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Five new species of Candoninae (Crustacea, Ostracoda) from the alluvial valley of the Upper Paraná River (Brazil, South America)

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Abstract. The present paper describes five new species of candonid ostracods in two genera: *Pseudocandona agostinhoi* sp. nov., *P. cillisi* sp. nov., *P. claudinae* sp. nov., *Candobrasilopsis elongata* sp. nov. and *C. acutis* sp. nov. The three species of *Pseudocandona* belong to the *caribbeana*-group in this genus. With the two new species of *Candobrasilopsis*, this genus now comprises four species. *Candobrasilopsis elongata* sp. nov. is the most common of the five new species described here, while *C. acutis* sp. nov. and *P. claudinae* sp. nov. are known from one locality only, which is furthermore the same for both species: a small streamlet entering the Paraná River. With the description of the present five species, the number of species known from the Paraná River alluvial valley, including the Taquaruçu lakes, now amounts to 49.

Key words. *Pseudocandona, Candobrasilopsis*, streams, taxonomy

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Introduction

There are about 2000 Recent non-marine ostracod species in the world (Martens *et al*. 2008). Close to 300 of these species have been described and reported from South America and more than 100 species are now known from Brazil (Martens & Behen 1994; Higuti *et al*. 2009a, 2013; Higuti & Martens 2012a, 2012b). Recent work on the alluvial valley of the Upper Paraná River (Higuti *et al*. 2007, 2009b, 2009c, 2010; Mormul *et al*. 2010) has contributed significantly to the general knowledge of ecology and biogeography of Brazilian freshwater ostracods, especially those occurring in the pleuston of floating plants. Floating plants such as species in the genera *Eichhornia*, *Pistia* and *Salvinia* are typical of South American (floodplain) lakes, and pleuston, the animal communities living in the root systems of such plants, are thus typical of such lakes.

The ecological realm of pleuston, next to the plankton and benthos (see Por 1995), is especially important in floodplain lakes. Sediments in floodplain lakes have low oxygen levels most of the time and sudden water level rise can render sediments anoxic virtually overnight. Thus, floating plants become important substrates for colonization by ostracods, since these macrophytes will simply follow rising water levels and local variables such as oxygen will change minimally on the root systems of the floating vegetation.

Many otherwise benthic organisms can thus be found in the pleuston in South American floodplain lakes.

The collections made to study the ecology of the ostracods in the pleuston in the alluvial valley of the Upper Paraná River (Higuti *et al.* 2007, 2009b, 2009c, 2010; Mormul *et al*. 2010) also served for taxonomic revisions and several new species and genera of ostracods have meanwhile been described from lakes, river beds and channels of this floodplain (Higuti *et al.* 2009a, 2013; Higuti & Martens 2012a, 2012b). Most of these new taxa belong to the family Cyprididae; only one paper thus far treated two species of Candonidae from this floodplain in detail (Higuti & Martens 2012b), describing a new genus and species, *Candobrasilopsis rochai* Higuti & Martens, 2012, and redescribing and generically transferring another species, *Candobrasilopsis brasiliensis* (Sars, 1901).

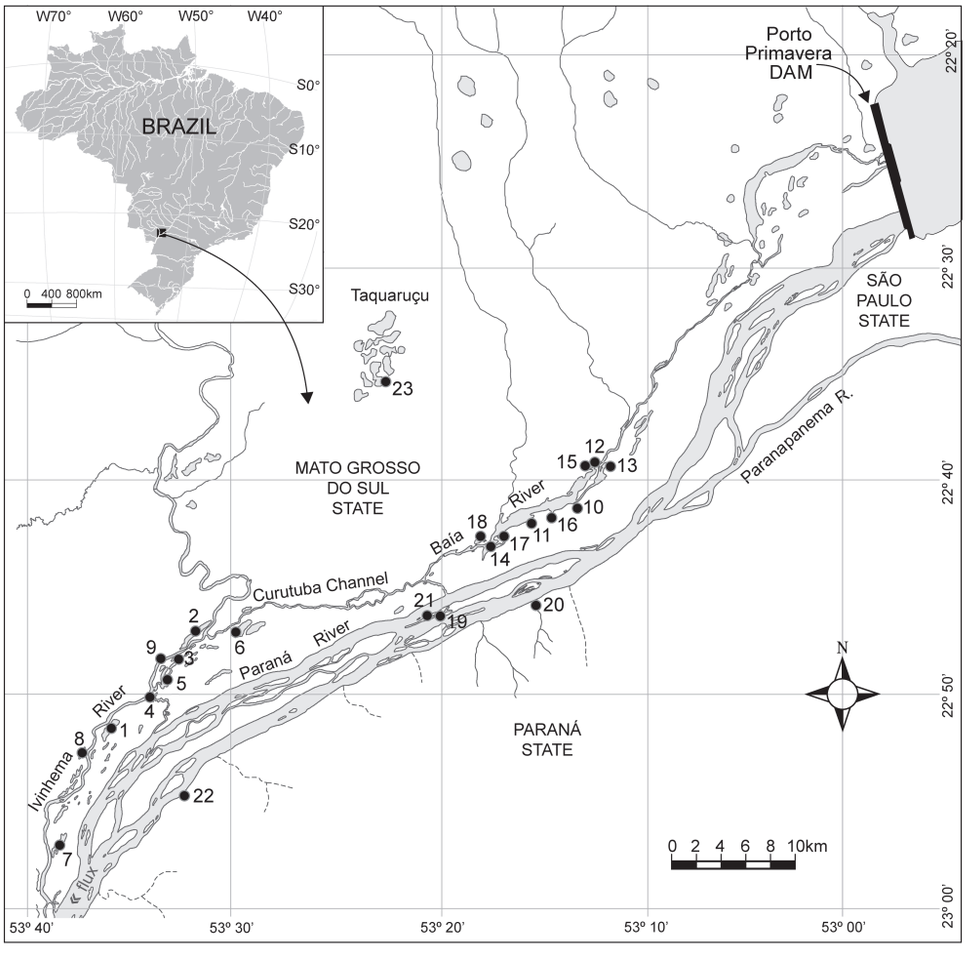

Fig. 1. Map of the study area, indicating the localities of three new species of *Pseudocandona* and two new species of *Candobrasilopsis*.

Here, we describe five new species of candonids from this floodplain in southern Brazil (South America); three new species belong to the genus *Pseudocandona* Kaufmann, 1900 and two new species to the genus *Candobrasilopsis* Higuti & Martens, 2012. Several new species from this and other Brazilian floodplains remain to be described, e.g., in the genera *Physocypria* (Candonidae), *Cypretta* and *Strandesia* as well as in several genera of the Cypridopsinae (Cyprididae).

Material and Methods

Study area

The Upper Paraná River floodplain is located between the Porto Primavera Reservoir and the Itaipu Reservoir, extending over about 230 km. In this area, three conservation units were created: "Área de Proteção Ambiental das Ilhas e Várzeas do Rio Paraná" (100,310 ha; an Environmental Protection Area), the "Parque Nacional de Ilha Grande" (78,800 ha; a National Park), and the "Parque Estadual do Ivinheima" (70,000 ha; a State Park) (Agostinho & Zalewski 1996; Agostinho *et al*. 2004). The floodplain, apart from the main channel of the Paraná River, also includes the Ivinhema and Baía Rivers and associated with it, the isolated lakes of the Taquaruçu area (Souza Filho & Stevaux 2004) (Fig. 1). Also several streams enter into the system, and these remain largely understudied.

Material

The samples were collected during the expeditions of 2004, 2011 and 2012 in the alluvial valley of the Upper Paraná River. Ostracods were sampled using a rectangular net (28 cm x 14 cm, mesh size *ca.* 160 µm) hauled close to the sediment-water interface for littoral collections. Floating vegetation was hand-collected, and roots were thoroughly washed in a bucket. The residues were washed in the same hand net.

Water temperature and dissolved oxygen (Oxymeter-YSI, YSI Incorporated World Headquarters, Yellow Springs, Ohio, U.S.A.), pH (pHmeter-Digimed, Digimed, São Paulo, Brazil) and electrical conductivity (conductivimeter-Digimed, Digimed, São Paulo, Brazil) were measured close to the surface of the water (Table 1).

All specimens with OC numbers are stored in the Ostracod Collection of the Royal Belgian Institute of Natural Sciences, Brussels. The material with MZUSP numbers are stored in the Museu de Zoologia da Universidade de São Paulo, São Paulo (Table 2).

Morphological analyses

Ostracods were dissected with valves stored dry in micropalaeontological slides and soft parts in glycerine in sealed slides. Drawings of soft parts were made with a *camera lucida* attached to a compound microscope (Olympus, BX51). Valves were illustrated and measured using scanning electron microscopy (Philips XL30 SEM at RBINS, Brussels).

Table 1. Localities (and some of their characteristics) from which the five new species of candonids were collected. Locality names of 1 to 9 are from the Ivinhema River System, 10 to 18 from the Baía River System, 19 to 22 from the Paraná River System and locality 23 is from the Taquaruçu System. Bold = type localities of the new species. WT = water temperature (°C), EC = electrical conductivity (µS cm^{-1}), DO = dissolved oxygen (mg L^{-1}), Pa = *Pseudocandona agostinhoi* sp. nov., Pc = *P. cillisi* sp. nov., Pcl = *P. claudinae* sp. nov., Ce = *Candobrasilopsis elongata* sp. nov., Ca = *C. acutis* sp. nov.

Locality name	Sample	Date	S°	S'	S"	W°	W'	W"	Loc. type	Substrate type	Temp	EC	pH	DO	Pa	Pc	Pcl	Ce	Ca
1. Ventura	PAR 1	13 Mar. 04	22	51	29	53	36	3	closed lake	littoral	26.5	36.2	6.6	7.2	x				
1. Ventura	PAR 122	6 Nov. 04	22	51	20	53	36	1	closed lake	*E. crassipes*	24.6	33.7	5.8	6.5	x				
2. Finado Raimundo	PAR 10	13 Mar. 04	22	47	41	53	32	22	open lake	littoral	28.1	39.6	7.2	7				x	
3. Capivara	PAR 17	13 Mar. 04	22	48	7	53	32	7	closed lake	littoral	28.3	44.8	6.2	4.2				x	
4. Boca do Ipoitã	PAR 61	16 Mar. 04	22	50	14	53	33	59	open lake	*E. crassipes*	33.5	49.6	6.3	4.8				x	
4. Boca do Ipoitã	PAR 226	11 Nov. 04	22	50	7.3	53	33	58.7	open lake	*E. crassipes*	25.7	41.8	5.8	3.5		x		x	
5. Patos	PAR 124	6 Nov. 04	22	49	33.2	53	33	13.8	open lake	*E. crassipes*	26	48.2	5.4	2.7	x			x	
5. Patos	**PAR 461**	**2 Feb. 11**	**22**	**49**	**48.2**	**53**	**33**	**20.3**	**open lake**	***E. crassipes***	**30.2**	**42.8**	**5.93**	**0.14**				**x**	
6. Jacaré	PAR 137	6 Nov. 04	22	46	59.1	53	29	52.9	closed lake	*P. stratiotes*	28.5	35.4	4.7	4.1				x	
7. Pintado	PAR 213	11 Nov. 04	22	56	50.1	53	38	36	open lake	*Salvinia* spp	25.8	43.3	5.6	4	x			x	
7. Pintado	PAR 215	11 Nov. 04	22	56	50.1	53	38	36	open lake	*E. azurea*	25.8	43.3	5.6	4				x	
8. Peroba	PAR 219	11 Nov. 04	22	54	32.8	53	38	23.4	open lake	*E. crassipes*	25.6	28.1	5.8	5.6	x				
8. Peroba	**PAR 710**	**16 Jul. 12**	**22**	**54**	**39.4**	**53**	**38**	**34.5**	**open lake**	***E. crassipes***	**17.3**	**34**	**5.41**	**0.90**	**x**				
9. Ivinhema	PAR 222	11 Nov. 04	22	54	37.6	53	38	19.4	river	*E. crassipes*	25.8	41.3	6.3	5.9				x	
10. Aurélio	PAR 22	14 Mar. 04	22	41	46	53	13	56	closed lake	littoral	28	36	6	3				x	
10. Aurélio	**PAR 150**	**7 Nov. 04**	**22**	**41**	**36.5**	**53**	**13**	**52**	**closed lake**	**floating plants**	**26.2**	**31.1**	**5**	**1**		**x**			
11. Pousada das Garças	PAR 25	14 Mar. 04	22	42	12	53	15	33	closed lake	littoral	27.5	29.3	6.2	4.4				x	
11. Pousada das Garças	PAR 146	7 Nov. 04	22	42	2.4	53	15	26	closed lake	*E. crassipes*	26.3	29.7	5.5	3.9				x	
12. Gavião	PAR 76	17 Mar. 04	22	39	49	53	12	19	open lake	*E. crassipes*	27.8	31.1	6.2	3.9				x	
12. Gavião	PAR 188	10 Nov. 04	22	39	37.1	53	12	14	open lake	*E. crassipes*	26.7	31.3	5.3	2		x		x	
13. Onça	PAR 81	17 Mar. 04	22	39	56	53	12	8	open lake	littoral	29.1	37.9	6	2.1	x				
13. Onça	PAR 185	10 Nov. 04	22	39	50.5	53	12	5	open lake	*E. crassipes*	26.6	25.8	5.1	1.2				x	
14. Baía	PAR 83	17 Mar. 04	22	41	8	53	13	3	river	*E. crassipes*	29.4	34.4	6	4.5	x	x		x	
14. Baía	PAR 192	10 Nov. 04	22	40	37.5	53	12	29	river	*H. ranunculoides*	26.7	30.9	5.7	3.1		x			

Locality name	Sample	Date	S°	S'	S"	W°	W'	W"	Loc. type	Substrate type	Temp	EC	pH	DO	Pa	Pc	Pcl	Ce	Ca
14. Baía	PAR 193	10 Nov. 04	22	40	37.5	53	12	29	river	*P. stratiotes*	26.7	30.9	5.7	3.1				x	
14. Baía	PAR 195	10 Nov. 04	22	40	37.5	53	12	29	river	*E. crassipes*	26.7	30.9	5.7	3.1		x		x	
15. Maria Luiza	PAR 88	17 Mar. 04	22	40	40	53	13	12	open lake	*E. crassipes*	30.4	40.8	6.1	3.5		x		x	
15. Maria Luiza	PAR 197	10 Nov. 04	22	40	29.4	53	13	5.8	open lake	*E. crassipes*	26.9	33.6	5.5	3.6		x		x	
16. Porcos	PAR 90	17 Mar. 04	22	42	20	53	14	47	open lake	*E. crassipes*	29.6	41.3	6.1	3.5				x	
16. Porcos	PAR 201	10 Nov. 04	22	42	6.9	53	14	42.5	open lake	*E. crassipes*	27.7	41.1	5.5	4.1				x	
17. Fechada	PAR 141	7 Nov. 04	22	42	32	53	16	31.6	closed lake	*P. stratiotes*	25.3	27	4.9	2.3		x			
18. Guaraná	PAR 207	10 Nov. 04	22	43	16.8	53	18	12.9	open lake	*P. stratiotes*	27.4	40.5	5.2	3.3				x	
19. Osmar	PAR 31	15 Mar. 04	22	46	38	53	20	1	closed lake	littoral	27.6	64.1	6.2	4.2	x				
20. Caracu	PAR 100	17 Mar. 04	22	46	6	53	15	28	stream	littoral	27.2	54.3	6.9	6.4	x				
21. Manezinho	PAR 211	10 Nov. 04	22	46	45.7	53	20	57.7	open lake	*E. crassipes*	26.6	58.8	6	5.4	x				
22. Matagal	**PAR 755**	**4 Oct.12**	**22**	**54**	**26.4**	**53**	**32**	**27.7**	**stream**	**littoral**	**23**	**179.9**	**6.2**	**1.73**			**x**		**x**
23. Samambaia 1	PAR 103	4 Jul. 04	22	36	16	53	22	33	closed lake	littoral	25.4	29.2	6.5	8.3				x	

Table 2. Locality data of specimens used for illustrations in the present paper.

