

## THREE NEW SPECIES OF AEGLIDAE (AEGLA LEACH, 1820) FROM PARANÁ STATE, BRAZIL

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### A B S T R A C T

This study describes three new aeglid species, *Aegla meloi*, *Aegla loyolai* and *Aegla lancinghas*, all of them recorded from Paraná State, Brazil. Along with the description, we also present an analysis of their phylogenetic relationships to other species of *Aegla*. The conservation status using the IUCN Red List criteria was assessed for each new species. The new species have restricted distributions and can be found in altitudes higher than 700 m. The new species are phylogenetically close to other species present in Paraná State and Ribeira do Iguaçu River basin, yet clearly differ morphologically and genetically from other known species of *Aegla*.

**KEY WORDS:** Anomura, diversity, Iguaçu River basin, IUCN Red List, Ivaí River basin, Upper Ribeira River basin

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### INTRODUCTION

The anomuran genus *Aegla* Leach, 1820 is distributed across temperate and subtropical South America, occurring in hydrographic basins through Argentina, Southern Bolivia, South and Southeastern Brazil, Central-southern Chile, Paraguay, and Uruguay (Bond-Buckup and Buckup, 1994; McLaughlin et al., 2010). A large number of species of *Aegla* are restricted to stream headwaters usually located on hillsides or higher altitude regions (Bond-Buckup and Buckup, 1994; Marchiori et al., 2014). The presence of aeglids in elevated regions associated with mountain ranges points to a possible contribution of the mountain range formation to crab diversification. According to various hypotheses, speciation may be driven predominantly by vicariance given that phylogenetically closely related species are geographically isolated, yet spatially close (Pérez-Losada et al., 2004; Santos et al., 2012). Yet phylogeographic studies of aeglids show both vicariance (Xu et al., 2009) and restricted gene flow as important factors in species diversification (Barber et al., 2012) depending on the species and geographic region.

In a previous study of *Aegla* diversity in southern South American freshwater ecoregions (Pérez-Losada et al., 2009), we found that the Laguna dos Patos Basin (bearing 17 species) and the Upper Uruguay ecoregion (10 species),

both in northeastern Rio Grande do Sul State, shelter the highest aeglid richness in Brazil. These regions are aligned with the Serra Geral formation, a mountain range that begins in Paraguay, enters Brazil running diagonally along Paraná State (separating the coast from the countryside of Santa Catarina State), continues through Rio Grande do Sul State, and eventually reaches into Argentina and Uruguay (Moreira and Lima, 1977). The Serra Geral reaches altitudes between 1000 and 2000 m to the east, on the cliff-side, and progressively declines westward until reaching the courses of Rivers Paraná and Uruguay (Moreira and Lima, 1977). Paraná State has one of the most peculiar reliefs in Brazil, with 52% of its area in altitudes higher than 600 m and only 3% in areas lower than 300 m (Fig. 1). In this region the main river is Paraná, which is also one of the largest hydrographic basins in South America (Fig. 1 and Table 1).

Based on material collected during field expeditions and from other scientific collections, this study presents the description of three new aeglid species, all of them recorded from Paraná State, a region in southern Brazil that has been previously overlooked, but represents great potential for discovery of new aeglid species. Along with the species descriptions, we also present an analysis of the phylogenetic relationships of these three new species and other Brazilian

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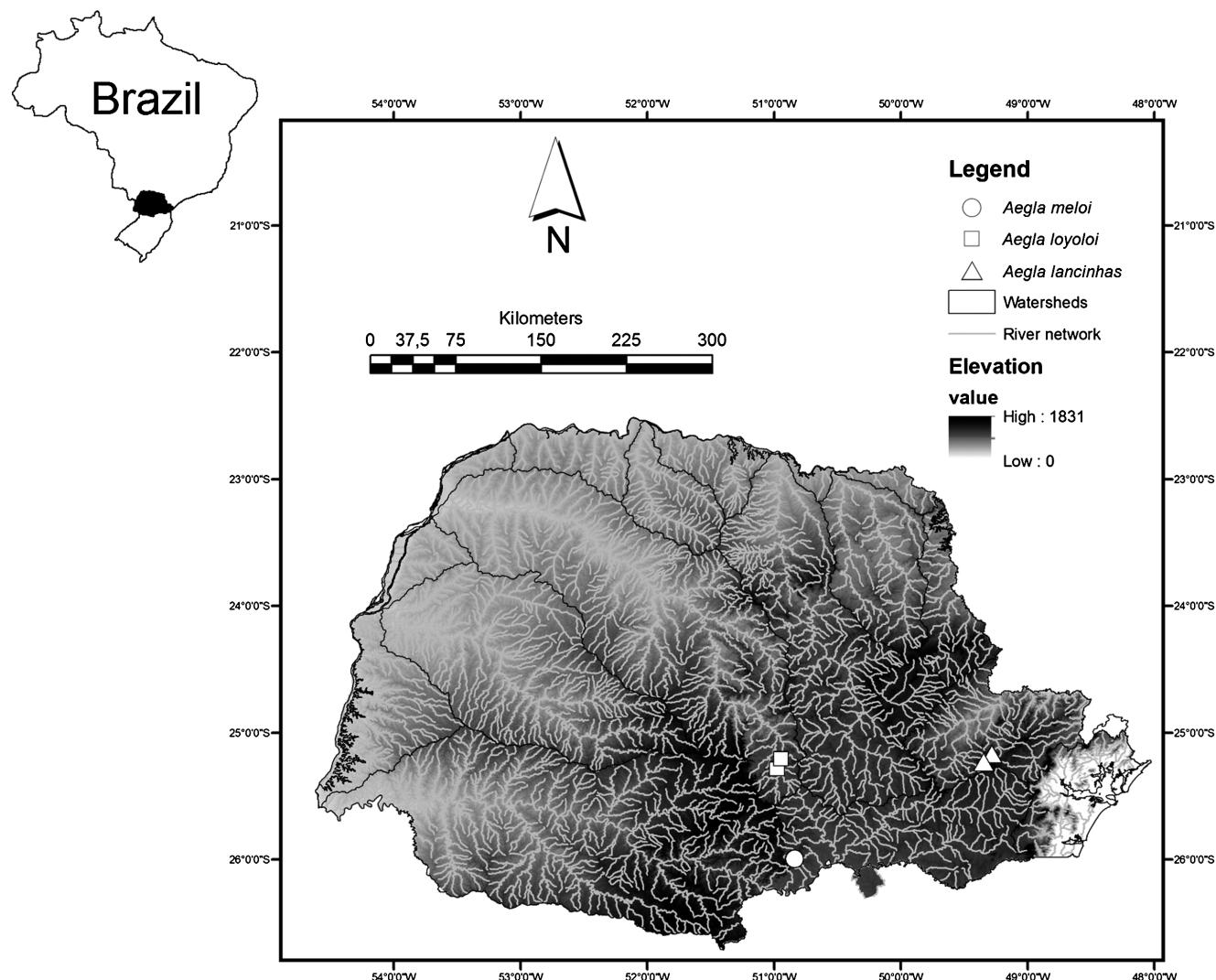


Fig. 1. Sampling locations in Paraná State, Brazil.

