwards instead of upwards (Fig. 45C). They remained in copulation for around 50 hours. Males seen already in copulation with females were always positioned by the right side (Figs 34A, 44, 45).

Males attach to the female in three ways: by grasping the female's subgenital plate with his curved cerci (Fig. 45D–E), by inserting his vomer underneath the praeopercular organ (hidden from view in the pictures) and by folding the lateral expansions of its tergum X, grasping the female praeopercular organ (Fig. 45D–E).

*Arumatia diamante* Ghirotto gen. et sp. nov.

[urn:lsid:zoobank.org:act:4C3A3807-C918-4147-97C4-521F0D1F1515](https://zoobank.org/act:4C3A3807-C918-4147-97C4-521F0D1F1515)

Figs 47–51, 52, 53I

## Diagnosis

### Females

Differs from all other known females of *Arumatia* gen. nov. by the presence of two large tubercles on tergum VI. It further differs from all other known females of *Arumatia* except *A. motenata* gen. et sp. nov. by the very elongate subrectangular head, the longer microtrichia on the galea, the absence of stronger spiniform setae on the carinae of the tarsi and on the apex of the mid and hind tibiae, the presence of an apical sessile spine on the apex of the ventral, antero- and posteroventral carinae of the tibiae, the very elongate epiproct, the shorter subgenital plate and the wider gonoplac in lateral view. It further differs from *A. dubia* gen. et comb. nov. and *A. fulgens* gen. et comb. nov. by the shorter median segment in relation to the metanotum, the slightly shorter cerci and the longer gonapophyses VIII, from *A. anyami* gen. et sp. nov. by the less emarginate posterior margin of tergum X, from *A. crassicerca* gen. et sp. nov. by the shorter median segment in relation to the metanotum and the longer cerci, from *A. aramatia* gen. et sp. nov. by the shorter median segment in relation to the metanotum, the shorter cerci and the longer gonapophyses VIII, and from *A. motenata* by the more elongate head, the proportionally shorter cerci and the longer epiproct and paraprocts.

### Eggs

Eggs of *Arumatia diamante* gen. et sp. nov. can be differentiated from eggs of all other species whose eggs are known except *A. aramatia* gen. et sp. nov. by the large and not constricted opercular collar. Eggs of *A. diamante* differ from those of *A. aramatia* by the straight, not sinuous ridges of the capitulum.

## Etymology

The specific epithet “*diamante*” is Portuguese for “diamond” referring both to the type locality, the diamond-bearing Chapada Diamantina formation (translated as “Diamantine Plateau”), and to the beautiful colouration of this species, composed of different shades resembling the effect caused by the reflection of light in diamonds. To be treated as a noun in apposition.

## Material examined

### Holotype

BRAZIL • ♀; Bahia, Abaíra, Catolés district, near trail to Pico do Elefante; 13°16'11.2" S, 41°54'22.2" W; 1400–1500 m a.s.l.; 4 Mar. 2022; P.H. Martins, A. Galleti-Lima *et al.* leg.; Chapada Diamantina plateau, savannah in campo rupestre vegetation; MZUSP V0650.

## Remarks

Only two egg capsules and a single capitulum were obtained from inside the abdomen of the only known female and might differ in some details from laid eggs. The extracted capitulum appeared to be underdeveloped with only faint markings delimiting its ridges. For comparison, analysis of eggs of *Arumatia dubia* gen. et comb. nov. extracted from the same region of the abdomen revealed that in this species the capitulum and micropylar plate were already formed but the whitish dorsal stains were not present and the texture of the capsule was sometimes smooth, still not formed.

## Description

### Female holotype (MZUSP V0650)

MEASUREMENTS (in mm). Body (without cerci) 85.7, head 5.3, antennae at least 46.5, pronotum 3.5, mesonotum 20.0, metanotum 8.1, median segment 5.6, abdomen (excluding median segment) 43.2, cercus 3.5, profemur 20.2, protibia 20.9, mesofemur 15.5, mesotibia 15.7, metafemur 20.1, metatibia 22.1.