Pseudocandona agostinhoi sp. nov. All specimens were sampled on 16 Jul. 2012, Peroba Lake (PAR 710), *Eichhornia crassipes*. Valves (male): MZUSP 32655, MZUSP 32660, MZUSP 32661, OC. 3304 Valves (female): OC. 3303, MZUSP 32667, MZUSP 32668, 0C. 3305 Soft parts (male): MZUSP 32655, MZUSP 32653, MZUSP 32656 Soft parts (female): MZUSP 32654
Pseudocandona cillisi sp. nov. All specimens were sampled on 7 Nov. 2004, Aurélio Lake (PAR 150), floating plants. The specimen MZUSP 32681 was sampled on 10 Nov. 2004, Baía River (PAR 195), *Eichhornia crassipes*. Valves (male): MZUSP 32681, MZUSP 32671, MZUSP 32677, OC. 3362 Valves (female): MZUSP 32672, MZUSP 32678, MZUSP 32680, 0C. 3364 Soft parts (male): MZUSP 32673
Pseudocandona claudinae sp. nov. All specimens were sampled on 4 Oct. 2012, Matagal Stream (PAR 755), littoral. Valves (female): MZUSP 32683, MZUSP 32684 Soft parts (female): MZUSP 32682
Candobrasilopsis elongata sp. nov. All specimens were sampled on 2 Feb. 2011, Patos Lake (PAR 461), *Eichhornia crassipes*. Valves (male): MZUSP 32687, MZUSP 32690, MZUSP 32691, MZUSP 32692 Valves (female): MZUSP 32686, MZUSP 32699, MZUSP 32696, MZUSP 32697 Soft parts (male): MZUSP 32685
Candobrasilopsis acutis sp. nov. All specimens were sampled on 4 Oct. 2012, Matagal Stream (PAR 755), littoral. Valves (male): MZUSP 32700, MZUSP 32704, OC. 3358 Valves (female): MZUSP 32701, MZUSP 32706, MZUSP 32707, OC. 3360 Soft parts (male): MZUSP 32703

Abbreviations used in text and figures

A1	=	Antennula
A2	=	Antenna
Cp	=	Carapace
CpD	=	Carapace dorsal
CpRl	=	Carapace right lateral
CpV	=	Carapace ventral
CR	=	Caudal ramus
CRa	=	Attachment of caudal ramus
Db	=	Dorsal branch of caudal ramus
H	=	Height of valves
JH	=	Janet Higuti
L	=	Length of valves
Lpp	=	Left prehensile palp
Ls	=	Lateral shield of hemipenis
LV	=	Left valve
LVi	=	Letf valve interior
Md	=	Mandibula
ms	=	Medial shield

Mx1	=	Maxillula
Rlo	=	Rake-like organ
Rpp	=	Right prehensile palp
RBINS	=	Royal Belgian Institute of Natural Sciences, Brussels, Belgium
RVi	=	Right valve interior
T1	=	First thoracopod, sometimes called Maxilla = Mx2
T2	=	Second thoracopod
T3	=	Third thoracopod
V	=	Valve
Vb	=	Ventral branch of caudal ramus
W	=	Width of carapace

The nomenclature of the limb chaetotaxy mostly follows Broodbakker & Danielopol (1982), for the second antenna we follow the revised model proposed by Martens (1987), while for the second and third thoracopods, Meisch's nomenclature (2000) is followed. Higher taxonomy of the Ostracoda follows the synopsis by Horne *et al*. (2002).

Results

Taxonomic descriptions

Class Ostracoda Latreille, 1806
Subclass Podocopa G.W. Müller, 1894
Order Podocopida G.O. Sars, 1866
Suborder Cypridocopina Baird, 1845
Superfamily Cypridoidea Baird, 1845
Family Candonidae Kaufmann, 1900
Subfamily Candoninae Kaufmann, 1900

Genus ***Pseudocandona*** Kaufmann, 1900

Type species

Candona insculpta G.W. Mueller, 1900 (N.B. *Candona pubescens* Koch, 1837 is an unused senior synonym of this species).

Other congeneric species in South and Central America (Neotropical)

Pseudocandona antilliana Broodbakker, 1983; *Pseudocandona caribbeana* Broodbakker, 1983; *Pseudocandona cubensis* Broodbakker, 1983; *Pseudocandona geratsi* Broodbakker, 1983; *Pseudocandona annae* (Méhes, 1914) following Broodbakker (1983) and Karanovic & Datry (2009).

Diagnosis

Carapace variously shaped, usually relatively short and stout, rarely elongated or triangular in lateral view. Surface of adults valves smooth or pitted, usually with long, stiff and perpendicularly attached setae. LV overlaps RV. Setal group of the second segment of the mandibular palp with 3 to 5 setae (plus beta-seta). Basal segment of T3 with 3 setae (d1, d2 and dp), medial seta of penultimate segment always missing, terminal segment with one short (h1) and two long setae (h2 and h3). Hemipenis with at least three distal lobes (a, b, h).

Remarks

1. All three new species described here have a group of 4 ventral setae (+ 1 β-seta) on the second segment of the Md-palp. In addition, claws G1 and GM of the A2 (in females) and claws G2, GM and z1 (in males) are long. The combination of these characters places the three new species in the *caribbeana*–group of the genus according to the scheme of Namiotko & Danielopol (2004). See the general discussion of the present paper for further discussion on this species group.
2. The genus *Pseudocandona* is speciose, and most species occur in the Palaearctic and the Nearctic, including a large radiation in the ancient Lake Baikal (Siberia). In the differential diagnoses in the present paper we will only compare our new species to those already described from the Neotropical region, although of course their morphology was also checked against the Holarctic species of which good descriptions and illustrations are available.
3. *Pseudocandona agostinhoi* sp. nov. is described in full, the descriptions of the other two new species in this genus are abbreviated.

Pseudocandona agostinhoi sp. nov.
urn:lsid:zoobank.org:act:479455A1-91AD-4866-AADB-B8D6EB3892B1
Figs 2–5

"*Candona"* sp. 4 nov. sp. Higuti *et al.,* 2007: 1935.
"*Candona"* sp. 2 n. sp. Higuti *et al.*, 2009c: 664.
"*Candona"* sp. 2 n. sp. Higuti *et al*., 2010: 267.

Diagnosis

Carapace rather elongated in lateral view, and with LV overlapping RV on all sides, especially at anterior and posterior extremities. Anterior calcified inner lamella in both valves relatively broad. LV with anterior and posterior inner list, situated well away from the valve margin. Second segment of Md palp ventrally with 4 setae (+ 1 β-seta). Prehensile palps distally hook-like and set with two thin, sub-apical setae. Penultimate segment of T3 not divided; seta h1 slightly more than half the length of seta h2. Hemipenis with lobe a small and sub-quadrate, with rounded distal margin; lobes b and h largely overlapping, except on ventro-apical side, asymmetrically rounded and pointed towards the ventral side.

Etymology

The new species is named after Prof. Dr Angelo Antonio Agostinho (Nupelia, Universidade Estadual de Maringá, Maringá, Brazil), in recognition of his vast contributions to the knowledge on the biodiversity and the conservation of Brazilian freshwater environments, mainly in ichthyology, and also to acknowledge him for being one of the founders of Nupelia (Research Group in Limnology, Ichthyology and Aquaculture).

Type material

All type material was collected on 16 Jul. 2012 by JH and students, by washing roots of *Eichhornia crassipes* (PAR 710) in a bucket and by filtering the material in a hand net with mesh size 160 µm. See Table 1 for measurements of water chemistry at time of collecting.

Holotype

♂, with soft parts dissected in glycerine in a sealed slide, and with valves stored dry in a micropalaeontological slide (MZUSP 32653).

Allotype

♀, dissected and stored like the holotype (MZUSP 32654).

Paratypes

8 ♂♂ dissected and stored like the holotype (MZUSP 32655, MZUSP 32656, MZUSP 32657, MZUSP 32658, MZUSP 32659, OC.3302, OC.3306, OC.3307); three ♂ carapaces stored dry in micropalaeontological slides (MZUSP 32660, MZUSP 32661, OC.3304); eight ♀♀ dissected and stored like the holotype (MZUSP 32662, MZUSP 32663, MZUSP 32664, MZUSP 32665, MZUSP 32666, OC.3303, OC.3308, OC.3309); three ♀ carapaces stored dry in micropalaeontological slides (MZUSP 32667, MZUSP 32668, OC.3305).

Other material investigated

A ♂ (MZUSP 32669) and a ♀ (MZUSP 32670) carapace stored dry in micropalaeontological slides from Ventura Lake (PAR 1) and Pintado Lake (PAR 213), respectively, are also deposited in the Museu de Zoologia da Universidade de São Paulo, São Paulo.

Type locality

BRAZIL: Peroba Lake in Upper Paraná River floodplain in roots of the floating plant species *Eichhornia crassipes*. Coordinates: 22º54'39.4" S, 53º38'34.5" W.

Differential diagnosis

Pseudocandona agostinhoi sp. nov. can be distinguished from *P. geratsi* Broodbakker, 1983 by the shape of the valves (dorsal margin straight and oblique in the middle in *P.a.,* rounded in *P.g.*), of the hemipenis (lobe a with distal margin rounded in *P.a.*, straight in *P.g.*) and of the prehensile palps (Rpp evenly rounded in *P.a.*, with blunt angles in *P.g.*; Lpp more narrow and position of setae more distal in *P.a.*). *Pseudocandona antilliana* Broodbakkker, 1983 also has the middle part of the dorsal margin of the valves straight in the female, but running parallel to the ventral margin, not sloping as in *P. agostinhoi* sp. nov., while also in this species the distal margin of lobe a of the hemipenis is straight (rounded in *P. agostinhoi* sp. nov.). *Pseudocandona caribbeana* Broodbakker, 1983 and *P. cubensis* Broodbakkker, 1983 both have short and high carapaces, with straight dorsal margin parallel to the ventral margin, and with at least *P. caribbeana* with an anterior rostrum in dorsal view. Both of the latter species are known from females only.

Pseudocandona agostinhoi sp. nov. differs from *P. annae* (Mehes, 1914) in several aspects of its morphology. The latter species is more elongated with a longer straight section of the dorsal margin. In *P. agostinhoi* sp. nov., the LV overlaps the RV on all sides, and especially strongly along the anterior and posterior margins, whereas the overlap appears to be minimal according to the drawings by Mehes (1914). The Rpp has a fully rounded dorsal-distal part in *P. agostinhoi* sp. nov., whereas this has a straight margin in *P. annae*. Finally, lobes a, b and h of the hemipenis in *P. agostinhoi* sp. nov. are almost equally long, whereas lobe a is much shorter in *P. annae*.

Description of male

Carapace in right lateral view (Fig. 2C) rather elongated, showing LV overlapping RV on all sides, with larger overlap at both anterior and posterior extremities, external surface of valves smooth. Cp in dorsal and ventral views (Fig. 2D–E) lancet-shaped, sharply pointed anteriorly, more broadly so posteriorly, greatest width situated slightly behind the middle.

Valves (Fig. 2A–B) with greatest height situated behind the middle (and with a blunt angle there), posteriorly rather broadly rounded, anteriorly less so. RV and LV of similar shape; anterior calcified inner lamella more broadly rounded than posterior calcified inner lamella. LV with anterior and posterior inner lists, situated closely to valve margin, yet clearly separated from it.