Table 1. Distribution of species of Aeglidae recorded in Paraná State, Brazil.

Basin	Sub-basins	Species	Reference
Paraná	Iguaçu River	<i>Aegla meloi</i> n. sp.	Present study
		<i>Aegla parana</i>	Bond-Buckup and Buckup (1994)
		<i>Aegla parva</i>	Bond-Buckup and Buckup (1994)
		<i>Aegla schmitti</i>	Bond-Buckup and Buckup (1994)
	Ivaí River	<i>Aegla castro</i>	Trevisan (2013)
		<i>Aegla loyolai</i> n. sp.	Present study
		<i>Aegla schmitti</i>	Bond-Buckup and Buckup (1994)
Litorânea	Paranapanema River	<i>Aegla castro</i>	Bond-Buckup and Buckup (1994)
		<i>Aegla castro</i>	Bond-Buckup and Buckup (1994)
		<i>Aegla lata</i>	Bond-Buckup and Buckup (1994)
	Tibagi River	<i>Aegla schmitti</i>	Trevisan et al. (2014)
		<i>Aegla marginata</i>	Bond-Buckup and Buckup (1994)
Ribeira do Iguape (Paraná and São Paulo States)	Litorânea	<i>Aegla schmitti</i>	Trevisan and Masunari (2010)
		<i>Aegla cavernicola</i>	Bond-Buckup and Buckup (1994)
	Upper Ribeira	<i>Aegla lancinhas</i> n. sp.	Present study
		<i>Aegla leptochela</i>	Bond-Buckup and Buckup (1994)
		<i>Aegla marginata</i>	Bond-Buckup and Buckup (1994)
		<i>Aegla microphthalmia</i>	Bond-Buckup and Buckup (1994)
		<i>Aegla schmitti</i>	Bond-Buckup and Buckup (1994)

aeglids. Finally, we assess the IUCN Red List criteria (IUCN, 2012) for the three new species described and evaluate them for endangered/threatened status.

## MATERIAL AND METHODS

Specimens were collected in streams of the Paraná and Upper Ribeira hydrographic basins during several collecting campaigns and deposited in the Crustacean Collection of the Department of Zoology, Biosciences Institute, Federal University of Rio Grande do Sul (UFRGS) and in the Museum of Zoology, University of São Paulo.

The description of the three new species was made based on characters from the type series. Measurements of specimens were made according to the methods of Bond-Buckup and Buckup (1994), using the following abbreviations: m, male(s); f, female(s); f ov, ovigerous females; j, juveniles; CL, total cephalothorax length (between tip of rostrum and middle point on rear margin of carapace); PCW, precervical width (between left and right epibranchial margins); FW, frontal width (between spine tips of anterolateral angles of carapace); AL, areola length; AW, areola width; RL, rostrum length (between tip of rostrum and midpoint of orbital margin); Museum codes: UFRGS, Federal University of Rio Grande do Sul, Porto Alegre, Brazil; MZUSP, Museum of Zoology, University of São Paulo, São Paulo, Brazil; MHNCI, Natural History Museum Capão da Imbuia, Curitiba, Paraná, Brazil; MNRJ, National Museum, Federal University of Rio de Janeiro, Rio de Janeiro, RJ, Brazil.

### Morphometric Analysis

The following body dimensions were recorded for all specimens in the type series and for the non-paratypes: CL, PCW, FW, AL, AW and RL. Morphometric ratios CL/RL, PCW/FW and AL/AW were calculated for the set of animals from each locality (Bond-Buckup and Buckup, 1994).

### Molecular Analysis

Total genomic DNA was extracted using methods described by Crandall and Fitzpatrick (1996). Fragments of the mitochondrial genes 16S, COI and COII were amplified via polymerase chain reaction (PCR), using primers developed by Pérez-Losada et al. (2004) and Xu et al. (2009). The PCR, sequencing conditions, and protocols were described in Pérez-Losada et al. (2004). Sequences were scanned for evidence of pseudogene contamination by examining open reading frames for stop codons (COI and COII) and spurious phylogenetic relationships as suggested by Song et al. (2008). Sequences are deposited in GenBank under accession numbers FJ360706-FJ360707, FJ360710-FJ360711, FJ360714-FJ360715, and KT319206-KT319223. The sequences obtained were aligned in MAFFT v7 (Katoh and Standley, 2013) and adjusted together with the data from Pérez-Losada et al. (2004), Bond-Buckup et al. (2010), and Santos et al. (2012, 2013). Maximum likelihood (ML) phylogenies were inferred using RAxML (Stamatakis, 2006; Stamatakis et al., 2008). One hundred searches were conducted (Stamatakis et al., 2008), using the GTR +  $\Gamma$  model, as selected by jModeltest2 (Darriba et al., 2012). Branch support was assessed via the bootstrap algorithm (1000 replicates) (Felsenstein, 1985).

### Conservation Status Assessment

We used IUCN Red List criteria (2012) to evaluate the conservation status of each of the three new species. Briefly, we evaluated their geographic range, which was inferred from sampling efforts in different streams in the surrounding region. The landscape characteristics at the periphery of their ranges were evaluated based on data for forest coverage (Fundação SOS Mata Atlântica and Instituto de Pesquisas Espaciais, 2014).

## SYSTEMATICS

### *Aegla meloi* n. sp. Bond-Buckup and Santos (Figs. 1, 2)

Type-Material.—Holotype: male, Brazil, State of Paraná, Paulo Frontin, Paraná River basin, Iguaçu River sub-basin, tributary of middle Iguaçu River sub-basin, 25°59'43.1"S – 50°50'22.8"W; 803 m, 22.VIII.2005; Bond-Buckup, G.; Zimmer, A.; Gonçalves, R. coll. (MZUSP 30031).

Paratypes: Iguaçu River sub-basin, tributary of middle Iguaçu River sub-basin, State of Paraná: 28 m, 22 f, 11 f ov, 2 f with j (UFRGS 4014P), same data as holotype.

**Diagnosis.**—Anterolateral spine of carapace not reaching base of cornea; protogastric lobes flat; extra-orbital sinus reduced. Rostrum styliform, medium length ( $4.0 < CL/RL < 4.9$ ), carinate. Proximal outer margin of movable finger of cheliped without lobe; palmar crest of cheliped subrectangular; anterior angle of ventral margin of epimeron 2 inermis (unarmed); inner margin of ventral face of ischium of cheliped with elevation ornamented with scale-shaped distal tubercle.

**Description.**—Carapace flat, area of gastric region nearly flattened, dorsal surface scabrous, covered with punctations; no clear limit between anterior dorsal region and basis of rostrum (Fig. 2).

Front large; PCW/FW ratio of male holotype 1.79.