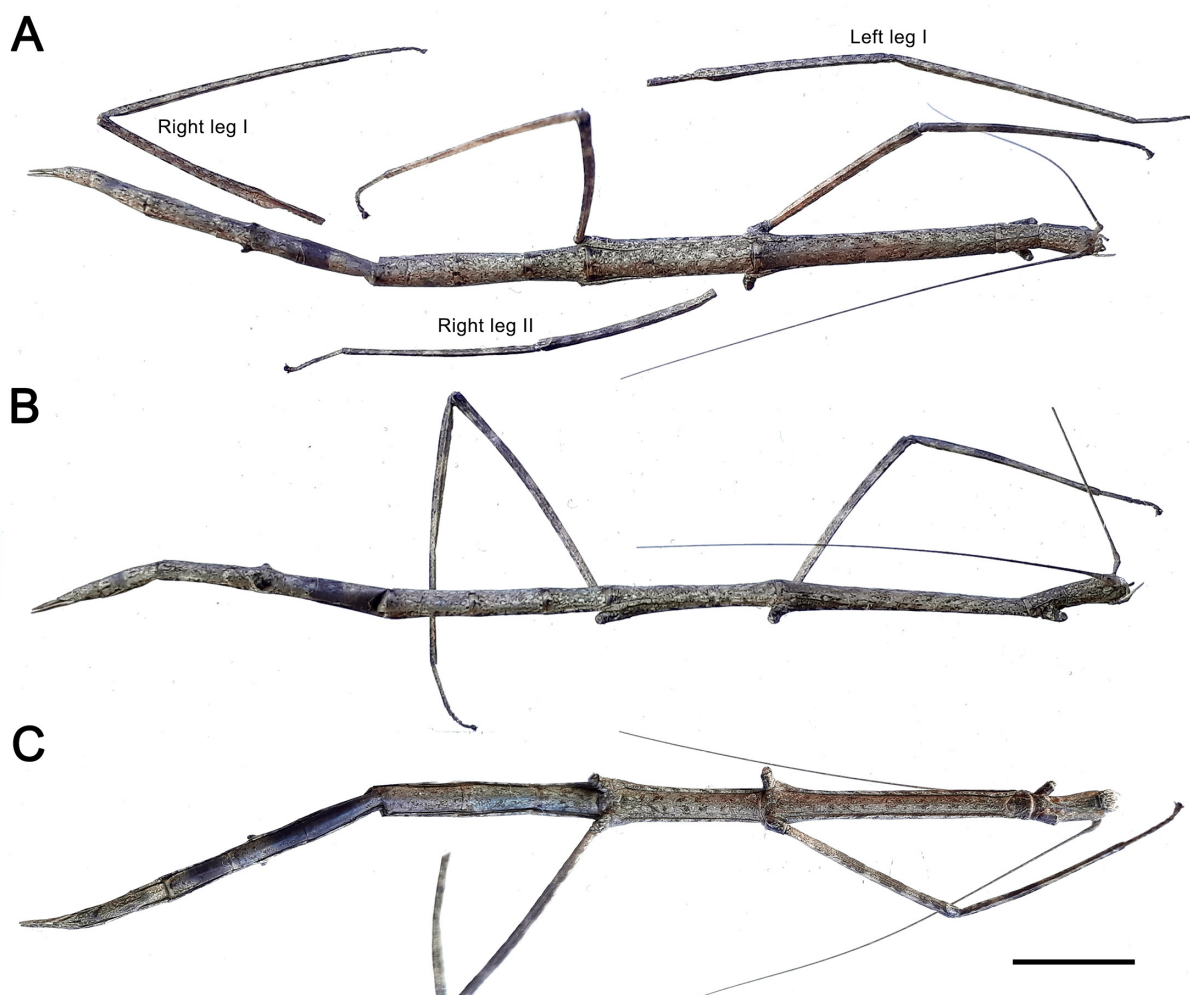
COLOUR (Figs 47–50). Entirely coloured of greyish to black, beige and brownish irregular stains with different shadings. Eyes grey. Mouthparts and cerci beige to light grey. Legs somewhat striped in darker and lighter patches.

HEAD (Figs 47–48). Very elongate ( $2.3 \times$  as long as wide), smooth, with sparse setae mostly in dorsal region, vertex totally flat, frontal convexity developed and frontal suture round (Fig. 48A–B). Eyes small, slightly elongate, slightly less than  $0.2 \times$  length of head. Cervix covering more than two thirds of head length, cervical sclerites elongate, weakly sclerotized. Gula elongate, subrectangular, bearing setae and covering ca more than half of cervix (Fig. 48D). Subgena narrow, with posterior projection ca as high as eye. Submentum narrow, only slightly curved backwards, mentum simple, prementum somewhat wide. Glossa elongate, rounded but slightly widened apically, paraglossa larger than glossa, roundly falcate, reaching labrum (Fig. 48C). Lacinia with three distal teeth, one large medially and two smaller laterally, mesal edge bearing bundles of large setae from base to sclerotized portion. Galea broad, elliptical, medially gently widened, bearing long setae, apically with dense tuft of large, hairy microtrichia forming semicircular band along apical edge (Fig. 48C). Galealobulus present, small, round and basally fused to galea (Fig. 48C). Palpal segments slightly flattened dorsoventrally (Fig. 48D). Clypeus wide, somewhat short, anterior surface with two parasagittal furrows, anterior margin medially with smooth wide notch. Labrum strongly notched anteromedially, round and very slightly asymmetric with right lobe barely larger than left one. Antennae filiform, extending approximately to second abdominal segment and about as long as forelegs, scapus ca  $2 \times$  as long as wide, compressed dorsoventrally. Pedicellus subglobose, large, more than half length of scapus, composed of 50–55 segments. Antennomeres bearing three types of setae as in *A. dubia*. Antennal bump very discrete on 12<sup>th</sup> antennomere.

THORAX (Figs 47, 48A–B, D, 49A). Smooth, with scarce scattered small setae. Pronotum slightly longer than wide, slightly constricted medially. Transverse sulcus conspicuous and gently curved backwards, longitudinal median sulcus distinct. Paranota curved, ca  $3 \times$  as long as wide, with transversal projection ventrally, procoxopleurite apically round (Fig. 48B). Probasisternum tapering towards anterior. Profurcasternum round (Fig. 48D). Mesothorax  $5.7 \times$  as long as prothorax, slightly wider than it.