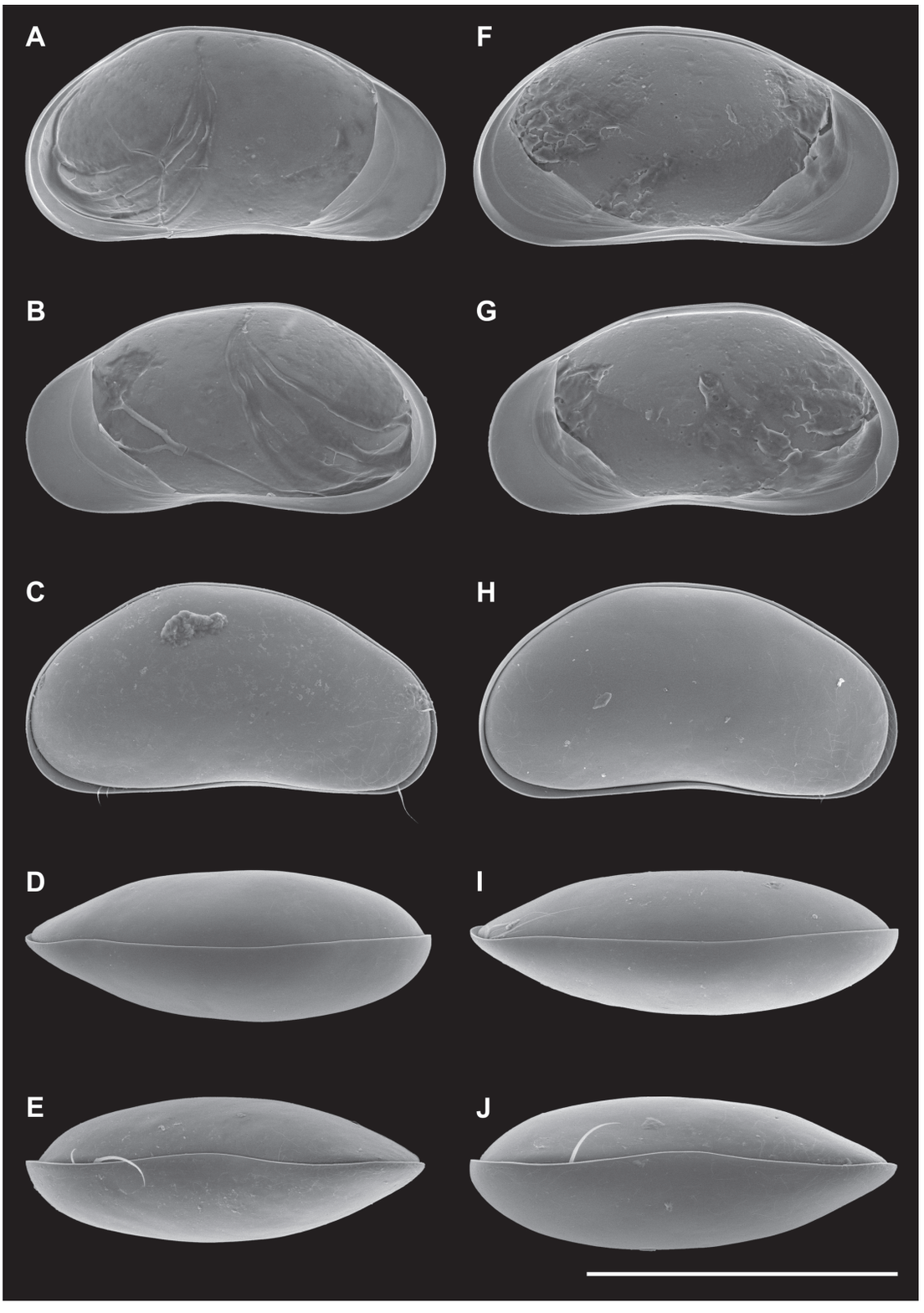

Fig. 2. Valves of *Pseudocandona agostinhoi* sp. nov. A–E ♂ and F–J ♀. **A, F**. LV, internal view (A = MZUSP 32655, F = OC. 3303). **B, G**. RV, internal view (B = MZUSP 32655, G = OC. 3303). **C, H**. Cp, right lateral view (C = MZUSP 32660, H = MZUSP 32667). **D, I**. Cp, dorsal view (D =MZUSP 32661, I = MZUSP 32668). **E, J**. Cp, ventral view (E = OC. 3304, J = OC. 3305). Scale bars: A–J = 500 μm.

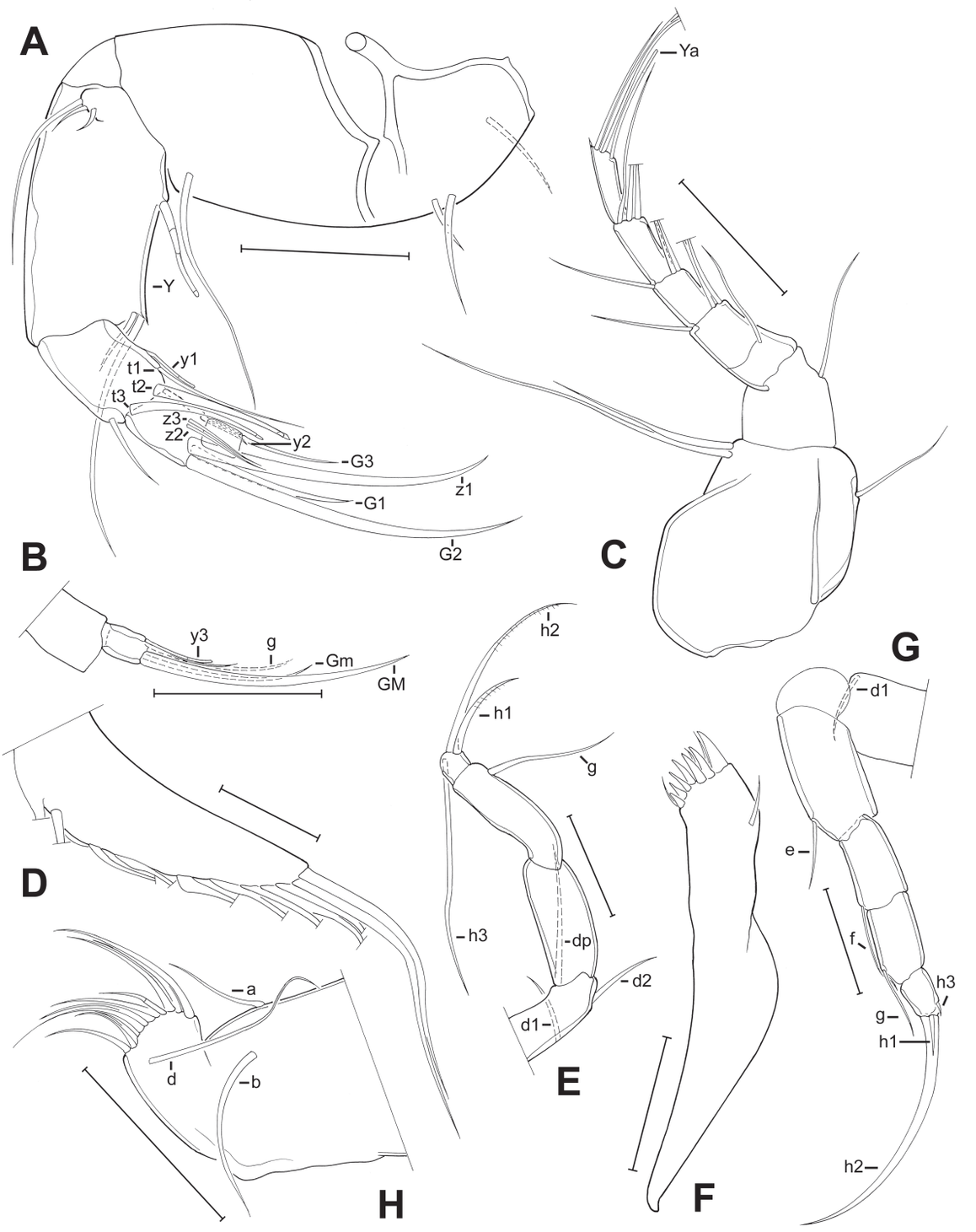

Fig. 3. Limbs of *Pseudocandona agostinhoi* sp. nov. (♂). **A**. A2 (MZUSP 32656). **B**. A2, detail of the last segment (MZUSP 32656). **C**. A1 (OC. 3302). **D**. Mx1, respiratory plate (OC. 3302). **E**. T3 (MZUSP 32655). **F**. Md, coxal plate (MZUSP 32653). **G**. T2 (MZUSP 32653). **H**. T1 (MZUSP 32653). Scale bars: A–H = 50 μm.

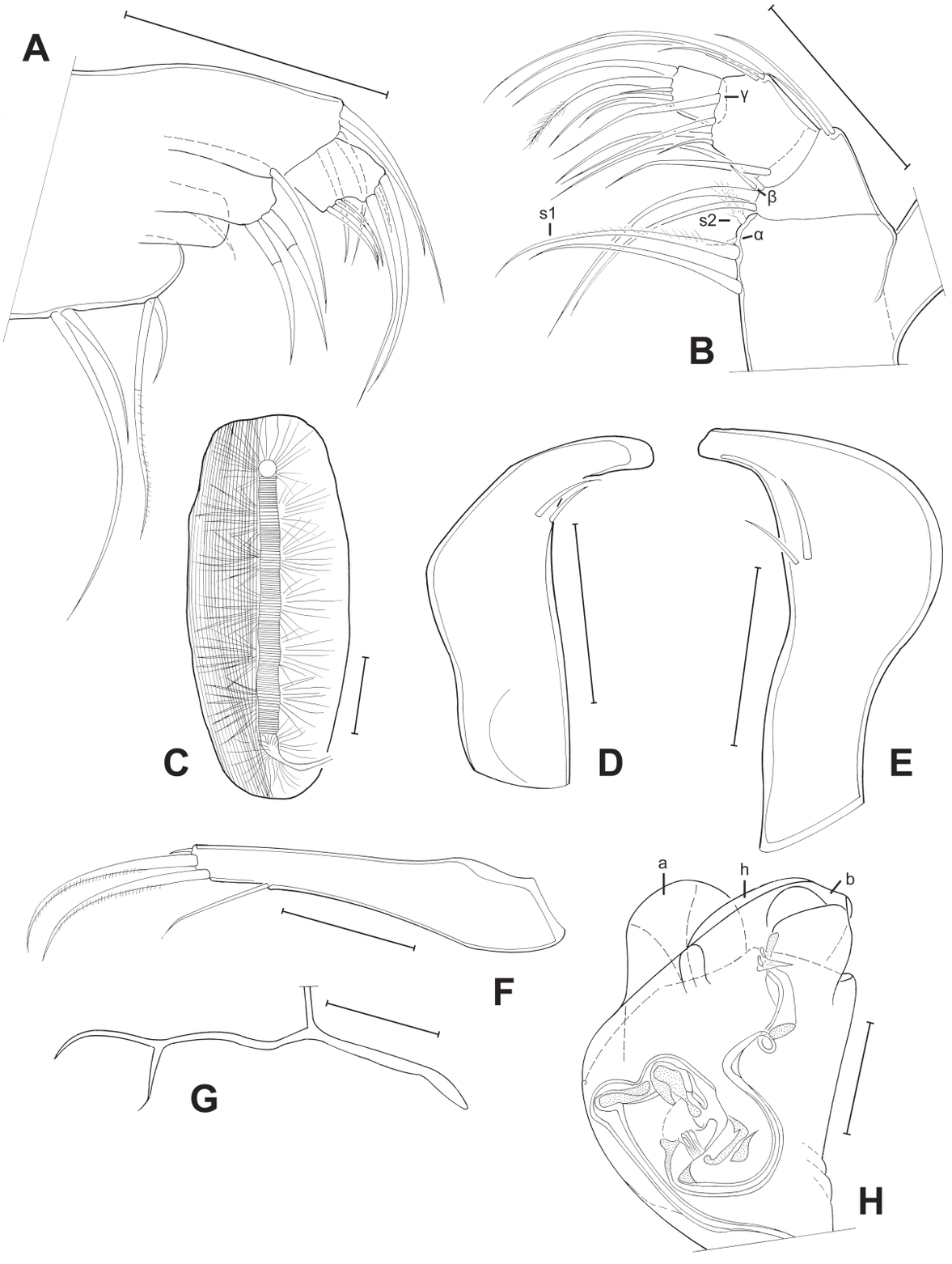

Fig. 4. Limbs of *Pseudocandona agostinhoi* sp. nov. (♂). **A**. Mx1 (MZUSP 32653). **B**. Md palp (MZUSP 32655). **C**. Zenker organ (MZUSP 32653). **D**. Right prehensile palp (MZUSP 32653). **E**. Left prehensile palp (MZUSP 32653). **F**. Caudal ramus (MZUSP 32653). **G**. Attachment of the caudal ramus (MZUSP 32653). **H**. Hemipenis (MZUSP 32653). Scale bars: A–H = 50 μm.

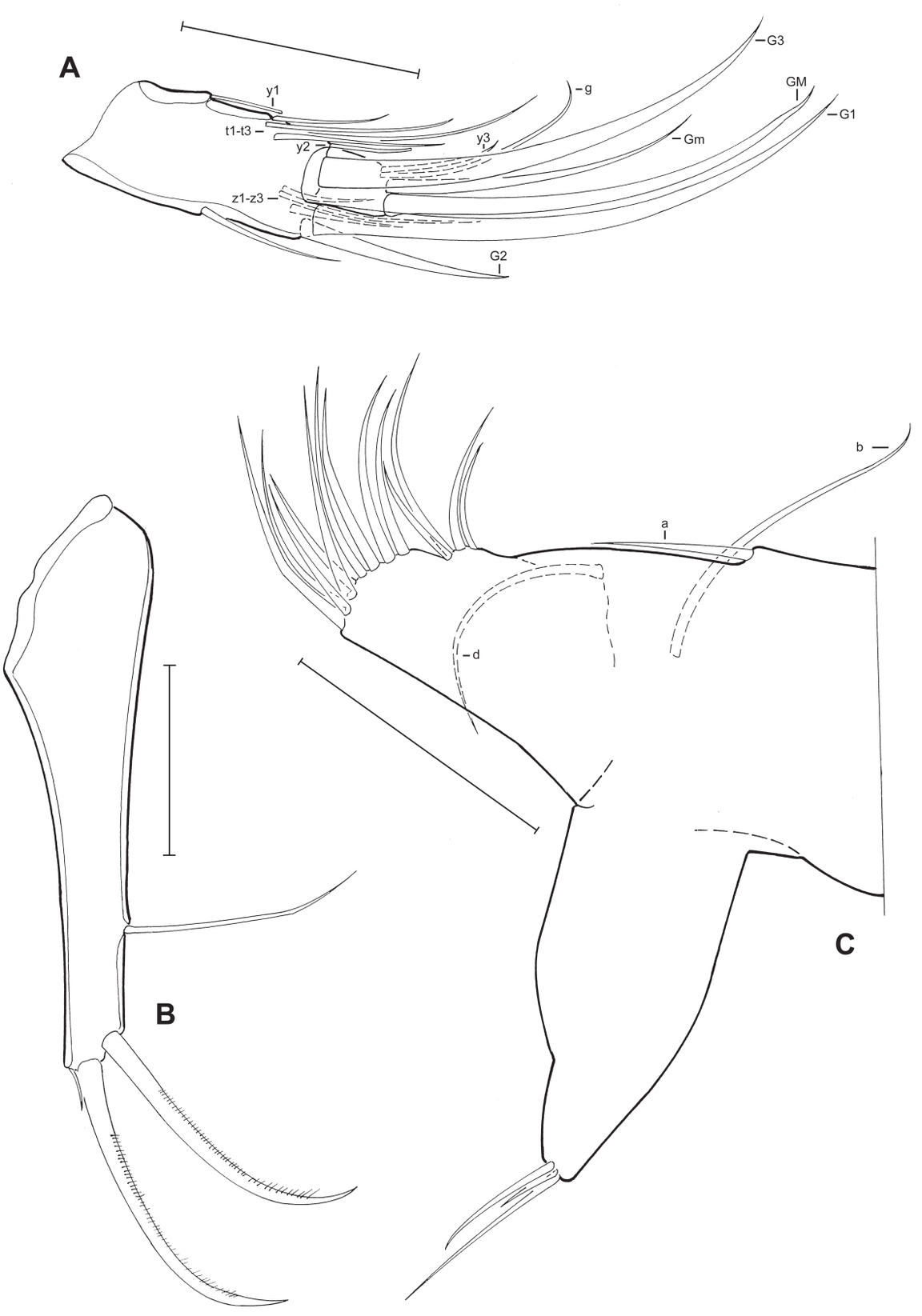

Fig. 5. Limbs of *Pseudocandona agostinhoi* sp. nov. (♀). **A**. A2, detail of the last segments (MZUSP 32654). **B**. Caudal ramus (MZUSP 32654). **C**. T1 (MZUSP 32654). Scale bars: A–C = 50 μm.