Rostrum styliform, carinate along entire length, straight, of medium length. Subrostral process developed; in profile, ventral portion of rostrum wider than dorsal. Rostral carina beginning at height of protogastric lobes, low; carina with 2 parallel rows of scales changing to 1 row on distal third near apex. Lateral margins of rostrum with scales juxtaposed.

Orbits wide, shallow, with orbital tubercle. Orbital margin with sparse scales. Extra-orbital sinus shallow and reduced.

Anterolateral angle of carapace weakly projecting anteriorly in tubercle not reaching base of cornea. Outer and inner margins of anterolateral lobe with scales.

First hepatic lobe delimited anteriorly by groove; lateral margin with scales; second and third hepatic lobes scarcely delimited, with only modest indicative; lateral margins with sparse scales.

Epigastric prominences absent, irregular surface with sparse scales. Protogastric lobes slightly evident, anterior margin marked by few scales.

Transverse dorsal line sinuous. Areola subquadrate. AL/AW of male holotype: 1.50.

Epibranchial area subrectangular with scales distributed at margin. Lateral margins of anterior branchial area with scales and setae; posterior with scarcer scales.

Anterior angle of ventral margin of epimeron 2 unarmed, only with small scales and setae; ventro-lateral margin slightly curved; posterior angle of ventral margin obtuse, unarmed. Epimera of 3rd to 6th segments obtuse ornamented with setae.

Telson divided by longitudinal suture.

Anterior extremity of third sternite triangular, projecting between coxae of exopodites of third maxillipeds. Fourth thoracic sternite flat at median region, without ornaments, with tuft of setae, anterolateral margins slightly recurved and ornamented with long setae.

Chelipeds subequal in shape, hand subrectangular, surface very scabrous. Minor cheliped with delicate aspect, elongated, covered with scales. Major cheliped with more globose aspect, palm little more inflated in posterolateral region, covered with scales. Palmar crest subrectangular, margin with scale-shaped tubercles. Pre-dactylar lobe modest, ornamented with scales. Fingers thin, covered with scales and tuft of short setae. Proximal outer margin of movable finger without lobe. Prehensile margins of fingers with

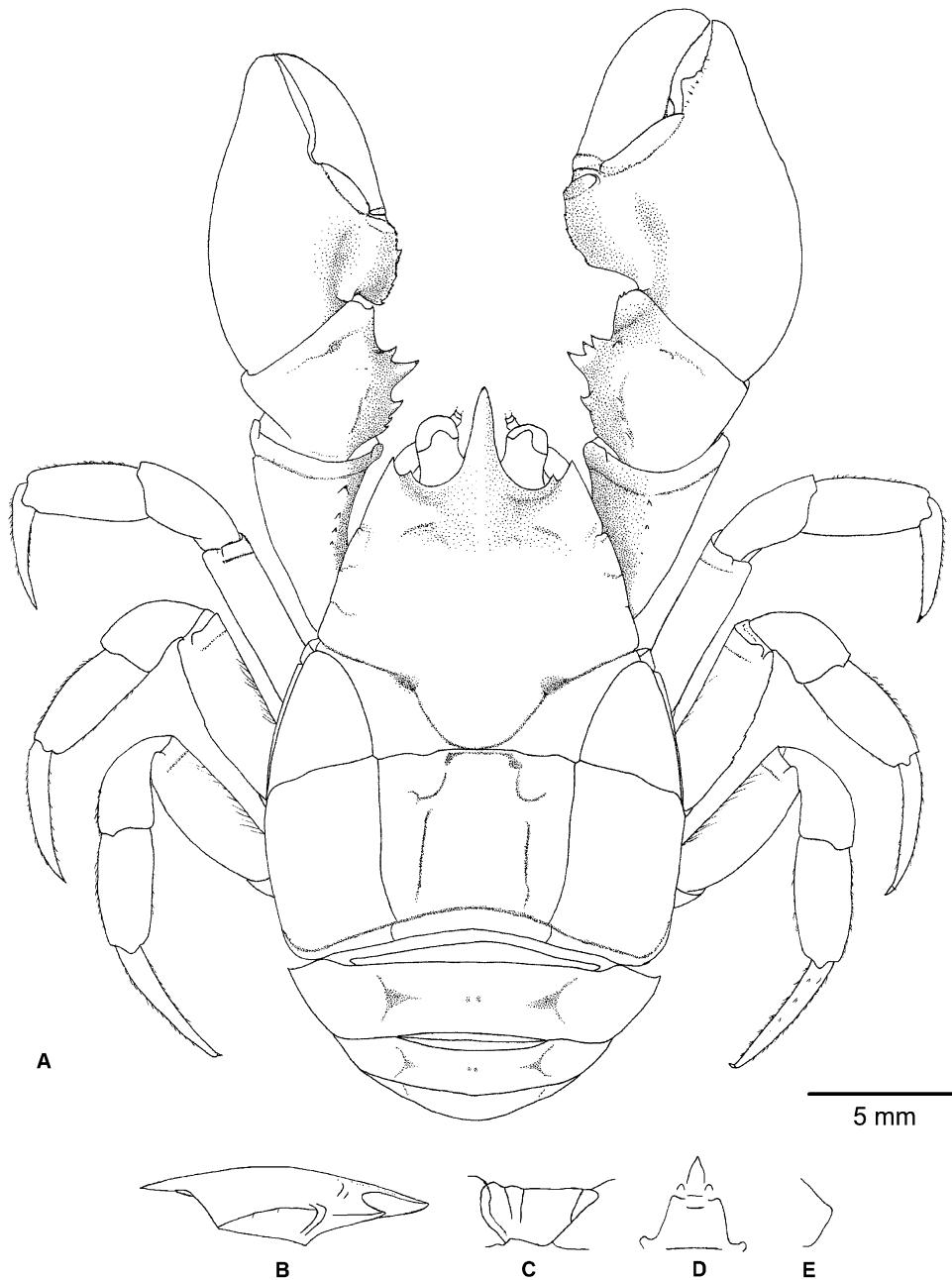


Fig. 2. *Aegla meloi* n. sp. Bond-Buckup and Santos: A, male holotype, dorsal view; B, precervical portion of carapace, lateral view; C, ischium of cheliped, ventral view; D, third and fourth sterna, ventral view; E, second pleomere epimeron, lateral view.

scale-shaped denticles along entire length, with prominent opposing, dove-tailed lobular teeth. Dorsal face of carpus scabrous, with scales; inner margin with 2 or 3 spines, distal spine being most robust and often having 1 or 2 smaller spines at basis, latter bearing scales and short setae on lateral margins; inner anterolateral angle subobtuse, with apical scale-shaped tubercles and scales; anterolateral margin without scales. Distal dorsal surface with depression parallel to distal margin. Carpal crest elevated along entire length, with scales clustered into groups of 2-5 units on elevations of crest; outer ventral angle of carpus with elevation ornamented with scale-shaped tubercle and tuft of setae. Dorsal

margin of merus of cheliped with 1 scale-shaped tubercle more pronounced, followed by smaller scale-shaped tubercles and tuft of long setae; antero-dorsal margin with scales and tuft of short setae. Lateral faces with scarce punctations. Inner ventral margin of merus with 1 distal spine. Outer ventral margin with 1 distal spine followed by scale-shaped tubercles. Dorsal margin of ischium with 1 tubercle and tuft of long setae; inner margin of ventral face with elevations ornamented with distal scale-shaped tubercle.