Mesonotum with pair of distinct lateral carinae, mesepisternum lanceolate and regularly widening posteriorly, mesepimeron slightly elongate, pointing towards posterior and slightly exceeding end of mesothorax. Mesocoxopleurite small, elongate, mesofurca Y-shaped. Metathorax continuing pair of lateral carinae of mesonotum, metepisternum long, similar to mesepisternum. Metepimeron extremely elongate, extending through entire length of median segment, posteriorly pointing and slightly exceeding end of median segment, metacoxopleurite very discrete and elongate, metafurca Y-shaped. Metanotum longer than median segment (Fig. 49A). Median segment anteriorly marked by median black stain (Fig. 49A) and barely continuing pair of thoracic lateral carinae.

LEGS (Figs 47, 49B–G). Slightly thick for genus. Hindlegs slightly exceeding cerci, anterior legs very slightly shorter than hindlegs, midlegs distinctly shorter than both. Coxae smooth. Pro- and metafemora similar in length to mesothorax. Profemur with distinct basal curvature. Femora and tibiae with five keeled carinae with very few or without setae between them (Fig. 49B–G), basitarsi with setae among carinae. Antero- and posteroventral carinae of femora with apical toothed prominence. Carinae of all femora, tibiae and basitarsi bearing row of short and somewhat stout setae, stronger on tibiae and basitarsi, except ventral carinae of pro- and mesobasitarsi with two or three rows of setae. Ventral, antero- and posteroventral carinae of tibiae ending in apical spiniform sessile projection parallel to tibiae, pointing



**Fig. 47.** *Arumatia diamante* Ghirotto gen. et sp. nov., holotype, ♀ (MZUSP V0650). A. Dorsal view. B. Lateral view. C. Ventral view. Scale bar: 10 mm.



towards tarsi; projection of protibiae weaker (Fig. 49E–G). Pro- and metabasitarsi very elongate, significantly longer than respective following tarsomeres combined, mesobasitarsi as long as respective following tarsomeres combined (Fig. 49B–D), basitarsi with hairy setae restricted to apical portion, on ventro-lateral patches (Fig. 49B–D). Remaining tarsomeres with setae on ventro-lateral patches in portions not covered by euplantulae. Tarsomeres I–III with discrete dorsal round apical projection. Arolium round and broad, bearing setae dorsally. Pretarsal claws symmetrical, dorsally and outwardly setose. Euplantulae well developed in all tarsomeres, composed of two symmetrical pads separated by median groove in tarsomeres I–IV and of single flattened lobed pad in tarsomeres V. Euplantulae present only apically at tarsomeres I–II, covering ca half length of tarsomeres III, covering two thirds length of tarsomeres IV and covering almost entire ventral surface of tarsomeres V (Fig. 49B–D).



**Fig. 48.** *Arumatia diamante* Ghirrotto gen. et sp. nov., holotype, ♀ (MZUSP V0650), head and prothorax morphology. **A.** Head and prothorax in dorsal view. **B.** Head and prothorax in lateral view. **C.** Left maxilla in ventral (external) view. **D.** Head and prothorax in ventral view. Abbreviations: Ant=antennomere; Bsl-I-II=pro- and mesothoracic basisterna; Cly=clypeus; Csc=cervical sclerite; Cx=coxa; Cxp=coxopleurite; Eye=compound eye; Fc=frontal convexity; Fs=prothoracic furcasternite; Ga=galea; Galea=galealobulus; Gl=glossa; Gu=gula; Lac=lacinia; Lb=labrum; Md=mandible; Msn=mesonotum; Mtr=microtrichia; Par=paranota; Pd=pedicellus; Pgl=paraglossa; Plb=labial palpus; Pmx=maxillary palpus; Prn=pronotum; Sc=scapus; Sg=subgena; Sme=submentum. Scale bars: A–B, D=1 mm; C=0.5 mm.



**Fig. 49.** *Arumatia diamante* Ghiorotto gen. et sp. nov., holotype, ♀ (MZUSP V0650), thorax and leg morphology. **A.** Metathorax and median segment in dorsal view, arrows indicate the length of each segment. **B.** Left fore tarsus, ventral view. **C.** Left mid tarsus, ventral view. **D.** Left hind tarsus, ventral view. **E.** Detail of left mid tibia and tarsus, ventral view, arrows showing apical sessile spines. **F.** Detail of left fore tibia and tarsus, ventro-retrolateral view, arrows showing apical sessile spines. **G.** Detail of right mid tibia and tarsus, retrolateral view, arrow showing apical sessile spine. Abbreviations: Ar=arolium; Cda=dorsal anterior carina; Cdp=dorsal posterior carina; Cl=claw; Cva=ventral anterior carina; Cve=ventral carina; Cvp; ventral posterior carina; Epm=epimeron; Eps=episternum; FTa=fore tarsomere; HTa=hind tarsomere; Mds=median segment; Msn=mesonotum; MTa=mid tarsomere; Mtn=metanotum; Tg=tergum; Tib=tibia. Scale bars: A–D=1 mm; E–G=0.5 mm.