A1 (Fig. 3B) with basal segment with 2 relatively short dorsal setae, one at *ca.* mid-length, the other sub-apical, and two dorsal, sub-apical setae: one long, the other slightly longer than half the length of the first. Second segment with one dorso-apical seta (reaching beyond basis of fourth segment), no ventro-apical seta present. Third segment with one sub-apical dorsal set, reaching beyond basis of fourth segment, no ventral seta present. Fourth and fifth segments with two longer dorso-apical and 1 shorter ventro-apical setae. Sixth and seventh segments most elongate of all; sixth segment with two longer dorso-apical and one shorter ventro-apical setae. Seventh (terminal segment) slightly sinuous, bearing one short and two longer setae and one aesthetasc Ya, the latter shorter than the shorter seta.

A2 (Fig. 3A) with basal segment broad, wide and relatively long, basally with 2 unequal setae, one relatively long, the other *ca.* half as long as the first; one long ventro-apical seta also present. Remnant of exopod consisting of a short plate, with one long and two unequal shorter setae. Endopod consisting of 4 segments (penultimate segment divided). First endopodal segment long, carrying one long aesthetasc Y at the base of the ventral side, and one long and one short ventro-apical setae. Second endopodal segment shorter and smaller, rectangular with one ventral aesthetasc y1 inserted about mid length, 3 t-setae, with t1 almost same length as t2, t2 and t3 modified into male-bristles; dorso-apically with 1 seta. Third endopodal segment with apical chaetotaxy sexually dimorphic, with z1 and z3 being short setae, z2 being modified into a long claw; G2 a long claw, G1 a long seta and G3 a short seta, aesthetasc y2 short and ventro-apically inserted. Terminal (fourth) segment small (Fig. 3B), distally with claws GM (long) and Gm (short), aesthetasc y3 with its companion seta, fused at the basis and of unequal length, and seta g, longer than y3.

Md with coxa (Fig. 3F) relatively slender, distally set with a series of strong teeth.

Md-palp (Fig. 4B) consisting of 4 segments. Basal segment dorsally carrying the respiratory plate (not fully shown), ventro-apically with 2 long setae, 1 hirsute s1 seta, the other seta smooth, the minute alpha seta, and seta s2 short, stout and hirsute. Second segment dorso-apically with 2 setae of unequal length, ventro-apically with a group of 5 setae: 3 long, one shorter, and the short beta-seta. Third segment with a group of 3 smooth dorso-subapical setae (2 long and one shorter), a central group of two setae, the ventral-most one being the gamma seta, and ventro-apically with 2 smooth setae. Terminal segment sub-quadrate, apically set with two large claw-like setae, one distally hirsute and three shorter setae of unequal length.

Mx1 (Fig. 4A) with a basal (basipodite) part carrying a large respiratory plate (exopodite), 3 endites and a two-segmented palp (endopodite). Respiratory plate elongated, carrying more than 10 long respiratory rays (Fig. 3D). Palp with first segment carrying 3+1 apical setae; terminal segment short and broad, carrying 2 longer claws and 4 short setae (one shorter than the other). Chaetotaxy of three endites impossible to determine. Sideways directed bristles near first endite stout, one long and another short.

T1 (Fig. 3H) consisting of basal part (basipodite), carrying respiratory plate (not shown), a palp (endopodite, modified to prehensile palp in males) and an endite distally set with *ca.* 10 setae of different morphology and length. Basal plate set with one long and stout ‘b’-seta, a long and more slender ‘d’-seta and one ‘a’-seta. Prehensile palps (Figs 4D–E) distally hook-like and set with two, thin sub-apical setae; palps slightly asymmetrical, left prehensile palp (Fig. 4E) margin tightly rounded.

T2 (walking limb, Fig. 3G) with 4-segmented endopodite (penultimate segment divided) and elongated. First segment with short seta d1. Knee-segment devoid of seta d2. First segment of endopod elongated, with short ventro-apical seta. Second segment also with one short ventro-apical seta. Third segment with two ventro-apical setae, one short, one slightly longer. Terminal segment with one short apical and one short sub-apical seta and a long apical claw.

Table 3. Measurements of specimens of the three new species of *Pseudocandona* and two new species of *Candobrasilopsis* described in the present paper.

Species	V/Cp	Sex	Code	L (µm)	H (µm)	W (µm)	Sex	Code	L (µm)	H (µm)	W (µm)
Pseudocandona agostinhoi sp. nov.	LVi	♂	MZUSP 32655	676	346		♀	OC. 3303	683	356	
	RVi			658	341				659	342	
	CpRl		MZUSP 32660	661	341			MZUSP 32667	673	348	
	CpD		MZUSP 32661	654		243		MZUSP 32668	690		229
	CpV		OC.3304	644		232		OC.3305	688		244
Pseudocandona cillisi sp. nov.	LVi	♂	MZUSP 32681	699	384		♀	MZUSP 32672	709	393	
	RVi			673	372				683	396	
	CpRl		MZUSP 32671	676	374			MZUSP 32678	750	399	
	CpD		OC.3362	683		268		OC.3364	720		300
	CpV		MZUSP 32677	698		276		MZUSP 32680	743		302
Pseudocandona claudinae sp. nov.	LVi						♀	MZUSP 32683	678	344	
	RVi								666	339	
	CpRl							MZUSP 32684	693	348	
	CpD							MZUSP 32684	696		232
	CpV							MZUSP 32684	698		234
Candobrasilopsis elongata sp. nov.	LVi	♂	MZUSP 32687	991	436		♀	MZUSP 32686	978	415	
	RVi			970	432				953	408	
	CpRl		MZUSP 32690	960	425			MZUSP 32699	917	401	
	CpD		MZUSP 32692	976		255		MZUSP 32696	929		245
	CpV		MZUSP 32691	954		253		MZUSP 32697	938		250
Candobrasilopsis acutis sp. nov.	LVi	♂	-				♀	MZUSP 32701	888	384	
	RVi		-						877	385	
	CpRl		MZUSP 32700	880	396			MZUSP 32706	859	370	
	CpD		MZUSP 32704	855		233		MZUSP 32707	865		226
	CpV		OC.3358	886		236		OC.3360	838		236

T3 (cleaning limb, Fig. 3E) as typical of the family. First segment with three setae, one short medial (d1), one short subapical (d2) and one long apical (dp). Second segment without seta. Penultimate segment with one long subapical seta (g). Terminal segment carrying three setae: 2 long, one of which hirsute (h2 and h3), and one short and hirsute (h1).

Caudal ramus (= furca, Fig. 4F) with stout ramus and two stout apical claws. Long proximal setae, distal seta a small spine. Attachhment to caudal ramus (Fig. 4G) long and stout, distally bifurcated and with additional lateral branch at *ca.* mid-length. Length ratio ramus / largest claw = 1.92.

Hemipenis (Fig. 4H) relatively small, with lobe a short, and with distal margin rounded, lobes b and h largely overlapping, reaching about as far as lobe a, but asymmetrially pointing towards the ventral side. Labyrinth with first (ascending) branch long, thin and slender; post-labyrinthal spermiduct S-shaped and simple.

Zenker organ (Fig. 4C) short and broad, with at least 5 spinous whorls.

Description of female

Valves (Fig. 2F–G) similar to those in the male; Cp (Fig. 2H) in lateral view with bigger overlap at the anterior extremity; Cp in D and V views (Figs 2I–J) equally narrow and lancet-shaped, in V view highlighting the overlap.

Soft parts (Fig. 5) largely as in the male, but with sexually dimorphic A2 and T1.

A2 (Fig. 5A) with setae t1-4 setae like, not transformed; z1and z3 short and slender setae, z2 longer and slender. Claws G1, G3 and GM all reaching to about the same point and claw G2 short.

T1 (Fig. 5C) with basal part as in the male and an endite distally set with *ca.* 13 setae of different morphology and length. Endopod a broad palp, with three unequal setae.

Caudal ramus (Fig. 5B) with stout ramus and two stout apical claws. Long proximal setae, distal seta a small spine. Length ratio ramus / largest claw = 1.79.

Measurements

See Table 3.

Pseudocandona cillisi sp. nov.
urn:lsid:zoobank.org:act:DC713AC3-23AA-4056-AE25-020DD6A1257C
Figs 6–7

"*Candona"* sp. 1 n. sp. Higuti *et al.*, 2009c: 664.
"*Candona"* sp. 1 n. sp. Higuti *et al*., 2010: 267.

Diagnosis

Valves small, high and short in lateral view. Anterior calcified inner lamella in both valves relatively broad; posterior calcified inner lamella very narrow. Second segment of Md palp with 4 setae. Prehensile palps distally hook-like, relatively short and set with one sub-apical spine and one sub-apical setae. Penultimate segment of T3 not divided; seta h1 *ca*. ⅓ of the length of seta h2. Hemipenis with lobe a short and broad, distal margin only slightly rounded, lobes b and h almost completely overlapping, asymmetrically rounded and pointed towards the ventral side.

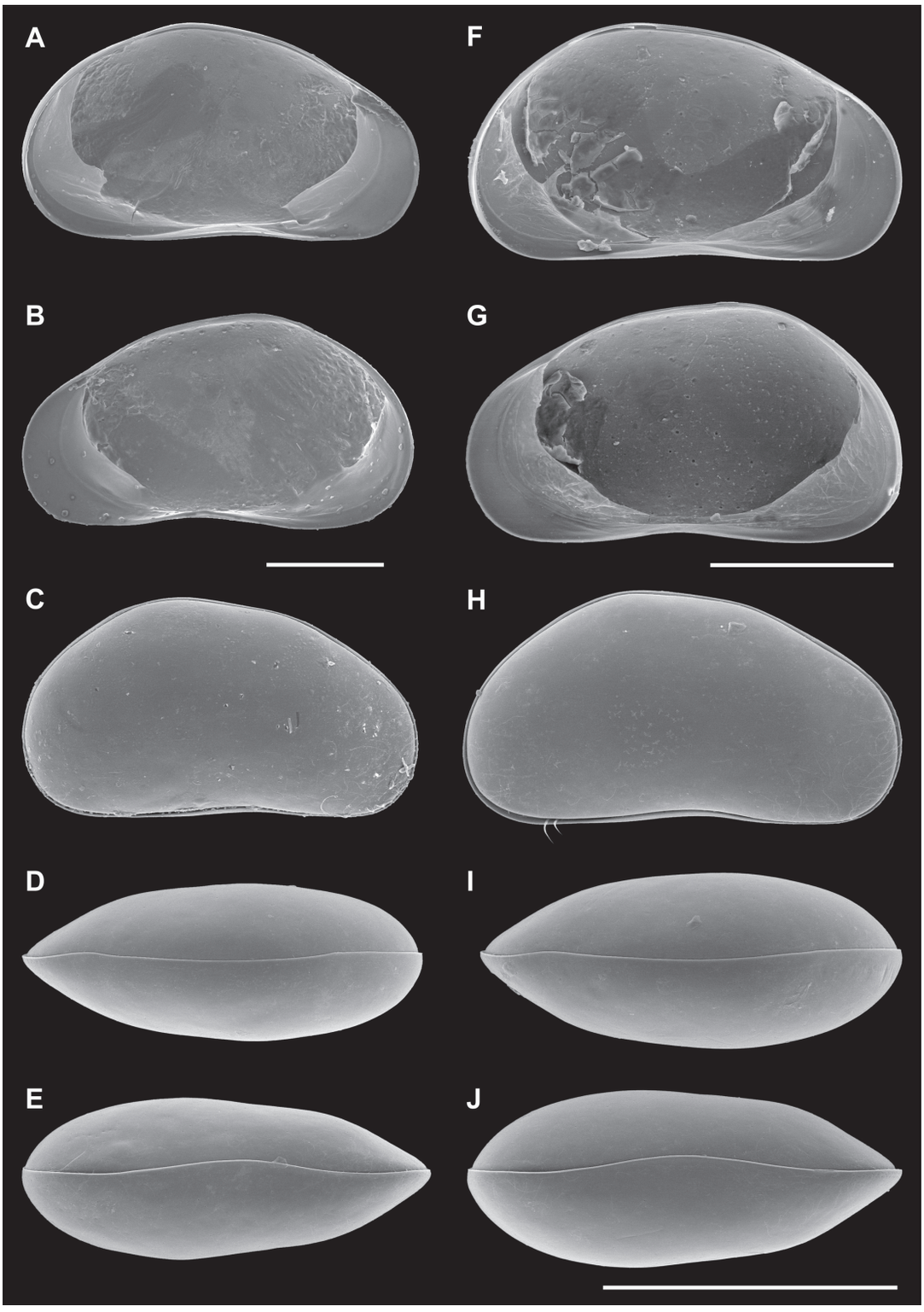

Fig. 6. Valves of *Pseudocandona cillisi* sp. nov. A–E ♂ and F–J ♀. **A, F**. LV, internal view (A = MZUSP 32681, F = MZUSP 32672). **B, G**. RV, internal view (B = MZUSP 32681, G = MZUSP 32672). **C, H**. Cp, right lateral view (C = MZUSP 32671, H = MZUSP 32678). **D, I**. Cp, dorsal view (D = OC. 3362, I = OC.3364). **E, J**. Cp, ventral view (E = MZUSP 32677, J = MZUSP 32680). Scale bars: A–B = 200 μm; C–E, H–J = 500 μm; F–G = 300 μm.