Dorsal margin of dactylus, propodus, and carpus of 2<sup>nd</sup>, 3<sup>rd</sup>, and 4<sup>th</sup> pereiopods with longitudinal rows of short setae and scales. Dorsal margin of merus of 2<sup>nd</sup>, 3<sup>rd</sup> and 4<sup>th</sup>

pereiopods with long setae, lending the surface a pubescent appearance; ventral margin with tubercles.

**Variations.**—Some males with right cheliped larger, characterizing heterochely. Females with more rectangular margin of the palmar crest compared to males; inner margin of carpus with 2 spines, most distal more developed and associated with smaller spine at basis.

**Measurements.**—Male holotype 15.73 mm CL. Mean of male paratypes 13.05 mm CL ( $n = 8$ ); mean of female paratypes, including ovigerous females, 13.32 mm CL ( $n = 15$ ).

PCW/FW ratio means of paratypes: males 1.77 ( $n = 8$ ), PCW/FW ratio ranging from 1.68 to 1.80; females 1.75 ( $n = 15$ ), ranging from 1.72 to 1.92.

AL/AW ratios of males paratypes ranging from 1.50 to 1.79, mean 1.67 ( $n = 8$ ); females ranging from 1.37 to 1.61, mean 1.47 ( $n = 15$ ).

**Distribution.**—Brazil: State of Paraná, Paraná River hydrographic basin, Iguaçu River sub-basin.

**Conservation Status.**—Critically Endangered (CR) – (B2-a-biii): B2) Area of occupancy (AOO = 1 km<sup>2</sup>) estimated to be less than 10 km<sup>2</sup>; a) Known to exist at only a single location; biii) Continuing decline in quality of habitat (IUCN, 2012): native vegetation accounted originally for 100% of the overall forest area in Paulo Frontin municipality, where *A. meloi* is situated, but only 15% remained in 2013 (Fundação SOS Mata Atlântica and Instituto de Pesquisas Espaciais, 2014); there are pine plantations at the periphery of the municipality and the water drainages are impacted by waste from the lumber industry.

**Etymology.**—*meloi* (genitive) of Melo, in honor of Dr. Gustavo S. de Melo, in acknowledgement for his important contributions to Brazilian carcinology.

**Remarks.**—*Aegla meloi* resembles *A. parva* Bond-Buckup and Buckup, 1994, which occurs in the same basin of Iguaçu River, in body shape and thin chelipeds. However, this new species has a flatter cephalothorax, rostrum not excavated with a lower rostral carina, and inner margin of ischium of cheliped without spines and areola subquadrate.

*Aegla meloi* is sympatric with *A. parana* Schmitt, 1942. The two can be easily distinguished by, among other characters, the very spiny appearance of *A. parana*. In *A. meloi*, the anterolateral spine of the carapace does not reach the base of the cornea, and the anterior angle of the ventral margin of epimeron 2 is inermis; while in *A. parana*, the anterolateral spine surpasses the midline of the cornea and epimeron 2 is projected in a spine.

Our ML tree (Fig. 3) suggests *A. castro* Schmitt, 1942 is the sister species to *A. meloi*. Several morphological characters distinguish these two taxa, including: 1) anterolateral spine of carapace surpassing base of cornea in *A. castro* and not reaching base of cornea in *A. meloi*; 2) proximal outer margin of movable finger with marked lobe in *A. castro* and lacking lobe in *A. meloi*; 3) palmar crest of cheliped disciform and excavated in *A. castro*, but subrectangular in *A. meloi*; and 4) protogastric lobes elevated in *A. castro* and flat in *A. meloi*.

***Aegla loyolai* n. sp. Bond-Buckup and Santos (Figs. 1, 4)**

**Type-Material.**—Holotype: male, Brazil, State of Paraná, Prudentópolis, Paraná River hydrographic basin, Pajanduvas River, tributary of upper Ivaí River, Ivaí River sub-basin, 25°12'22.3"S, 50°56'38.2"W; 745 m, 22.VIII.2005; G. Bond-Buckup, A. Zimmer and R. Gonçalves coll. (MZUSP 30032).

Paratypes: 6 m, 4 f, 2 f ov (UFRGS 4017P), same date as holotype; 4 m, 3 f, same date as holotype; 25°17'4.1"S, 50°58'29"W (UFRGS 4016P).

**Diagnosis.**—Anterolateral spine of carapace reaching middle of cornea; protogastric lobes present; extra-orbital sinus present, rostrum elongated, with medium length (4.0 < CL/RL < 4.9), straight, carinate along entire length; outer proximal margin of movable finger of cheliped with pronounced lobe tipped with scaliform tubercle; palmar crest of cheliped subdisciform; anterior angle of ventral margin of epimeron projecting in a spine; inner margin of ventral face of ischium of cheliped with distal tubercle (Fig. 4).

**Description.**—Carapace moderately elevated, area of gastric region more marked, dorsal surface scabrous, covered with punctations.

Front wide; PCW/FW ratio of holotype male 1.87.

Rostrum elongated, tending to styliform, elevated along entire length, straight, carinate along entire length, of medium length. Subrostral process absent; in profile, ventral portion of rostrum narrower than dorsal portion. Rostral carina beginning between protogastric lobes, elevated, with 2 imbricated rows of scales near apex; excavated in proximal portion. Lateral margins of rostrum with scales.

Orbits wide, deep, with modest orbital spine. Orbital margin with scarce small scales. Extra-orbital sinus weakly developed, V-shaped.

Antero-lateral angle of carapace projecting anteriorly in a spine, reaching midline of cornea. Outer and inner margins of antero-lateral lobe with sparse scales.

First hepatic lobe delimited anteriorly by distinct groove; lateral margin with scales; 2<sup>nd</sup> and 3<sup>rd</sup> hepatic lobes modestly marked; lateral margins with scales.

Epigastric prominences weakly marked, irregular surface, indefinite in form, elongated toward base of 1<sup>st</sup> hepatic lobe, with sparse scales. Protogastric lobes moderately elevated, anterior margin marked by row of scales.

Transversal dorsal line sinuous. Areola subquadrate to quadrate. AL/AW ratio of male holotype: 1.59.

Epibranchial area triangular, with 1 apical tubercle followed by scales. Lateral margins of anterior and posterior branchial area with subequal scales.

Anterior angle of ventral margin of epimeron 2 projected and armed with 1 spine; ventro-lateral margin slightly convex; posterior angle of ventral margin obtuse, unarmed. Epimera of 3<sup>rd</sup> to 6<sup>th</sup> segments anteriorly projected; on 3<sup>rd</sup> and 4<sup>th</sup> lateral projection ornamented with 1 small apical scale.