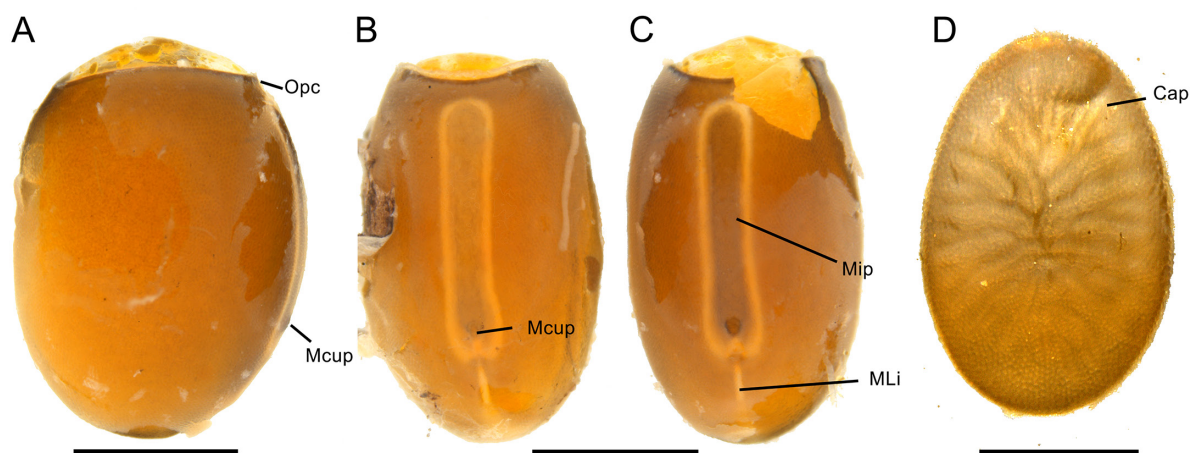
**Fig. 50.** *Arumatia diamante* Ghirrotto gen. et sp. nov., holotype, ♀ (MZUSP V0650), terminalia morphology. **A.** Dorsal view. **B.** Detail of dorsal view. **C.** Lateral view. **D.** Ventral view. **E.** Sixth segment in lateral view showing a tubercle. **F.** Detail of preopercular organ, ventral view. **G.** Detail of external genitalia, lateral view. Abbreviations: Ce=cercus; Ep=epiproct; Gap=gonapophysis; Gpl=gonoplac; Pre=preopercular organ; Prp=paraproct; Sp=subgenital plate; St=sternum; Tg=tergum. Scale bars: 1 mm.



ABDOMEN (Figs 47, 49A, 50). External surface as in thorax bearing few setae across entire length. Median segment ca  $0.7\times$  as long as metanotum (Fig. 49A). Combined length of segments II–X slightly longer than combined length of head, thorax and median segment. Terga II–VII and sterna II–VIII with discrete lateral carinae near lateral margins. All segments longer than wide (Fig. 47). Segment II shorter than III–VII. Segments III, IV and VII similar in length, very slightly shorter than V, segment VI about as long as V. Tergum VIII significantly shorter than preceding segment and slightly longer than IX and X, tergum IX very slightly longer than X. Tergum II widest, slightly wider than III–IV, tergum V slightly wider than VI and wider than VII at medial width. Tergum VI dorsally with two large parasagittal rugose and somewhat round tubercles pointing towards lateral (Figs 47, 50A, E). Tergum VII widening towards posterior, tergum VIII slightly narrower than preceding segment and tapering towards posterior, tergum IX narrower than VIII and X, tergum X slightly thinner than VIII, very gently tapering towards posterior, posterior margin broadly and gently emarginate (Fig. 50B). Epiproct very large, elongate, lanceolate, almost  $\frac{2}{3}$  length of tergum X, dorsoventrally flattened (Fig. 50B–C). Paraprocts very elongate, posteriorly tapering and very acute, straight, setose on posterior margin, reaching end of epiproct (Fig. 50D). Cerci extremely elongate, straight, basally slightly narrower fitting paraprocts, gradually tapering towards apex, slightly shorter than tergum X and epiproct combined (Fig. 50A–D) and bearing four types of setae similarly to *A. dubia*. Praeopercular organ present and very small, showing as small dark convexity (Fig. 50F). Subgenital plate roundly lanceolate, reaching  $\frac{1}{3}$  of length of tergum X, bearing two parasagittal carinae beginning on anterior margin and running half length of segment before becoming flatter and more setose, gradually tapering towards posterior and totally covering gonapophyses and gonoplac (Fig. 50C–D). Gonapophyses and gonoplac flattened, dorsoventrally for gonapophyses VIII, lateroventrally for gonapophyses IX and laterally for gonoplac. Gonapophyses VIII linear and elongate, longer than IX and gonoplac, exceeding posterior margin of tergum IX (Fig. 50G). Gonapophyses IX short, dorsally tapering towards posterior, shorter than gonoplac (Fig. 50G). Gonapophyses IX ventrally folded to fit within gonapophyses VIII. Gonangulum distinctly reduced. Gonoplac somewhat wide, lorate, not reaching posterior margin of tergum IX (Fig. 50G).