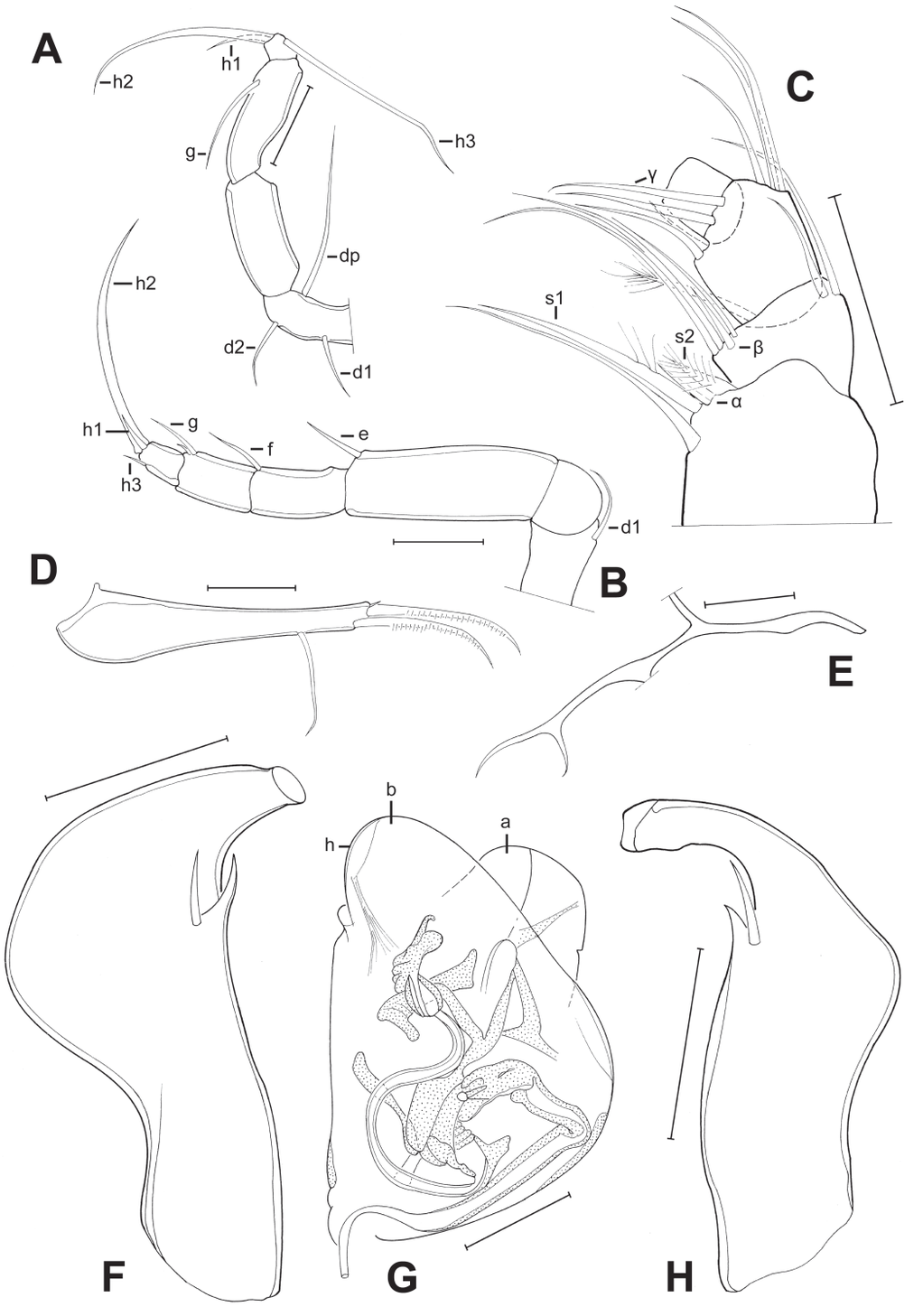

Fig. 7. Limbs of *Pseudocandona cillisi* sp. nov. (♂). **A**. T3 (MZUSP 32673). **B**. T2 (MZUSP 32673). **C**. Md palp (MZUSP 32673). **D**. Caudal ramus (MZUSP 32673). **E**. Attachment of the caudal ramus (MZUSP 32673). **F**. Left prehensile palp (MZUSP 32673). **G**. Hemipenis (MZUSP 32673). **H**. Right prehensile palp (MZUSP 32673). Scale bars: A–H = 50 μm.

Etymology

The new species is named in honour of Julien Cillis (RBINS), in recognition of his continuous technical assistance with the scanning electron microscopy (SEM) images of ostracod valves at RBINS for more than 2 decades.

Type material

All type material was collected on 7 Nov. 2004 by the authors, by washing roots of floating plants (PAR 150) in a bucket and the material was filtered in a hand net with mesh size 160 µm. See Table 1 for measurements of water chemistry at time of collecting.

Holotype

♂ carapace stored dry in a micropalaeontological slide (MZUSP 32671).

Allotype

♀, with soft parts dissected in glycerine in a sealed slide, and with valves stored dry in a micropalaeontological slide (MZUSP 32672).

Paratypes

A ♂ dissected,with LV stored dry in a micropalaeontological slide (OC. 3363); four ♂♂ dissected and with the valves lost (MZUSP 32673, MZUSP 32674, MZUSP 32675, MZUSP 32676); two ♂ carapaces stored dry in micropalaeontological slides (MZUSP 32677, OC. 3362); four ♀ carapaces stored dry in micropalaeontological slides (MZUSP 32678, MZUSP 32679, MZUSP 32680, OC. 3364).

Other material investigated

A ♂ dissected, with soft parts lost and with valves stored dry in a micropalaeontological slide (MZUSP 32681) from Baía River (PAR 195) is also deposited in the Museu de Zoologia da Universidade de São Paulo, São Paulo.

Type locality

BRAZIL: Aurélio Lake in Upper Paraná River floodplain in a mix of floating macrophyte species. Coordinates: 22º41'36.5" S, 53º13'52" W.

Differential diagnosis

Pseudocandona cillisi sp. nov. has valves which are much shorter and higher than those of *P. geratsi* and *P. antilliana*, while the (straight) dorsal margin is much more sloping than in *P. caribbeana* and *P. cubensis*. The new species also differs from *P. annae* Mehes, 1914 in the shape of the valves, which are more elongated in the latter species.

Description of male

Valves (Fig. 6A–B) small, high and short in lateral view, with greatest height situated behind the middle (and bluntly pointed there), anteriorly and posteriorly rather broadly rounded, RV and LV of highly similar shape; anterior calcified inner lamella broadly rounded, posterior calcified inner lamella narrow and narrower towards the dorsal side.

Carapace in right lateral view (Fig. 6C) showing LV overlapping RV slightly on all sides; anteriorly and posteriorly widely beyond the RV, external surface of valves smooth.

In dorsal view (Fig. 6D), carapace lancet-shaped, sharply pointed in the anteriorly, more broadly so posteriorly, greatest width situated well behind the middle.

Carapace also in ventral view (Fig. 6E) lancet-shaped, with anterior side more acutely pointed than posterior side, in V view with slight rostrum.

Md-palp (Fig. 7C) consisting of 4 segments. Basal segment dorsally carrying the respiratory plate (not shown), ventro-apically with 2 long setae (only one hirsute = s1), the alpha seta and a short , stout and hirsute seta s2. Second segment dorso-apically with 2 setae of unequal length, ventro-basally with a short, stout and hirsute seta and ventro-apically with a group of 5 setae: 2 long setae, 2 shorter (one hirsute), and the short beta-seta. Third segment with a group of 3 smooth dorso-subapical setae of unequal length, a central group of two setae, one of which being the gamma seta, and a ventro-apical group of 2 smooth setae. Terminal segment subquadrate, chaetotaxy as in *P. agostinhoi* sp. nov.

T1: Prehensile palps (Fig. 7F, H) distally hook-like and set with two unequal sub-apical setae; palps slightly asymmetrical, robust left prehensile palp (Fig. 7F) margin tightly rounded.

T2 (walking limb - Fig. 7B) with 4-segmented endopodite (penultimate segment divided) and elongated. First segment with short seta d1. Knee-segment devoid of seta d2. First segment of endopod elongated, with short ventro-apical seta. Second segment also with one short ventro-apical seta. Third segment with two ventro-apical setae, one short, one slightly longer. Terminal segment with one short apical and one short sub-apical seta and a long apical claw.

T3 (cleaning limb, Fig. 7A) as typical of the family. First segment with three setae, one short medial (d1), one short subapical (d2) and one long apical (dp). Second segment without seta. Penultimate segment with one long subapical seta (g). Terminal segment carrying three setae: 2 long (h2 and h3) and one very short (h1).

Caudal ramus (furca, Fig. 7D) with stout ramus and two stout apical claws. Long proximal setae, distal seta a small spine. Attachment to caudal ramus (Fig. 7E) long and stout, distally bifurcated and with 2 additional lateral branches. Length ratio ramus / largest claw = 2.0.

Hemipenis (Fig. 7G) relatively small, with lobe a short and broad, distal margin only slightly rounded, lobes b and h almost completely overlapping, asymmetrically rounded and pointed towards the ventral side. Labyrinth with first (ascending) branch long, thin and slender; post-labyrinthal spermiduct S-shaped and simple.

Description of female

Valves (Fig. 6F–G): Cp in lateral view (Fig. 6H) and in D and V views (Fig. 6I–J) similar to those in the male.

Measurements

See Table 3.

Pseudocandona claudinae sp. nov.

urn:lsid:zoobank.org:act:198F7F5F-49D0-4883-845A-386E0CAA4970

Figs 8–9

Diagnosis

Valves in lateral view elongated and with dorsal margin rounded, greatest height situated well behind the middle; anterior calcified inner lamella in both valves broader than very narrow posterior calcified inner lamella. Carapace in dorsal and ventral views relatively narrow; LV overlapping RV on all sides.

Seta h1 less than half the length (*ca*. ⅓) of seta h2. Caudal ramus with distal seta clearly developed, not spine-like.

Etymology

The new species is named in honour of Claudine Behen (RBINS), in recognition of her continued technical assistance with the line drawings of ostracod limbs over many years at RBINS.

Type material

All type material was collected on 4 Oct. 2012 by the authors and students, by hand net with mesh size 160 μm. See Table 1 for measurements of water chemistry at time of collecting.

Holotype

♀, with soft parts dissected in glycerine in a sealed slide, and with valves stored dry in a micro-palaeontological slide (MZUSP 32682).

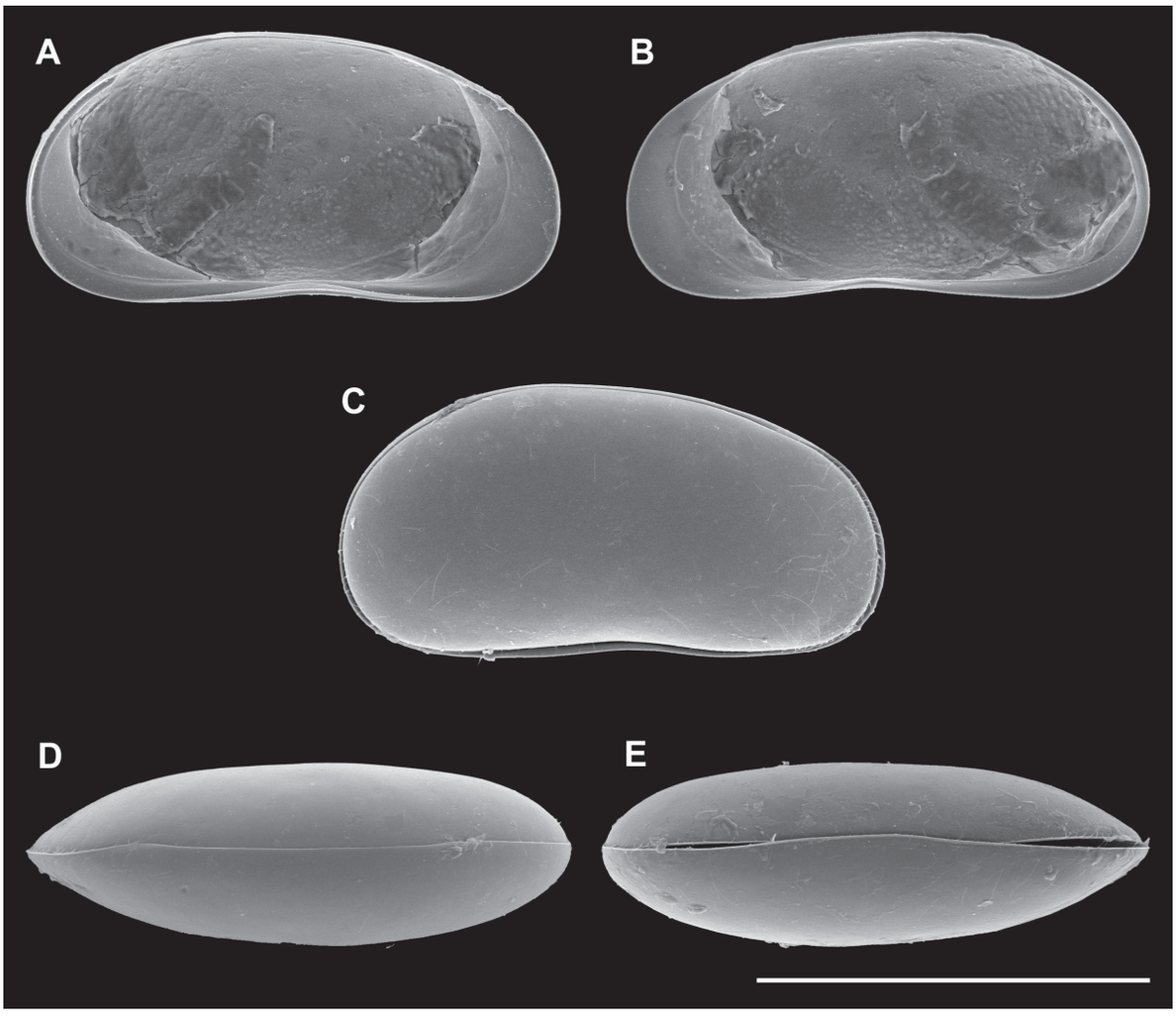

Fig. 8. Valves of *Pseudocandona claudinae* sp. nov. (♀). **A**. LV, internal view (MZUSP 32683). **B**. RV, internal view (MZUSP 32683). **C**. Cp, right lateral view (MZUSP 32684). **D**. Cp, dorsal view (MZUSP 32684). **E**. Cp, ventral view (MZUSP 32684). Scale bars: A–E = 500 μm.

Paratypes

3 ♀♀ dissected and stored like the holotype (MZUSP 32683, OC3365, OC3366); a ♀ carapace stored dry in micropalaeontological slides (MZUSP 32684).

Type locality

BRAZIL: Matagal Stream in Upper Paraná River floodplain in sediment amongst grasses and other terrestrial vegetation in very shallow water (named littoral in Table 1). Coordinates: 22º54'26.4" S, 53º32'27.7" W.