Telson divided by longitudinal suture.

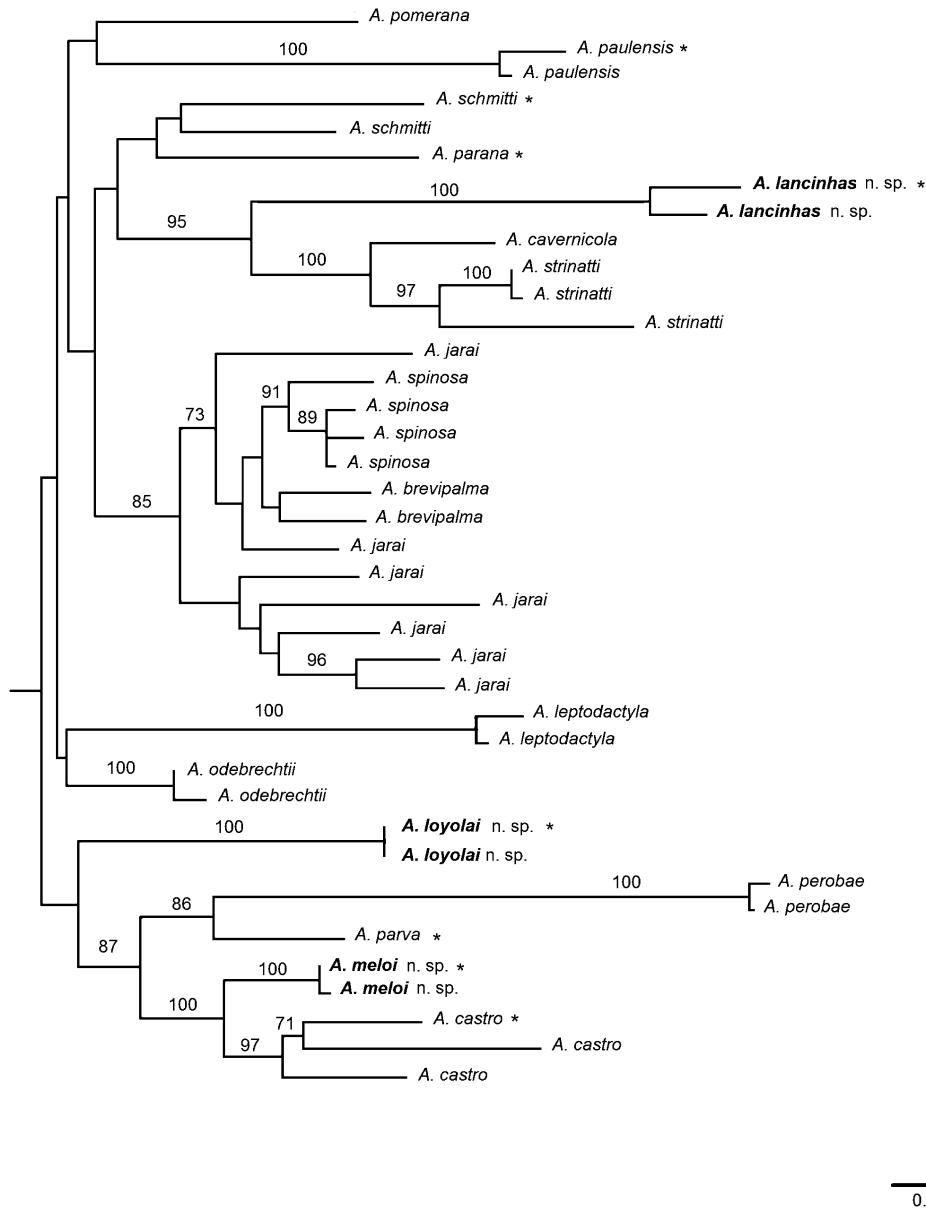


Fig. 3. Section of maximum-likelihood tree, including the three new species (in bold), in relation to the other species studied by Pérez-Losada et al. (2004) in clade C and to species described by Bond-Buckup et al. (2010) and Santos et al. (2012, 2013). Branch lengths are proportional to scale, given in substitutions per site. Bootstrap values (>70%) are shown as percentages and are based on 1000 replications. Asterisks indicate the species occurring in Paraná State.

Anterior extremity of 3<sup>rd</sup> sternite truncated, projecting between coxae of exopodites of third maxillipeds. Fourth thoracic sternite flat in median region, without ornament, lateral margins well recurved.

Cheliped subequal, hand subrectangular to subquadrate. Major cheliped with proximal outer margin slightly more inflated, covered with corneal scales. Palmar crest subdisciform to disciform, with indented margin and ornamented with scaliform tubercles, indicating lobes. Anterior pre-dactylar lobe absent. Fingers robust, covered by scales and scaliform tubercles. Outer proximal margin of movable finger with marked lobe projected in scaliform tubercle. Pre-hensile margins of fingers with scaliform denticles along entire length, with marked opposing, dove-tailed lobular teeth.

Dorsal surface of carpus scabrous, with scales; inner margin with 3 spines, distal spine being most robust; these spines with rare scales on lateral margins; small spine between distal spine and inner antero-lateral angle of carpus, in an inner position; inner antero-lateral angle acute, with apical spine; antero-dorsal margin with scales. Dorso-distal surface with depression parallel to distal margin. Carpal crest marked, more elevated in median-proximal region, with scales clustered into groups of 2 to 4 units on elevations of crest; outer ventral angle of carpus with scales; ventral face with 1 conical spine and tuft of setae. Dorsal margin of merus of cheliped with 1 spine, rest of margin with scaliform tubercles; antero-dorsal margin with scales. Lateral faces with punctations. Inner ventral margin of merus with 1 distal spine