**Egg (Fig. 51)**

Egg not fully formed, retrieved from inside female holotype. Measurements in mm (N = 2): length 2.4–2.6, height 1.7–1.8, width 1.4–1.5. Relatively small, ovoid in lateral view, not constricted at opercular

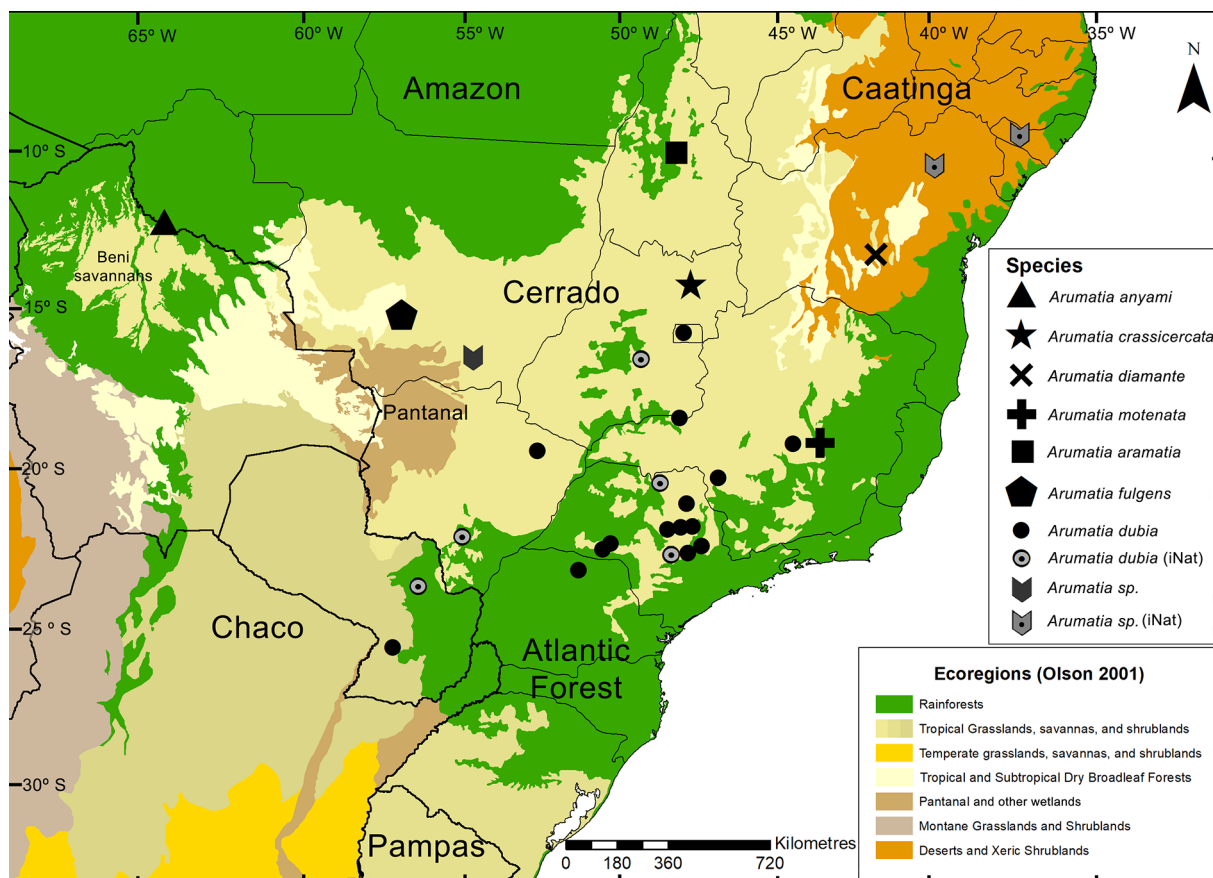


**Fig. 51.** *Arumatia diamante* Ghiorotto gen. et sp. nov., egg morphology from the holotype female. **A.** Lateral view. **B–C.** Dorsal view. **D.** Detail of operculum, anterior view. Abbreviations: Cap = capitulum; Mcup = micropylar cup; Mip = micropylar plate; MLi = median line; Opc = operculum. Scale bars: A–C = 1 mm; D = 0.5 mm.

collar, gently compressed laterally, ca  $1.8 \times$  as long as wide and  $1.4 \times$  as long as tall (Fig. 51A–C). Capsule surface smooth but with finely punctuated appearance (Fig. 51A). Colour yellowish brown. Micropylar plate very elongate occupying a large area of the dorsal region, with round margins, almost parallel-sided (Fig. 51B–C). Micropylar cup small, rounded, only slightly elevated. Median line short and of same colour and elevation as elevated margin of micropylar plate, almost reaching polar area (Fig. 51B–C). Opercular collar very wide, as wide as surrounding capsule, smooth (Fig. 51A–C). Operculum elliptical, with branching radial ridges arising from central ridge along longer axis of operculum (Fig. 51D).