Differential diagnosis

Pseudocandona claudinae sp. nov. can be distinguished from *P. antilliana, P. caribbeana* and *P. cubensis* by the elongated shape of the valves and the rounded dorsal margin. *Pseudocandona claudinae* sp. nov. appears to be closely related to *P. geratsi*, but the female valves of *P. claudinae* sp. nov. resemble those of the males in *P. geratsi*, while the female valves in this latter species are shorter and higher than those of the male. As no males of *P. claudinae* sp. nov. are known, the copulatory appendages cannot be

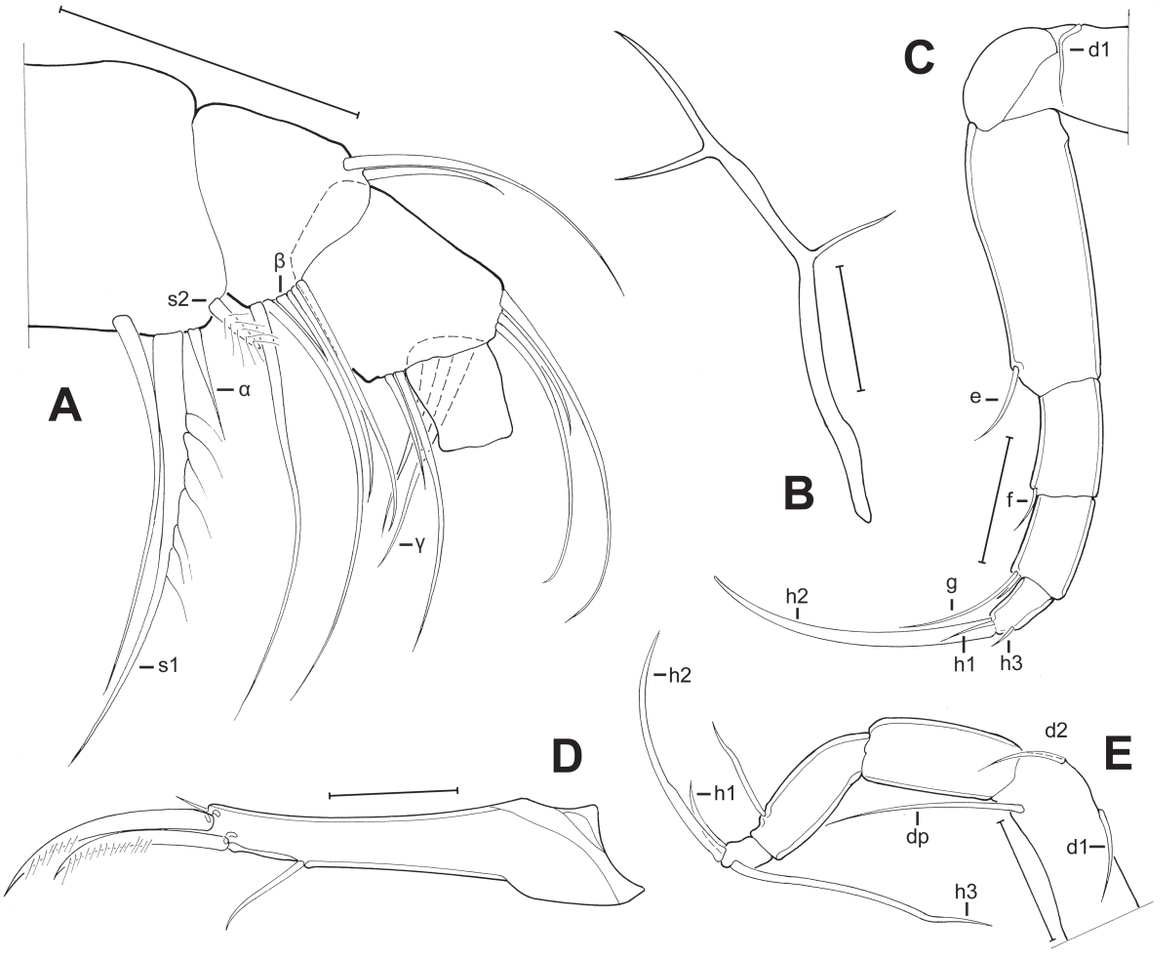

Fig. 9. Limbs of *Pseudocandona claudinae* sp. nov. (♀). **A**. Md palp (MZUSP 32682). **B**. Attachment of the caudal ramus (MZUSP 32682). **C**. T2 (MZUSP 32682). **D**. Caudal ramus (MZUSP 32682). **E**. T3 (MZUSP 32682). Scale bars: A–E = 50 μm.

compared. In addition, the attachment of the caudal ramus in *P. geratsi* has two lateral branches, whereas there is only one in *P. claudinae* sp. nov.

Pseudocandona claudinae sp. nov. differs from *P. annae* by the more elongated valves, with a dorsal margin which is fully rounded (with a straight part in *P. annae*).

Description of female

Valves (Fig 8A–B) small and short, with greatest height situated behind the middle. Anteriorly and posteriorly rather broadly rounded, RV and LV of highly similar shape; anterior calcified inner lamella broadly rounded, posterior calcified inner lamella very narrow and almost disappearing towards the dorsal side.

Carapace in right lateral view (Fig. 8C) showing LV overlapping RV slightly on all sides; external surface of valves smooth. In lateral view dorsally more rounded.

In dorsal view (Fig. 8D), carapace lancet-shaped, sharply pointed anteriorly, more broadly so posteriorly.

Carapace in ventral view (Fig. 8E) lancet-shaped, with anterior side more acutely pointed than posterior side.

Md-palp (Fig. 9A) consisting of 4 segments. Basal segment dorsally carrying the respiratory plate (not shown), ventro-apically with 2 long setae (only one hirsute (= s1), the thin and smooth alpha seta and a short and stout hirsute seta (= s2). Second segment dorso-apically with 2 setae of unequal length, ventro-basally with a short, stout and hirsute seta and ventro-apically with a group of 5 setae: 2 long setae, 2 shorter, and the short and beta-seta. Third segment with a group of 3 dorso-subapical setae of unequal length, all smooth, a central group of two setae, one of which being the gamma seta, and a ventro-apical group of 2 setae, one long and one short, both smooth. Terminal segment subquadrate, chaetotaxy as in *P. agostinhoi* sp. nov.

T2 (walking limb, Fig. 9C) with 4-segmented endopodite (penultimate segment divided) and elongated. First segment with short seta d1. Knee-segment devoid of seta d2. First segment of endopod elongated, with short ventro-apical seta. Second segment also with one short ventro-apical seta. Third segment with two ventro-apical setae, one short, one very long. Terminal segment with one short apical and one short sub-apical seta and a long apical claw.

T3 (cleaning limb, Fig. 9E) as typical of the family. First segment with three setae, one short medial (d1), one short subapical (d2) and one long apical (dp). Second segment without seta. Penultimate segment with one long subapical seta (g). Terminal segment carrying three setae: 2 long (h2 and h3) and one very short (h1).

Caudal ramus (furca, Fig. 9D) with stout ramus and two stout apical claws. Long proximal setae, distal seta a small spine. Attachment to caudal ramus (Fig. 9B) long and stout, distally bifurcated and with additional lateral branch at *ca.* mid-length.

Male unknown

Measurements

See Table 3.

Genus ***Candobrasilopsis*** Higuti & Martens, 2012

Type species

Candobrasilopsis rochai Higuti & Martens, 2012

Other species

Candobrasilopsis acutis sp. nov.; *C. brasiliensis* (Sars, 1901); *C. elongata* sp. nov.

Diagnosis

Anterior calcified inner lamella broad, anterior inner margin sinuous, posterior calcified inner lamella narrow, posterior inner margin running parallel to valve margin. Terminal Md-palp segment short (L ≤ 1.5 x basal width). Prehensile palps one-segmented, base inflated, distal finger long, hook-like. Hemipenis of triangular type, without protruding lobes a and b. Caudal ramus without proximal seta, distal seta reduced to a small spine.

Remarks

As the genus was characterised by a full description of its type species, *C. rochai*, by Higuti & Martens (2012b), the descriptions of the following two new species are shortened.

Candobrasilopsis elongata sp. nov.
urn:lsid:zoobank.org:act:197FB8BE-2703-4FA6-97CA-2D40A8342325
Figs 10–11

Candonopsis sp. 3 n. sp. in Higuti *et al*., 2009c: 664.
Candonopsis sp. 3 n. sp. in Higuti *et al*., 2010: 267.

Diagnosis

A species with very elongated valves, greatest height well behind the middle; in lateral view with dorsal margin straight for more than half the total length. Anterior calcified inner lamella in both valves broad, almost ¼ of total length and with inner margin sinuous, not parallel to valve margin. Both valves externally set with elongated micro-ridges.

Prehensile palps one-segmented. Right prehensile palp set with two subequal and robust lateral setae. Left prehensile palp larger and more elongated, with hook-like distal part, distal tip slightly swollen. Hemipenis atypical of the genus, with leaf-like lobe ls, distally rounded and proximally narrowing, lobe ms broad, distally with almost straight margin, ventro-distally bluntly pointed.

Etymology

The present species is named after the very elongated carapace.

Type material

All type material was collected on 2 Feb. 2011 by JH and students, by washing roots of *Eichhornia crassipes* (PAR 461) in a bucket and by filtering the material in a hand net with mesh size 160 µm. See Table 1 for measurements of water chemistry at time of collecting.

Holotype

♂, with soft parts dissected in glycerine in a sealed slide, and with valves stored dry in a micro-palaeontological slide (MZUSP 32685).

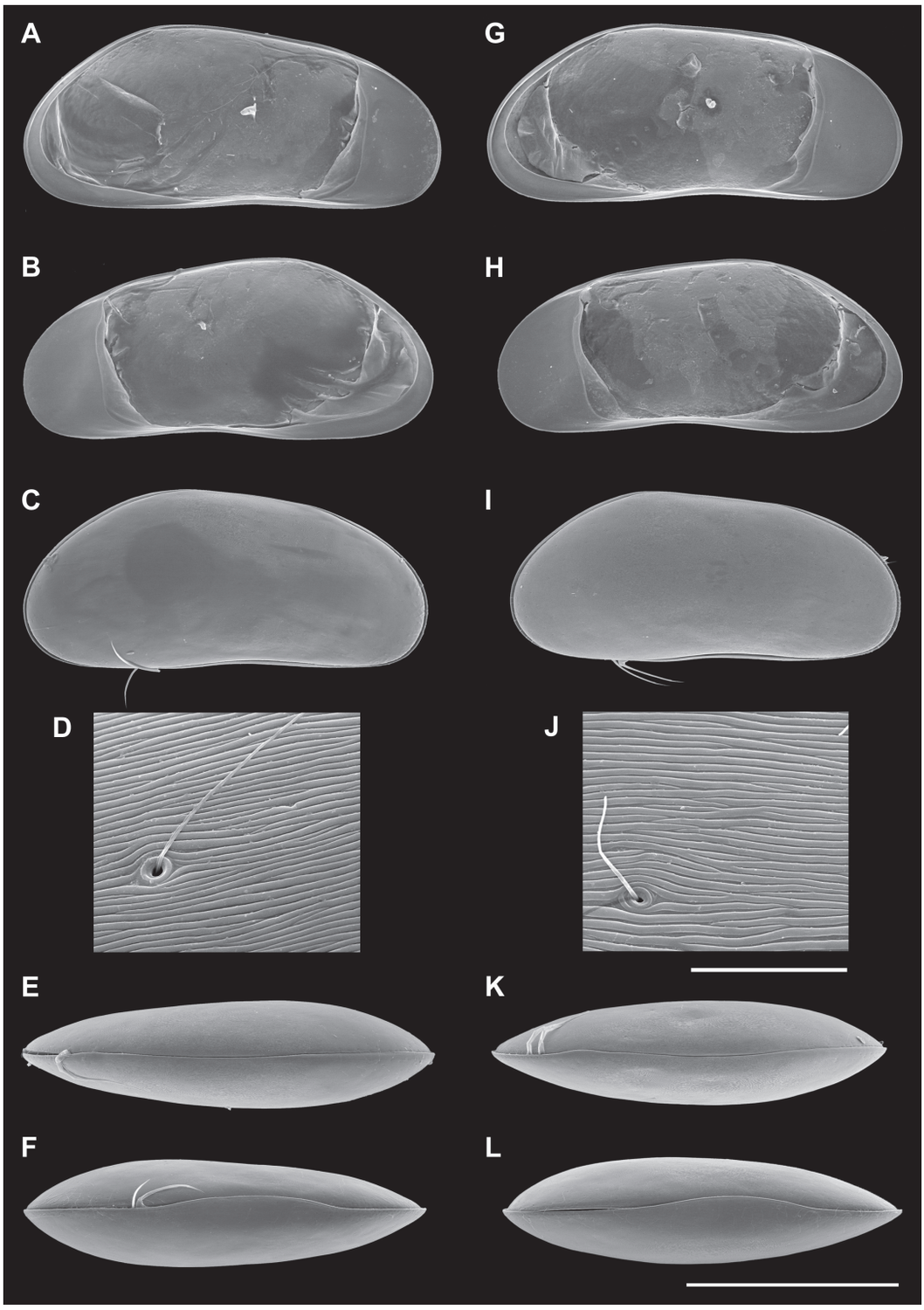

Fig. 10. Valves of *Candobrasilopsis elongata* sp. nov. A–F ♂ and G–L ♀. **A, G**. LV, internal view (A = MZUSP 32687, G = MZUSP 32686). **B, H**. RV, internal view (B = MZUSP 32687, H = MZUSP 32686). **C, I**. Cp, right lateral view (C = MZUSP 32690, I = MZUSP 32699). **D, J**. Cp, right lateral view detail (D = MZUSP 32690, J = MZUSP 32699). **E, K**. Cp, dorsal view (E = MZUSP 32692, K = MZUSP 32696). **F, L**. Cp, ventral view (F = MZUSP 32691, L = MZUSP 32697). Scale bars: A–C, E–I, K–L = 500 μm; D, J = 20 μm.

Allotype

A ♀, dissected and stored like the holotype (MZUSP 32686).