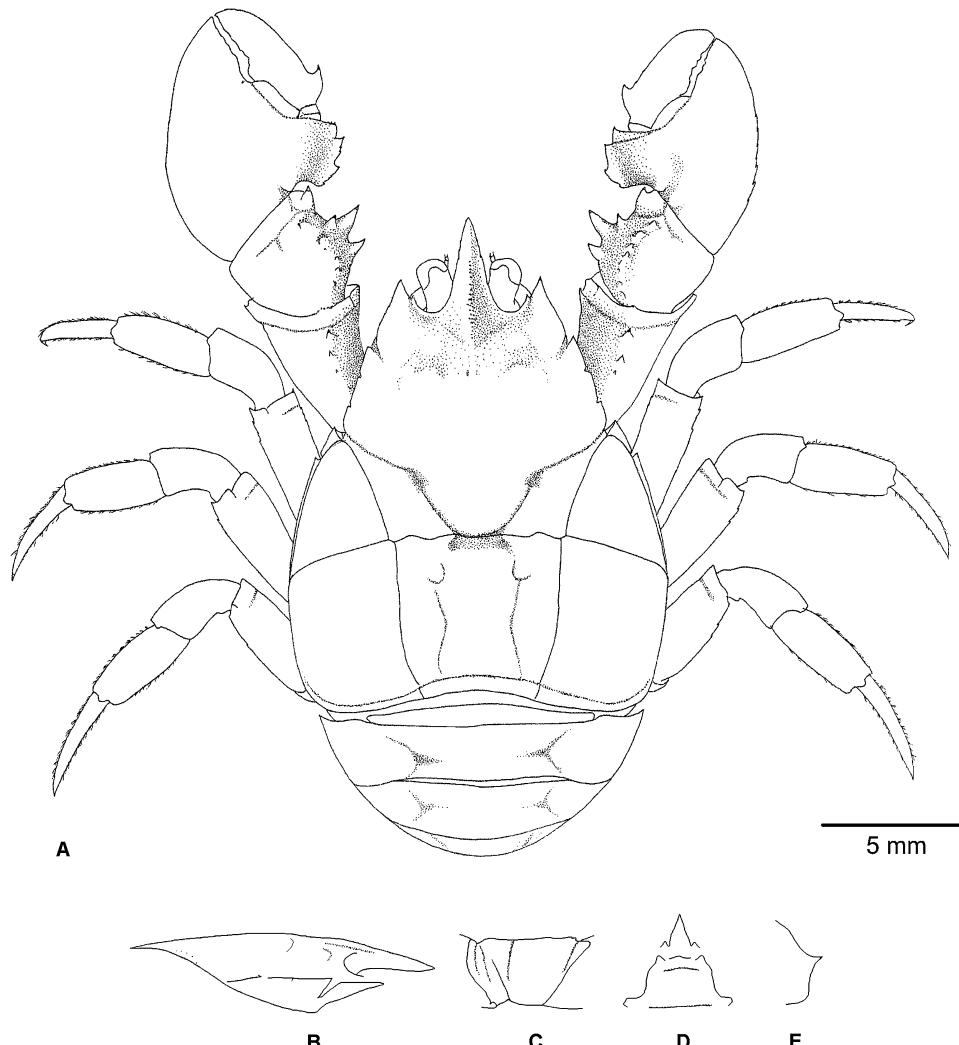


Fig. 4. *Aegla loyolai* n. sp. Bond-Buckup and Santos: A, male holotype, dorsal view; B, precervical portion of carapace, lateral view; C, ischium of cheliped, ventral view; D, third and fourth sterna, ventral view; E, second pleomere epimeron, lateral view.

followed by scaliform tubercles; outer ventral margin with 2 distinguished distal tubercles followed by scales. Dorsal margin of ischium with 1 tubercle; inner margin of ventral face with distal conical tubercle followed by some scales along the margin. Dorsal margin of dactylus, propodus and carpus of 2<sup>nd</sup>, 3<sup>rd</sup> and 4<sup>th</sup> pereiopods with longitudinal rows of setae and scales; ventral surface with scaliform tubercles.

**Variations.**—Some variations in paratypes; rostral carina with multi-rows of scales instead of 2 rows; lobe of movable finger of cheliped with 1 or 2 tubercles; palmar crest less indented, without lobes; ventral face of ischium of chelipeds ornamented only with an elevation. Females presenting chelipeds and fingers more delicate and thinner than males.

**Measurements.**—Male holotype 13.86 mm CL.

Mean of male paratypes 12.45 mm CL ( $n = 7$ ); mean of female paratype 10.62 mm CL ( $n = 9$ ).

PCW/FW ratio means of paratypes: males 1.84 ( $n = 7$ ), PCW/FW ratio ranging from 1.78-1.90; females 1.86 ( $n = 9$ ), ranging from 1.70 to 2.00.

AL/AW ratios of male paratypes ranging from 1.62 to 2.27, mean 1.65 ( $n = 7$ ); females ranging from 1.11 to 2.10, mean 1.60 ( $n = 9$ ).

**Distribution.**—Brazil: State of Paraná, Prudentópolis, Paraná River hydrographic basin, Ivaí River sub-basin.

**Conservation Status.**—ENDANGERED (EN) – (B1-B2-a-biii): B1) Extent of occurrence (EOO = 1550 km<sup>2</sup>) estimated to be less than 5000 km<sup>2</sup>; B2) Area of occupancy (AOO = 2 km<sup>2</sup>) estimated to be less than 10 km<sup>2</sup>; a) Known to exist at no more than five locations; biii) Continuing decline in quality of habitat (IUCN, 2012): native vegetation accounted originally for 100% of the overall forest area in Prudentópolis Municipality, where the occurrence area of *A. loyolai* is situated, but only 16% remained in 2013 (Fundação SOS Mata Atlântica and Instituto de Pesquisas Espaciais, 2014); there are pine plantations at the periphery of the municipality and the water drainages are impacted by waste from the lumber industry.

**Etymology.**—*loyolai* (genitive), of Loyola, in honor of Dr. Jayme Loyola, eminent Brazilian carcinologist, who dedicated his studies to marine isopods.

**Remarks.**—The characteristic short palm of *Aegla loyolai* is shared with *A. plana* Buckup and Rossi, 1977 and with *A. brevipalma* Bond-Buckup and Santos, 2012 (Santos et al., 2012), as well as in other species from the Argentinean region. Notwithstanding, *A. loyolai* differs from *A. brevipalma* and *A. plana* in having an extra-orbital sinus, a more elevated carapace, marked protogastric lobes, and differently shaped rostrum and rostral carina. Another differential morphologic character that distinguishes it from these morphologically similar species is the presence of the marked lobe on the movable finger of the cheliped, similar to that of *A. singularis* Ringuelet, 1948.

*A. loyolai* is sympatric with *A. castro* at the type-locality. These two species can be differentiated by the expanded lateral margins of the carapace in the branchial region and the more robust hands in *A. castro*.

In the molecular phylogeny (Fig. 3), *A. loyolai* clustered in the same subclade as *A. castro*, *A. meloi*, *A. parva* and *A. perobae* Hebling and Rodrigues, 1977, but in a more basal position.

***Aegla lencinhas* n. sp.** Bond-Buckup and Buckup (Figs. 1, 5)

*Aegla paulensis* – Bond-Buckup and Buckup, 1994: 241.

**Type-Material.**—Holotype: male, Brazil, State of Paraná, Rio Branco do Sul, Lencinhas Grot, Ribeira do Iguape River basin, Upper Ribeira sub-basin, tributary of Açuñui River, 25°10'0.3"S, 49°17'10.9"W; 900 m, 6.X.2003; G. Bond-Buckup and L. Buckup coll. (MZUSP 30033).

Paratypes: 4 m, 8 f (UFRGS 2658P), same date as holotype; 29 m, 9 f (UFRGS 2662P), State of Paraná, Itaperuçú, Itaperuçú Fountain, Ribeira do Iguape basin, Upper Ribeira sub-basin, tributary of Açuñui River, 25°13'28.8"S, 49°20'28.5"W; 990 m, 6.X.2003; G. Bond-Buckup and L. Buckup coll.; 1 m (UFRGS 2661P), idem, 200 m from the grot, X.1956, J. Loyola coll.; 1 m (UFRGS 1175P), Lencinhas Grot, Rio Branco do Sul, 19.VII.1986, J. R. Botelho coll.; 1 m, 1 ov f (UFRGS 2844P), idem, idem, 19.VII.1986, Pinto da Rocha.