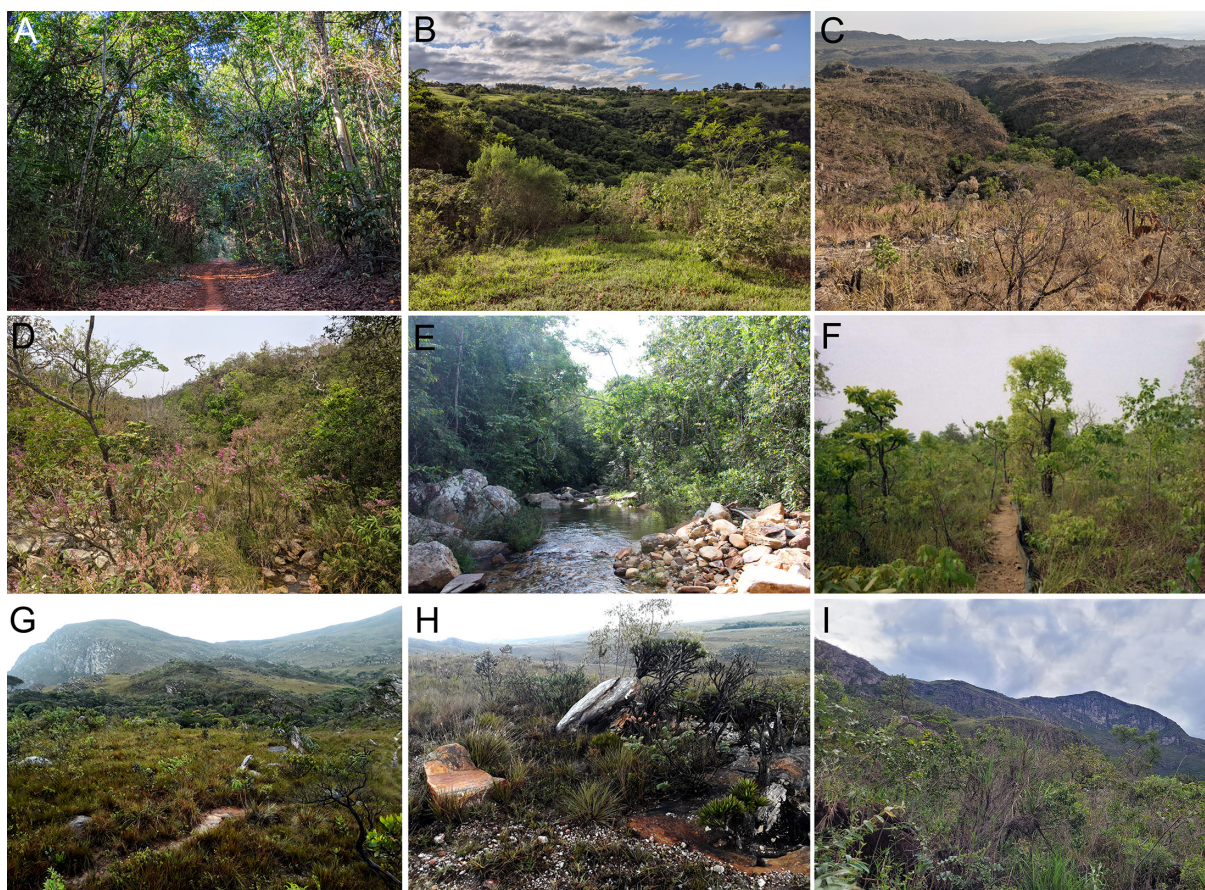
**Distribution** (Fig. 52)

Known only from the type locality, the Catolés district, Abaíra, Bahia, Brazil. Catolés is located in the Chapada Diamantina plateau which is the northern part of the Serra do Espinhaço formation that is typically dominated by campos rupestres. The Chapada Diamantina is mainly covered by the Caatinga but also has Cerrado patches (Fig. 52). The holotype was found in a Cerrado area in dense savannic rocky formations (dense campos rupestres) (Fig. 53I).



**Fig. 52.** Distribution map of species of *Arumatia* Ghiorotto gen. nov. in central South America. Brazil is further divided into states which are shown in a thinner line. Note that grey dotted circles represent photographic records of *Arumatia dubia* gen. et comb. nov. from the iNaturalist (iNat) online platform, the black shield represents an unidentified nymph of *Arumatia* gen. nov. from MZUSP collection and the grey dotted shields represent photographic records of a potentially new species from iNaturalist.





**Fig. 53.** Habitats of *Arumatia* Ghiorotto gen. nov. in the Cerrado of Brazil. **A–D.** Habitat of *Arumatia dubia* gen. et comb. nov., seasonal forest at Assis, São Paulo (A), seasonal forest at Echaporã, São Paulo (B), savannah formation at Delfinópolis, Minas Gerais (C–D). **E.** Type locality of *Arumatia crassicerca* Ghiorotto, Crispino & Engelking gen. et sp. nov., gallery forest at Chapada dos Veadeiros plateau, Alto Paraíso de Goiás, Goiás. **F.** Type locality of *Arumatia aramatia* Ghiorotto gen. et sp. nov., savannah formation in Luzimangues district, Porto Nacional, Tocantins (photo courtesy of Dante Pavan). **G–H.** Type locality of *Arumatia motenata* Ghiorotto gen. et sp. nov., rocky savannah formations (campos rupestres) at Serra do Cipó district, Santana do Riacho, Minas Gerais. **I.** Type locality of *Arumatia diamante* Ghiorotto gen. et sp. nov., dense rocky savannah formations (campos rupestres) at Catolés, Abaíra, Bahia (photo courtesy of Pedro H. Martins).

Genus *Megaphasma* Caudell, 1903

*Megaphasma denticrus* (Stål, 1875)

Fig. 54

*Diapheromera denticrus* Stål, 1875: 73.

*Diapheromera armata* Piza, 1973: 183. **Syn. nov.**

*Diapheromera denticrus* – see Brock *et al.* 2022 for an extensive citation list.