Paratypes

Five ♂♂ dissected and stored like the holotype (MZUSP 32687, MZUSP 32688, MZUSP 32689, OC. 3353, OC. 3354); three ♂ carapaces stored dry in micropalaeontological slides (MZUSP 32690, MZUSP 32691, MZUSP 32692); five ♀♀ dissected and stored like the holotype (MZUSP 32693, MZUSP 32694, OC. 3355, OC. 3356, OC. 3357) and a ♀ dissected with valves lost (MZUSP 32695); four ♀ carapaces

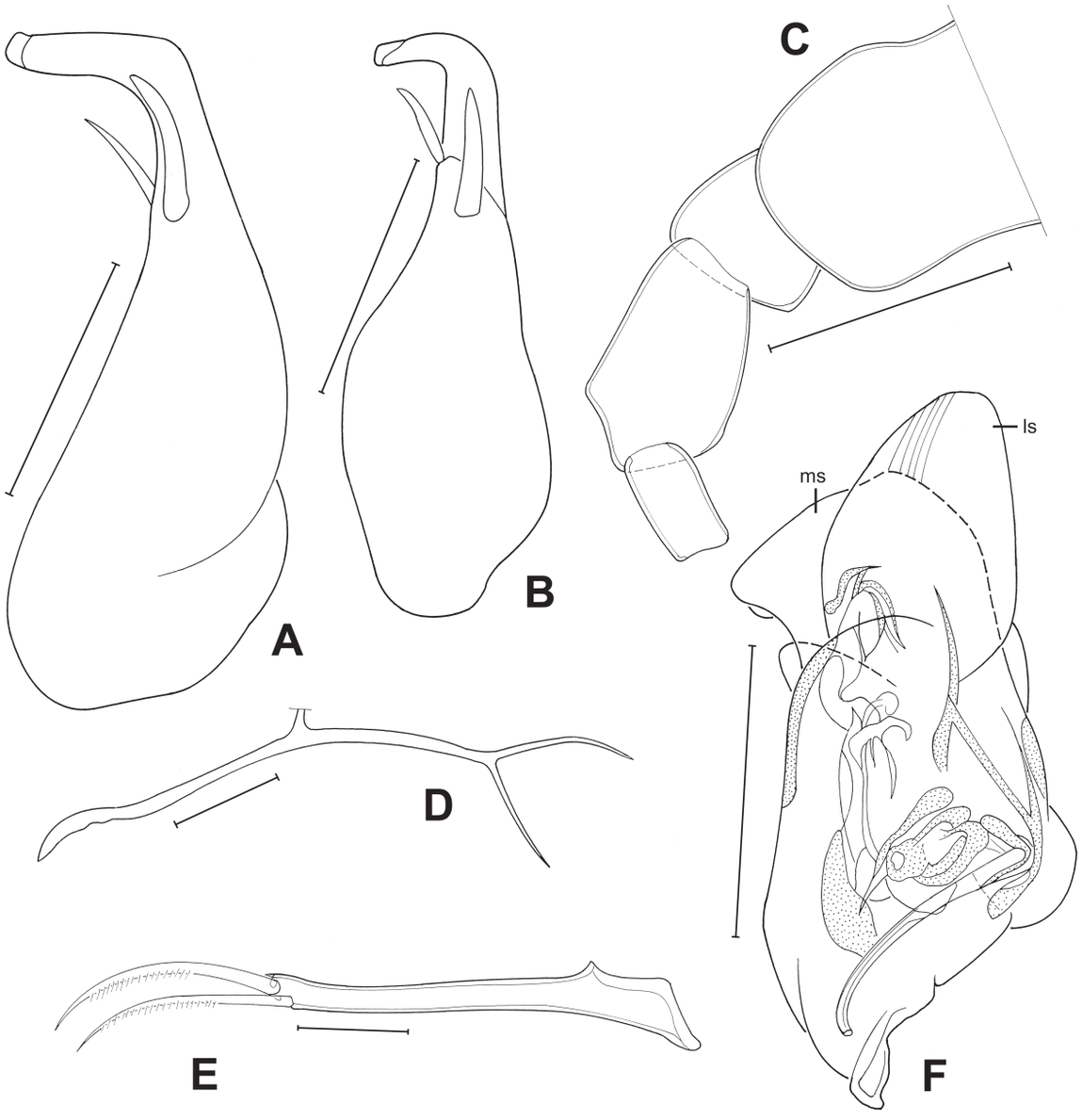

Fig. 11. Limbs of *Candobrasilopsis elongata* sp. nov. (♂). **A**. Left prehensile palp (MZUSP 32685). **B**. Right prehensile palp (MZUSP 32685). **C**. Md palp (MZUSP 32685). **D**. Attachment of the caudal ramus (MZUSP 32685). **E**. Caudal ramus (MZUSP 32685). **F**. Hemipenis (MZUSP 32685). Scale bars: A–E = 50 μm; F = 100 μm .

stored dry in micropalaeontological slides (MZUSP 32696, MZUSP 32697, MZUSP 32698, MZUSP 32699).

Type locality

BRAZIL: Patos Lake in Upper Paraná River floodplain in floating plants (*E. crassipes*). Coordinates: 22º49'48.2" S, 53º33'20.3" W.

Differential diagnosis

Candobrasilopsis elongata sp. nov. differs from *C. rochai* and *C. brasiliensis* by the more elongated shape of the valves, and from *C. acutis* sp. nov., which also has elongated valves, by the presence of external micro-ridges on the valves. *Candobrasilopsis elongata* sp. nov. can be distinguished from its three congeners by the atypical hemipenis, which has a lobe ls with rounded (not pointed) distal margin, and a lobe ml with almost straight distal margin (not rounded).

Description of male

Carapace in right lateral view (Fig. 10C) showing LV overlapping RV slightly on all sides. Carapace, in dorsal (Fig. 10E) and ventral views (Fig. 10F), narrow and lancet-shaped, with anterior and posterior side pointed, greatest width situated well behind the middle.

Both valves (Fig. 10A–B) very elongated, with greatest height situated behind the middle (and bluntly pointed there), anteriorly rather broadly and posteriorly rather narrowly rounded, RV and LV of highly similar shape; anterior calcified inner lamella broadly rounded, posterior calcified inner lamella very narrow and almost disappearing towards the dorsal side; inner margin of anterior calcified inner lamella slightly sinuous in both valves. External surface of both valves striated (Fig. 10D).

A1, A2, Mx1, T1-3 as typical of the genus and not illustrated.

Md-palp (Fig. 11C) consisting of 4 segments, terminal segment short (L ≤ 1.5 x basal width).

Prehensile palps (Fig. 11A–B) one-segmented, distally hook-like and set with two unequal and robust, sub-apical setae; both palps slightly asymmetrical, left prehensile palp (Fig. 11A) basally slightly more swollen.

Caudal ramus (Fig. 11E) with stout ramus and two stout apical claws. Proximal setae missing, distal seta a small spine. Attachment to caudal ramus (Fig. 11D) long and stout, distally bifurcated and with additional lateral branch at *ca.* mid-length. Length ratio ramus / largest claw = 1.85.

Hemipenis (Fig. 11F) atypical of the genus, with lobe ls leaf-like, distally rounded and proximally narrowing, lobe ms broad, distally with almost straight margin, ventro-distally bluntly pointed; an additional small ventral lobe present proximal of lobe ms. Internal labyrinth short and stout, postlabyrinthal spermiduct narrow and straight; internal copulatory process stout, beak-like and sharply pointed.

Description of female

Valves (Fig. 10G–H) and Cp (Fig. 10I–J) in lateral view similar to those in the male. Cp in D and V views (Fig. 10K–L) equally narrow and lancet-shaped, with anterior and posterior side pointed.

Soft parts as typical of the genus and, except for sexually dimorphic ones, similar to those of the male.

Measurements

See Table 3.

Candobrasilopsis acutis sp. nov.
urn:lsid:zoobank.org:act:2894DAF9-9CF7-4A60-B25F-6ED4BFEF8E09
Figs 12–13

Diagnosis

A species with very elongated valves, greatest height well behind the middle; carapace in lateral view with weakly rounded dorsal margin, nearly straight. Anterior calcified inner lamella in both valves broad, almost ⅕ of total length and with inner margin sinuous, not parallel to valve margin. External valve surface smooth, devoid of ridges.

Both prehensile palps one-segmented. Right prehensile palp with distal part curved, distal tip slightly expanded, set with two subequal lateral setae. Left prehensile palp narrower and more elongated, with hook-like distal part, distal tip slightly swollen. Hemipenis with triangular and sharply pointed lobe ls.

Etymology

Named after "pointed" (Latin = acutis). The shape of lobe ls of the hemipenis is triangular and distally very pointed.

Type material

All type material was collected on 4 Oct. 2012 by the authors and students, by hand net with mesh size 160 µm. See Table 1 for measurements of water chemistry at time of collecting.

Holotype

♂ carapace stored dry in a micropalaeontological slide (MZUSP 32700).

Allotype

♀, with soft parts dissected in glycerine in a sealed slide, and with valves stored dry in a micropalaeontological slide (MZUSP 32701).

Paratypes

A ♂ with soft parts dissected in glycerine in a sealed slide and with LV stored dry in a micropalaeontological slide (OC. 3359); two ♂♂ dissected and with the valves lost (MZUSP 32702, MZUSP 32703); two ♂ carapaces stored dry in micropalaeontological slides (MZUSP 32704, OC. 3358); a ♀ with soft parts dissected in glycerine in a sealed slide and with LV stored dry in a micropalaeontological slide (MZUSP 32705); a ♀ with soft parts dissected in glycerine in a sealed slide and with the valves lost (OC. 3361); three ♀ carapaces stored dry in micropalaeontological slides (MZUSP 32706, MZUSP 32707, OC. 3360).

Type locality

BRAZIL: Matagal Stream in Upper Paraná River floodplain in sediment amongst grasses and other terrestrial vegetation in very shallow water (named littoral in Table 1). Coordinates: 22º54'26.4" S, 53º32'27.7" W.

Differential diagnosis

Candobrasilopsis acutis sp. nov. is characterized by the shape of both prehensile palps and especially by the very pointed lateral shield of the hemipenis, by which it can easily be distinguished from the other three species in the genus. The shape of the valves of *C. acutis* sp. nov. is quite similar to those of *C. elongata* sp. nov., but *C. acutis* sp. nov. lacks the clear external striation of the latter species (compare Figs 10D, J with 12D, H).

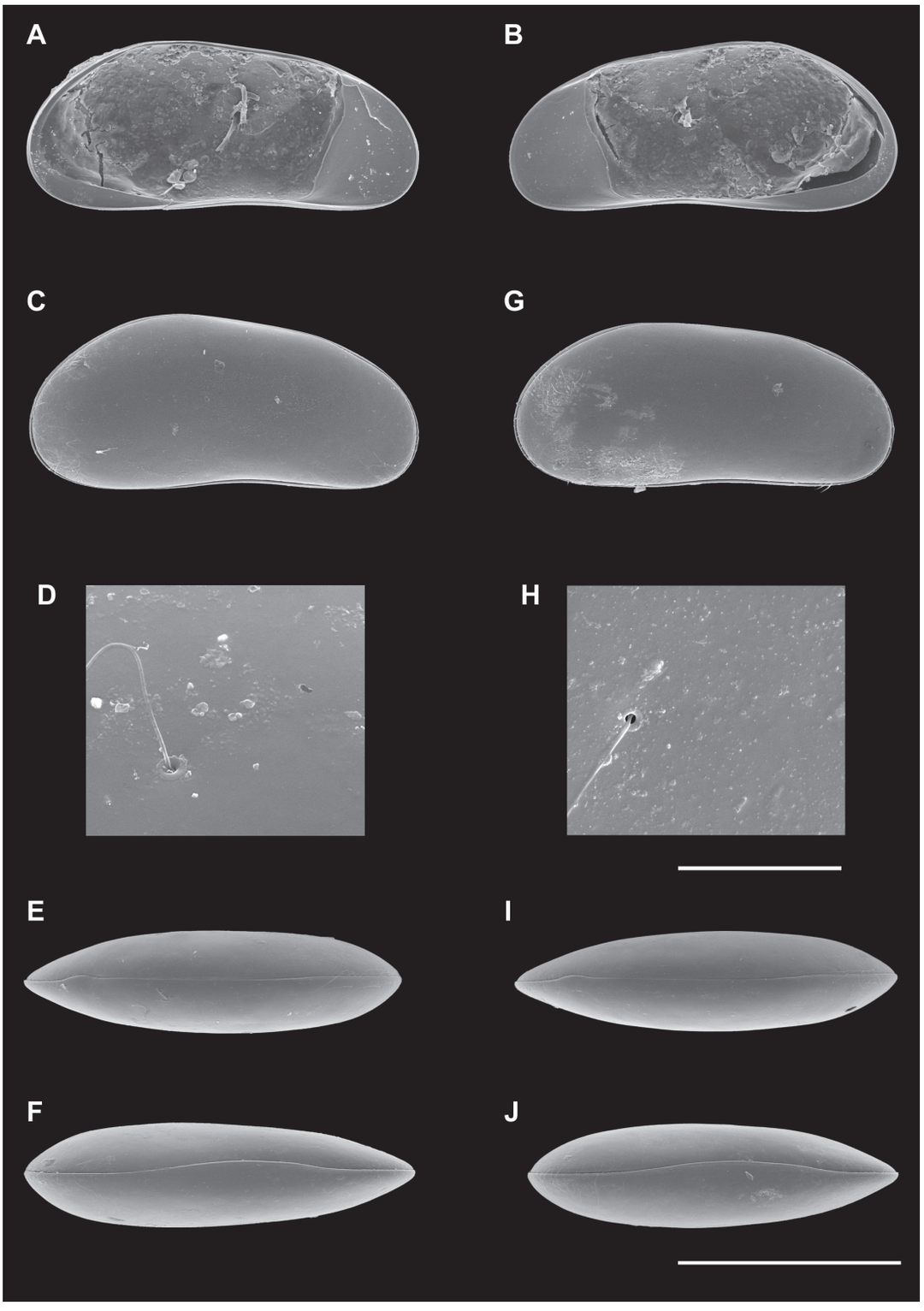

Fig. 12. Valves of *Candobrasilopsis acutis* sp. nov. C–F ♂ and A–B, G–J ♀. **A**. LV, internal view. (MZUSP 32701) **B**. RV, internal view (MZUSP 32701). **C, G**. Cp, right lateral view (C = MZUSP 32700, G = MZUSP 32706). **D, H**. Cp, right lateral view, detail (D = MZUSP 32700, H = MZUSP 32706). **E, I**. Cp, dorsal view (E = MZUSP 32704, I = MZUSP 32707). **F, J**. Cp, ventral view (F = OC. 3358, J = OC. 3360). Scale bars: A–C, E–G, I–J = 500 μm; D, H = 20 μm.

Description of male

Carapace very elongated in right lateral view (Fig. 12C), with greatest height situated behind the middle, anteriorly and posteriorly broadly rounded; LV overlapping RV slightly on all sides; external surface of valves smooth (Fig. 12D). In dorsal view (Fig. 12E) and ventral view (Fig. 12F) carapace lancet-shaped, sharply pointed anteriorly, more broadly so posteriorly.

Internal valve anatomy as in the female (see below).

A1, A2, Mx1, T1-3 as typical of the genus and not illustrated.