**Diagnosis.**—Antero-lateral spine of carapace reaching base of cornea; protogastric lobes weakly marked and epigastric lobes tubercle-shaped, very marked; extra-orbital sinus present, rostrum triangular, slightly ligulate, straight, carinate in 2 proximal thirds, outer proximal margin of movable finger of cheliped without lobe; palmar crest of cheliped modest, subdisciform, slightly concave; anterior angle of ventral margin of epimeron 2 inermis; inner margin of ventral face of ischium of cheliped with 1 distal scaliform tubercle and smaller scales (Fig. 5).

**Description.**—Carapace slightly flattened, dorsal surface scabrous, covered with punctations and scales.

Front wide; PCW/FW ratio of male holotype 1.82.

Rostrum triangular, slightly ligulate, straight, carinate in the 2 proximal thirds, short length. Subrostral process well developed; in profile, rostrum with ventral portion wider than dorsal portion. Rostral carina beginning at height of

epigastric lobes with imbricated scales not reaching apex; carina elevated in median portion and absent in distal third. Lateral margins of rostrum with scales.

Orbits wide, deep, orbital spine modest. Orbital margin scabrous with scales. Extra-orbital sinus present and U-shaped.

Antero-lateral angle of carapace projected anteriorly in a spine, reaching base of cornea. Margin recurved; outer and inner margins of antero-lateral lobe with sparse scales.

First hepatic lobe recurved, anteriorly delimited by incision; lateral margin with scales; 2<sup>nd</sup> hepatic lobe modestly indicated; lateral margins with scales.

Epigastric prominences very marked, elevated, scabrous surface. Protogastric lobes slightly prominent, indicated only by 1 line of scales.

Transverse dorsal line sinuous. Areola quadrate. AL/AW ratio of male holotype: 1.73.

Epibranchial area triangular, with imbricated scales. Lateral margins of anterior and posterior branchial area with sparse scales, subequal.

Anterior angle of ventral margin of epimeron 2 unarmed, surface covered with long setae; ventro-lateral margin slightly convex; posterior angle of ventral margin obtuse, unarmed. Epimera of 3<sup>rd</sup> to 6<sup>th</sup> segments anteriorly projected; on 3<sup>rd</sup> and 4<sup>th</sup> segments, lateral projection ornamented with small apical scale.

Telson divided by longitudinal suture.

Anterior extremity of 3<sup>rd</sup> sternite triangular, tapered, projected between coxae of exopodites of 3<sup>rd</sup> maxillipeds. Fourth thoracic sternite slightly elevated in median region, with many long setae, lateral margins recurved.

Chelipeds subequal, hand subrectangular. Chelae delicate in appearance, covered with scales. Major cheliped with slightly more robust aspect than minor cheliped. Palmar crest subdisciform, with margin ornamented with scaliform tubercles, slightly concave. Pre-dactylar lobe absent. Fingers thin, covered with scales and long setae. Outer proximal margin of movable finger without lobe. Prehensile margins of fingers with scaliform denticles along entire length and with opposing, dove-tailed lobular teeth. Dorsal face of carpus scabrous, with scales; inner margin with 3 spines, distal spine being more robust; 1 modest tubercle between distal spine and inner lateral angle; no scales on lateral margins of spines, only tuft of setae; inner anterolateral angle inermis, only with scales; anterodorsal margin with scales. Distal dorsal surface flat, without depression. Carpal crest weakly marked, more elevated in proximal region; medial and distal portions with scales clumped in groups on elevations of crest; outer ventral angle of carpus obtuse, unarmed; ventral face with modest conical spine and tuft of setae. Dorsal margin of merus of cheliped with elevations tipped with scales, decreasing in size proximally; anterodorsal margin with sparse scales. Lateral faces smooth. Inner ventral margin of merus with distal tubercle followed by scaliform tubercles and scales; outer ventral margin with a marked distal scaliform tubercle followed by scales and tuft of setae. Dorsal margin of ischium with 1 conical tubercle and long setae; inner margin of ventral face of ischium with distal scaliform tubercle.