*Megaphasma denticrus* [sic] – Caudell 1903: 572 (misspelling of “*denticrus*”).

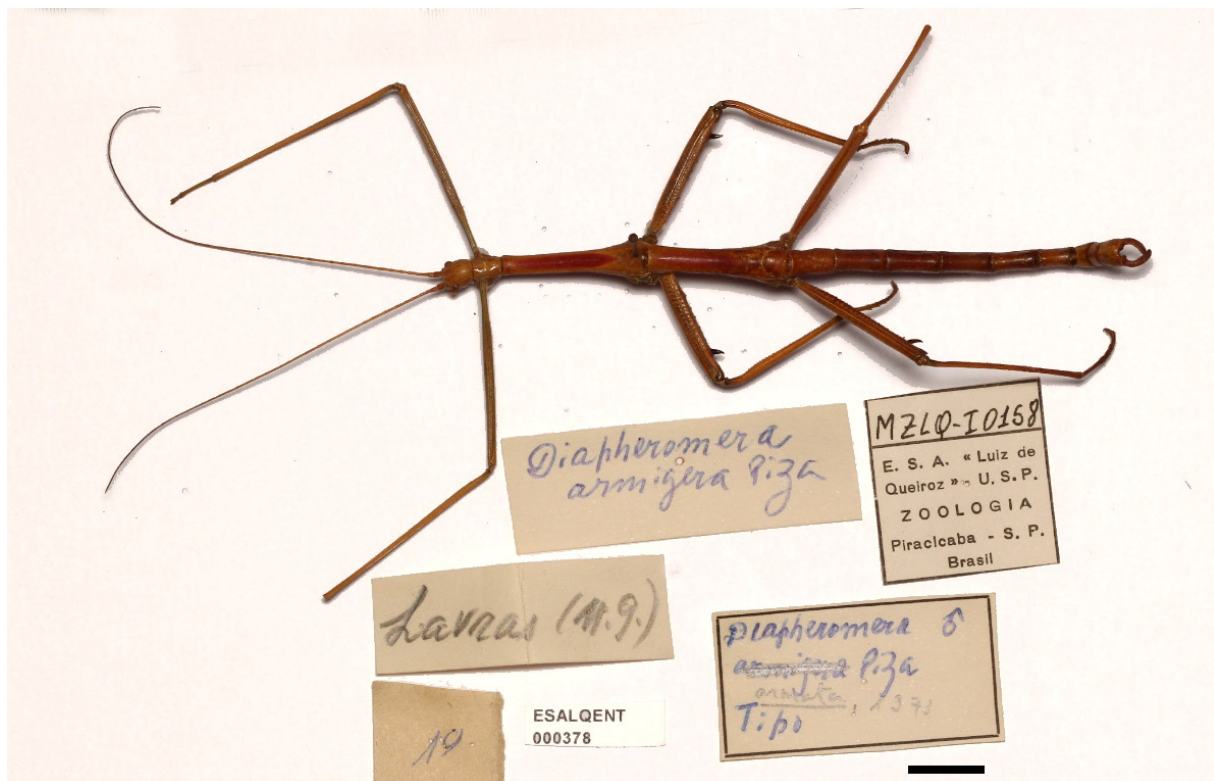
*Megaphasma denticrus* – Rehn 1903: 329. (see Brock *et al.* 2022 for an extensive citation list)



**Remarks**

While analysing specimens at MELQ, the authors came across the holotype of *Diapheromera armata* Piza, 1973 (Fig. 54) which was described based on that male, purportedly collected in the municipality of Lavras, state of Minas Gerais, Brazil. Piza, following traditional taxonomic practices at his time, usually considered slight phenotypic variations as enough evidence to propose a new species (see Chamorro-Rengifo & Braun 2010 and Crispino *et al.* 2020). Piza (1973) stated that a few differences mainly in body proportions separated *D. armata* from *Megaphasma denticrus* (Stål, 1875). His species, however, matches the morphology of *M. denticrus* described in the literature and observed in photographs of type material and additional specimens (Caudell 1903; Brock *et al.* 2022), so it is here synonymized under *Megaphasma denticrus* (Stål, 1875). Phasmids belonging to *Megaphasma* and related genera occur only in North America. Therefore, we do not consider this doubtful record of *M. denticrus* from Brazil to be valid nor the lineage to have representatives native or introduced to South America. This record could be equivocal and explained by a simple mislabelling or, more unlikely, be explained by an actual event of introduction which is until now unconfirmed and lacks further evidence.

At least two other exotic phasmids were described as Brazilian species by Piza (1938): *Dilophoccephalus paradiacanthoides* Piza, 1938 and *Dixippus brasiliensis* Piza, 1938, both of which were later synonymized by Bragg (2001) under other names. The holotype of at least one of these species came from the zoological collection of the Museu Paulista which preceded the creation of the MZUSP (Grola 2014) and went through several rearrangements and loss of information (Chamorro-Rengifo & Braun 2010). The same could be true for the holotype of *D. armata*, leading to a mislabelling of the specimen.



**Fig. 54.** Holotype of *Diapheromera armata* Piza, 1973 at MELQ and accompanying labels. Note that the specific epithet was written as *armigera* on one of the labels but later corrected by pencil to the published name. Scale bar: 10 mm.

## Discussion

Currently, the subfamily Diapheromerinae comprises 46 genera (including *Arumatia* Ghirotto gen. nov.), several of which inhabit the Amazon region including some recorded from Brazil (Brock *et al.* 2022). For non-Amazonian Brazil, only two genera were recorded so far, *Otocrania* Redtenbacher, 1908 and *Exocnophila* Zompro, 2001, both inhabiting the Atlantic Forest (Brock *et al.* 2022) and both being the only Diapheromerinae so far sampled by frequent fieldwork in the Atlantic Forest of southeast Brazil by the Projeto Pasma team. *Arumatia* gen. nov. is not only the third genus of this group recorded for non-Amazonian Brazil but the first Diapheromerinae known to occur in the Cerrado. Therefore, *Arumatia* gen. nov., representing a new genus and containing both new and misplaced species described a long time ago, exemplifies the still poor knowledge on Brazilian (and Neotropical) Phasmatodea as a whole, which fortunately has been receiving much more attention and efforts lately (Madeira-Ott *et al.* 2020). Furthermore, it illustrates that several Brazilian environments are still understudied, especially regarding groups lacking taxonomists as is the case for phasmids. The Cerrado is a wide heterogeneous domain, a biodiversity hotspot and it is severely threatened (Batalha 2011), highlighting the ever-growing importance of scientific studies and subsequent conservation efforts towards this domain. Certainly, the increase of taxonomic studies on phasmids in Brazil not restricted to but especially in poorly sampled environments will reveal many more new taxa. Hopefully, an increasing taxonomic knowledge will help to shed light on phasmid diversity and biogeographical patterns in the Neotropics.

The iNaturalist platform not only helped to complement records of one of the known species but further provided records of a potentially new species in the xeric and also poorly studied Caatinga biome in Brazil. It is expected that with future research and samplings *Arumatia* gen. nov. will be recorded for the Caatinga. This shows that iNaturalist, when considered with caution, can be a powerful tool to aid scientific research.

Here, we reinforce that diagnostic characteristics for stick insects are not limited to external overall morphology. The shape of mouthparts, the pattern and morphology of setae on the legs, and the female valves (e.g., gonapophyses VIII and IX, gonoplac and gonangulum) differ among species of *Arumatia* gen. nov. and proved to be useful characters for identification especially of females, which often are more similar among different species in Phasmatodea. The evolutionary aspects behind the diversity of these characteristics are not yet understood but could be linked with distinct interactions with the environment, foodplants or oviposition. More specific studies must be conducted to attend to these questions. Nevertheless, this is one more of recent recurring examples of the benefits of an integrative taxonomy in Phasmatodea (Gutiérrez-Valencia *et al.* 2017; Crispino *et al.* 2020; Chiquetto-Machado & Canello 2021; Ghirotto 2021; Chiquetto-Machado *et al.* 2022).

Several lineages of Phasmatodea present males with specialisations for grasping the female terminalia, often involving modifications of the cerci or tergum X (Bradler 2009). However, we are not aware of any specialisation similar to that of *Arumatia motenata* gen. et sp. nov., which presents the tergum X of the male with lateral expansions, flexing ventrally, and also bearing teeth as well as forming a lock-and-key mechanism with the female's well developed and prominent praeopercular organ. There are no similar structures in related taxa (i.e., other Diapheromerini).

There are few and very simple accounts of Phasmatodea sexual behaviour prior to mating, especially for Euphasmatodea (Bedford 1978) only describing males mounting on females and copulation starting (Sivinski 1979). We provide one of the first accounts of male courtship and a description of pre-mating sexual behaviour. The courtship was very brief and it is uncertain whether the female significantly took part in it or not. The male repeatedly touched the female with his antennae while both were shaking frenetically, then proceeded to tap her with his abdomen prior to attachment. It is possible that careful

observation of Phasmatodea mating will reveal that stick insects have a more complex courtship behaviour than previously known.

Interestingly, some representatives of Neotropical Diapheromerini, including *Phantasca* and *Arumatia* gen. nov., share a few female features with some representatives of the Diapheromerini clade Eusermyleformia (see Bradler 2009; Hennemann & Conle 2012), more specifically with species of the North American genera *Manomera* Rehn & Hebard, 1907 and *Diapheromera* Gray, 1835, which could be better compared through available literature. These common features consist of the short subgenital plate, the prominent epiproct visible in dorsal view, the parallel, posteriorly pointing and often elongate cerci, the very long gonoplac and absent or reduced gonangulum, the reduction or lack of a praeopercular organ, the incurved and widened posterior region of tergum VII and the often elongate basitarsi. Furthermore, the eggs of *Phantasca*, *Arumatia* gen. nov., *Manomera* and *Diapheromera* share the following characteristics: micropylar plate and operculum surrounded by white regions against a darker background, a similar and very elongate micropylar area with white elevated borders, a black and small micropylar cup region, long and thin light bristles surrounding the operculum and a similar non-stalked capitulum with an irregular net matrix. It is important to note, however, that some key features both in female and male representatives of Eusermyleformia distinguish them from other Diapheromerini as illustrated by Bradler (2009). The above-mentioned characteristics shared by Eusermyleformia and other Diapheromerini may be useful in evaluating phylogenetic relationships within the Diapheromerinae.

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