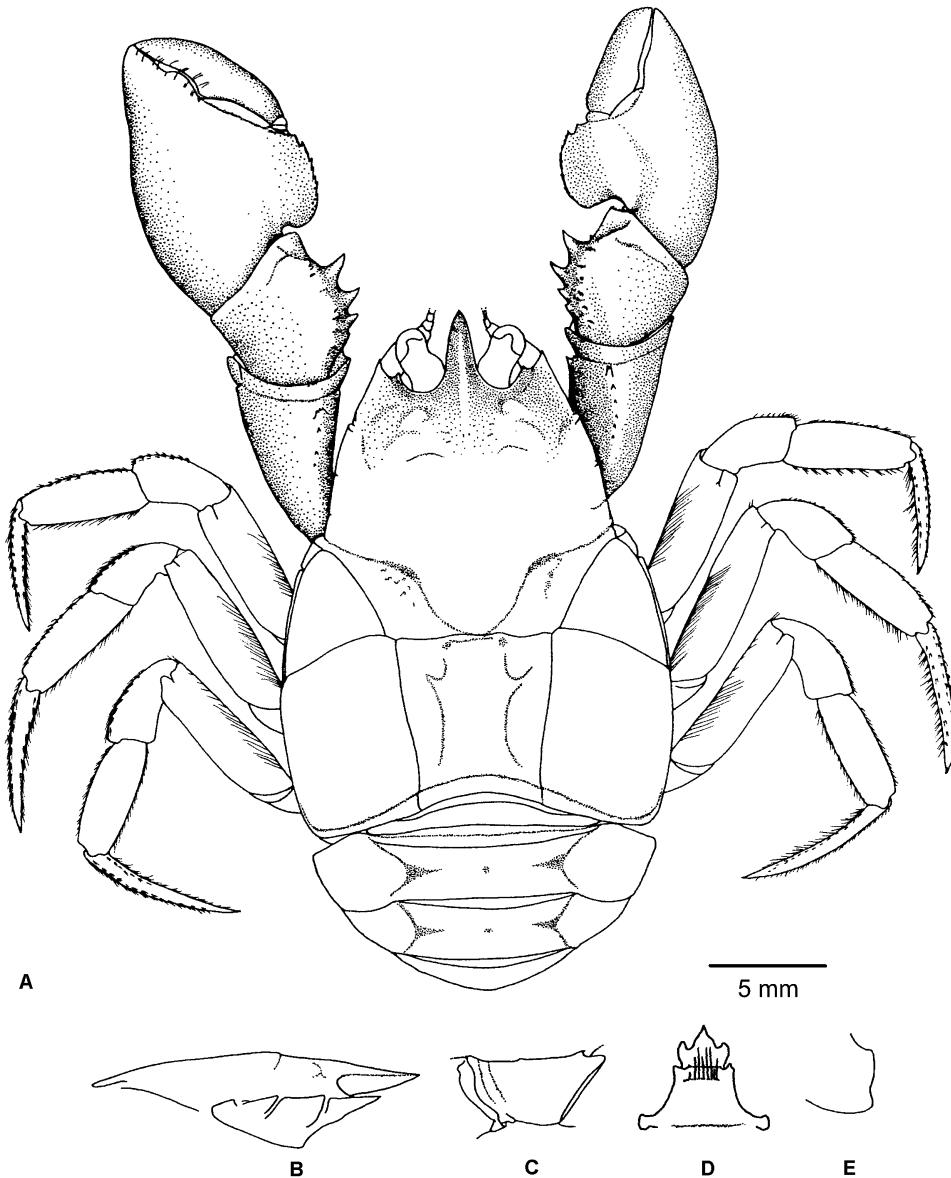


Fig. 5. *Aegla lancinhas* n. sp. Bond-Buckup and Santos: A, male holotype, dorsal view; B, precervical portion of carapace, lateral view; C, ischium of cheliped, ventral view; D, third and fourth sterna, ventral view; E, second pleomere epimeron, lateral view.

Dorsal margin of dactylus, propodus and carpus of 2<sup>nd</sup>, 3<sup>rd</sup> and 4<sup>th</sup> pereiopods with longitudinal rows of setae, scales, and long setae. Ventral margins of 2<sup>nd</sup>, 3<sup>rd</sup> and 4<sup>th</sup> pereiopods with scales and short setae.

**Variations.**—Largest males with left chelae more inflated, palmar crest more concave, and carpal crest more marked, elevated. Females with chelae thinner with many setae; palmar crest weakly developed and less excavated than males.

**Measurements.**—Male holotype 20.04 CL.

Ovate female measured 18.89 mm CL; mean CL of 23 paratypes was 13.92 mm, ranging from 10.90 to 26.98 mm.

PCW/FW ratio of paratypes 1.82 ( $n = 23$ ), ranging from 1.63 to 1.94, representing a relatively wide front ( $1.79 < \text{PCW/FW} < 1.89$ ).

AL/AW ratio of paratypes 1.61 ( $n = 23$ ), ranging from 1.42 to 2.02, resulting in a subquadrate areola.

**Distribution.**—Brazil: State of Paraná, Rio Branco do Sul and Itaperuçu Municipalities, Upper Ribeira do Iguape River sub-basin.

**Conservation Status.**—ENDANGERED (EN) – (B1-B2-a-biii): B1) Extent of occurrence (EOO = 374 km<sup>2</sup>) estimated to be less than 5000 km<sup>2</sup>; B2) Area of occupancy (AOO = 2 km<sup>2</sup>) estimated to be less than 10 km<sup>2</sup>; a) Known to exist at no more than five locations; biii) Continuing decline in quality of habitat (IUCN, 2012): native vegetation accounted originally for 100% of the overall forest area in Rio Branco do Sul and Itaperuçu Municipalities, where the area of occurrence for *A. lancinhas* is situated, but about only 10% had been left in 2013 (Fundação SOS Mata Atlântica

and Instituto de Pesquisas Espaciais, 2014); there are pine plantations at the periphery of the municipalities; the caves where the species can be found are used as recreation areas by the local population and are impacted by garbage discarded by people on the bank of the watercourse.

**Etymology.**—The species name, *lancinhas*, is given after the cave of the type-locality.

**Remarks.**—Bond-Buckup and Buckup (1994: page 242) allocated some lots (MHNCI 904; MHNCI 906; MHNCI 1116; MNRJ 1426) from the cave of Lancinhas and Itaperuçu Fountain as *A. paulensis*. A more detailed examination of the characters, with a greater number of animals, allowed the division of specimens into two species.

The shape of chelae (manus) is very similar in *A. lancinhas* and *A. paulensis*, however, the chelae is more inflated in the new species. The palmar crest of *A. lancinhas* is more excavated and recurved. The new species has a flatter carapace, a more ligulate rostrum and a more subquadrate areola. *A. paulensis* has a more inflated carapace, the rostrum is shorter, and the spines of carpus are more robust.

In the molecular phylogeny (Fig. 3), *A. lancinhas* is clustered in the same subclade as *A. cavernicola* Türkay, 1972 and *A. strinatti* Türkay, 1972, which are also cave species.

## DISCUSSION

Herein we describe three new species of *Aegla* for the Brazilian State of Paraná, all of them occurring in the Serra Geral mountain range, in streams from the Paraná and Ribeira do Iguaçu river hydrographic basins. The new species have restricted distributions and can be found in altitudes higher than 700 m.

Among the three basins where the new species are found, Ribeira do Iguaçu has the greatest diversity of aeglids, despite being the smallest in area (9736 km<sup>2</sup>). In addition to the species listed in Table 1 for Paraná State, we can also find *A. strinatti* in this basin, in the Brazilian State of São Paulo; bringing the total to eight species if we consider *A. lancinhas* n. sp. On the other hand, *A. loyolai* is the third aeglid species described from the Ivá River sub-basin (total area: 36,540 km<sup>2</sup>). *A. meloi* is the fourth species described from the Iguaçu River sub-basin (total area: 70,800 km<sup>2</sup>) (Table 1).

The estimated phylogenetic tree (Fig. 3) shows that *A. loyolai*, *A. meloi*, and *A. lancinhas* differ evolutionarily from other known species of *Aegla* in the Paraná region. Moreover, *A. meloi* and *A. loyolai* have clearly diverged from *A. parana* and *A. castro*, despite their sympatric occurrence. *Aegla lancinhas* is also distinct from *A. paulensis*, the species to which specimens from Lancinhas Cave were first assigned (Bond-Buckup and Buckup, 1994).

All three new species clustered in clade C of the ML phylogeny presented in Pérez-Losada et al. (2004), which encompasses Brazilian species, most from the Paraná River basin, including some cave species such as *A. cavernicola*, *A. strinatti* and *A. perobae*.

During our fieldwork, we observed that rivers throughout the region of Paraná State have been degraded as a result of intense bank deforestation. Moreover, there are lumber

industries near the rivers discharging waste into these basins. The three new species have restricted distributions, all of them with an area of occupancy estimated to be less than 10 km<sup>2</sup>. *A. meloi* n. sp. is known to exist at only one location and we recommend this species be listed as “Critically Endangered” (CR). *A. loyolai* n. sp. and *A. lancinhas* n. sp. are known to occur at only two locations and we recommend a categorization of “Endangered” (EN), following the IUCN (2012) criteria.

Because of the relief and hydrography, there is a great potential to find new species of Aeglidae in the Brazilian State of Paraná. New field studies are being carried out to better understand the aeglid fauna from this region and to help better protect this biodiversity.

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