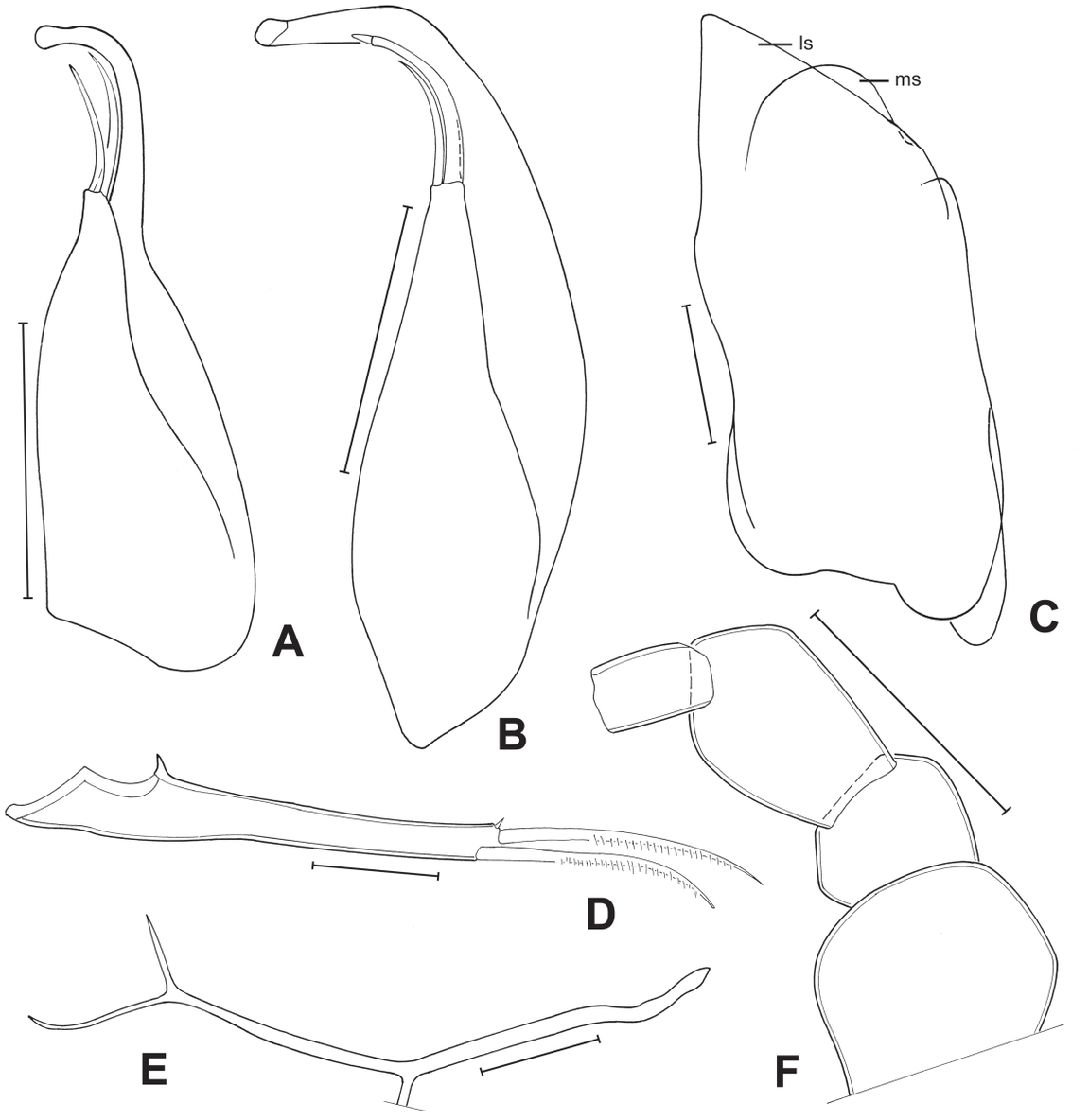

Fig. 13. Limbs of *Candobrasilopsis acutis* sp. nov. (♂). **A**. Right prehensile palp (MZUSP 32703). **B**. Left prehensile palp (MZUSP 32703). **C**. Hemipenis (MZUSP 32703). **D**. Caudal ramus (MZUSP 32703). **E**. Attachment of the caudal ramus (MZUSP 32703). **F**. Md palp (MZUSP 32703). Scale bars: A–F = 50 μm.

Md-palp (Fig. 13F) consisting of 4 segments, terminal segment short (L ≤ 1.5 x basal width).

Prehensile palps (Fig. 13A–B) both segmented, distally hook-like and set with two unequal, sub-apical setae; palps slightly asymmetrical, right prehensile palp (Fig. 13A) basally slightly more swollen and with distal hook-like expansion apically swollen.

Caudal ramus (furca, Fig. 13D) with stout ramus and two stout apical claws. Proximal setae missing, distal seta a small (hirsute) spine. Attachment to caudal ramus (Fig. 13E) long and stout, distally bifurcated and with additional lateral branch at *ca.* mid-length. Length ratio ramus / largest claw = 1.84.

Hemipenis (Fig. 13C) typical of the genus, with small and rounded ms and very pointed, triangular ls.

Description of female

Valves (Fig. 12A–B) very elongated, with greatest height situated behind the middle, anteriorly and posteriorly broadly rounded; RV and LV of highly similar shape; anterior calcified inner lamella broadly rounded, posterior calcified inner lamella very narrow and almost disappearing towards the dorsal side; inner margin of anterior calcified inner lamella slightly sinuous in both valves.

Carapace in right lateral (Fig. 12G), dorsal (Fig. 12I) and ventral views (Fig. 12J) similar to those in the male.

Soft parts as typical of the genus and, except for sexually dimorphic ones, similar to those of the male.

Measurements

See Table 3.

Discussion

Taxonomy of *Pseudocandona* and *Typhlocypris*

Vejdovsky (1882) erected *Typhlocypris* as a subgenus of *Cypris* to accommodate the distinct species *Cypris eremita* Vejdovsky, 1880, while Kaufmann (1900) established the genus *Pseudocandona* for the species *Candona pubescens* Koch, 1837. For historical reasons, the species *Cypris eremita* was transferred to *Pseudocandona* and *Typhlocypris* became an unused senior synonym (Danielopol 1978; Meisch 2000). Karanovic (2005) synonymised the whole of *Pseudocandona* with the older taxon *Typhlocypris*, simply because the older name has priority over the more recent name following the ICZN. Whereas this was technically correct, the name *Pseudocandona* was so well-used at that stage that this move was not in the interest of nomenclatorial stability. For some time, this created an uneasy and confusing situation.

Meisch (2000) foreshadowed a solution, by suggesting that the *eremita*-group of *Pseudocandona* has a clearly distinct morphology, sufficient to consider it a genus separate from *Pseudocandona*.

Namiotko *et al*. (2014) meanwhile have indeed reinstated *Typhlocypris* as a separate genus for the *eremita*-lineage, while Danielopol *et al*. (2012) have created the genus *Marmocandona* for the *zschokkei*-species group in *Pseudocandona*. We follow this position and maintain all other species groups for the time being within *Pseudocandona*, although, as foreshadowed by Danielopol (1978), at least the *Pseudocandona* species of the Siberian Lake Baikal will eventually have to be transferred to a new genus.

For a full discussion on the taxonomic and nomenclatorial history of *Typhlocypris* and *Pseudocandona*, see Namiotko *et al*. (2014).

Taxonomic position of *Candona annae* Mehes, 1914

Broodbakker (1983) described four species in the genus *Pseudocandona* from the West Indies and also transferred the Columbian species *Candona annae* Mehes, 1914 to this genus, albeit implicitly. Mehes (1914, fig. 10d) had indeed illustrated four long setae (small beta setae not drawn) on the second segment of the Md-palp, which falls within the diagnosis of this genus. Furtos (1936) provided excellent illustrations of a single male specimen from Florida that she referred to this species, but which had a fairly different lobe "a" on the hemipenis and with the second segment of the Rpp being almost evenly rounded. Furtos (1935) described *P. annae* var *septentrionalis* from Massachusetts, mainly differing from the Florida specimen by the presence of a distal seta on the caudal ramus and the absence of a fused zone in the valves. Valve shape, and shape of hemipenis and of the prehensile palps are similar in both forms described by Furtos.

According to Broodbakker (1983), the specimen reported by Furtos (1936) from Florida was in fact not *P. annae*, but a different species, possibly closely related to either his *P. geratisi*, or more likely *P. antilliana*. Later on in the same paper, he wrote that the Florida male of Furtos (1936) could very well belong to *P. antilliana*. Broodbakker further mentioned that also *P. elliptica* (Furtos, 1933) from Ohio is closely related to *P. antilliana*. Broodbakker did not comment on the position of *P. annae septentrionalis* (Furtos, 1935).

Karanovic (2006) transferred *P. annae* to the re-instated genus *Typhlocypris* Vejdovsky, 1882. Karanovic (2005) explicitly transferred *P. geratsi* Broodbakker (1983) to *Typhlocypris*, while Karanovic & Datry (2009) also moved *P. caribbeana* Broodbakker, 1983 to *Typhlocypris*, but did not mention the position of the other *Pseudocandona* species described by Broodbakker (1983) in their list of South and Central American candonids. As outlined above, *Typhlocypris* now only comprises the old '*P. eremita*' group, so none of the South and Central American species belong to this genus.

Karanovic (2006) provided a redescription of *P. a. septentrionalis*, based on one of the original dissections of a male by Furtos, and synonymised it with *P. annae s.s.* At the same time, Karanovic (loc.cit.) also sank *P. antilliana* Broodbakker, 1983 into the synonymy of *P. annae*. Strangely enough, the caudal ramus, originally illustrated by Furtos (1935) with a clear distal seta, one of the major characters of this form, lacks this seta in the illustration by Karanovic (2006).

Finally, Karanovic (2005) illustrated *P. cf. geratsi* (in *Typhlocypris*, *sic*) from interstitial waters near Perth, Western Australia, but also illustrated some aspects of the morphology of the holotype of *P. geratsi* Broodbakker, 1983, including a hemipenis in erection, not illustrated by Broodbakker (loc.cit.). Such a wide distribution for a candonid species would be highly unusual, though of course not impossible.

In conclusion, we here maintain *P. annae* and *P. antillana* as separate species, with the male from Florida most likely belonging to the latter species. The positions of *P. annae septentrionalis* (Furtos, 1935) and of the Australian species *P. cf. geratsi* remain uncertain.

Taxonomic position of the presently described *Pseudocandona* species

With the *eremita*-group now back in *Typhlocypris* and the *zschokkei*-group allocated to *Marmocandona*, *Pseudocandona* now comprises species from the *compressa-, rostrata-, prespica-* and the *caribbeana*-groups (according to Namiotko & Danielopol 2004), together with the Lake Baikal species flock. Namiotko & Danielopol (2004) allocated *P. caribbeana* and *P. cubensis* to a separate species group (the *caribbeana*-group), but *P. antilliana* and *P. geratsi* to the *rostrata*-group within the genus. Nevertheless, both *P. geratsi* and *P. antilliana* have 4 ventral setae (plus beta-seta) on the second segment of the Md-palp, and thus belong with *P. caribbeana* and *P. cubensis* to the same species group, which is not the *rostrata*-group of which the species have 3 setae plus the beta seta there. Namiotko & Danielopol (2004,

Table 4. Re-appraisal of the homology of claws and setae on two species in the *P. caribbeana* group, based on Broodbakker (1983) and Martens (1987), NA = not applicable.

	Female		Male	
Species	**Modern nomenclature**	**Morphology**	**Nomenclature in Broodbakker 1983**	**Morphology**
P. agostinhoi sp. nov.	G2	short claw	NA	long claw
	G1	long claw	NA	short claw
	G3	long claw	NA	short claw
	GM	long claw	NA	long claw
	z1	short seta	NA	long claw
	z2	medium seta	NA	short seta
	z3	short seta	NA	short seta
P. antilliana	G2	short claw	G1	longest claw
	G1	long claw	G2	short claw
	G3	long claw	z1	short claw
	GM	long claw	GM	long claw
	z1	short claw?	G3	long claw
	z2	medium seta	z2	short seta
	z3	short seta	z3	medium seta

table 2) provided an alternative set of characters to distinguish between the different species groups in *Pseudocandona*, namely by looking at the length of claws on the A2, relative to the combined lengths of the second and third segments of the endopod. Also here, the new species fall well into the range of the species of the *caribbeana*-group (including *P. geratsi* and *P. antiliana*). For example, the ratio G1 / E2+3 in females is 1.6–1.9 for the *caribbeana*-group, and 1.68 for *P. agostinhoi* sp. nov.; the ratio GM / E2+3 in females is 1.3–1.5 for the *caribbeana*-group and 1.38 for *P. agostinhoi* sp. nov.

One potential pitfall in interpreting the illustrations of Broodbakker (1983) is the use of different nomenclature for the claws and setae on the A2. Martens (1987) demonstrated that, in the sexual dimorphism in A2-chaetotaxy, form and shape of the claws and setae can change dramatically, but relatively position does not. The work by Broodbakker (1983) predates this finding, and thus setae and claws were named based on appearance, not on relative position. Table 4 corrects this situation and homologizes Broodbakker's nomenclature with the modern one. In doing so, the close relationship between our and Broodbakker's species becomes even more clear.

There are some small differences that need further investigation. For example, the reduced seta s2 on the Md-palp is *ca.* twice as long in *P. antilliana* as in *P. agostinhoi* sp. nov., while the seta z1 in the female is illustrated as a short claw in *P. antilliana* (Broodbakker 1983, fig. 4D), which would be unusual in females.

In all, however, the three new species here allocated to *Pseudocandona* appear to belong in one lineage with the four species described by Broodbakker (1983), which, following Namiotko & Danielopol (2004), we here continue to name the *caribbeana*-group.

From a zoogeographical point of view, uniting these seven species into one lineage, and maybe including also others like *P. annae*, seems logical.

Ecology

The five new species of candonids were found in 23 localities in the alluvial valley of the Upper Paraná River. The most common species of the five newly described here is *Candobrasilopsis elongata* sp. nov., which was recorded from 16 localities; *Pseudocandona agostinhoi* sp. nov. was found in nine localities, *P. cillisi* sp. nov. in six, and *C. acutis* sp. nov. and *P. claudinae* sp. nov. were only recorded in one, and the same, locality.

The latter two new species were found in sediments (named littoral in Table 1) of the Matagal stream, with pH 6.2, a low value of dissolved oxygen (1.73 mg L^{-1}) and a high value of electrical conductivity (179.9 µS cm^{-1}). At the time of collecting, the surface water available was less than $1m^2$, and only a few mm of standing water hidden by many grasses could be sampled.

Candobrasilopsis elongata sp. nov., was recorded in localities with pH values ranging between 4.7 and 7.2, electrical conductivity between 25.8 and 49.6 µS cm^{-1} and dissolved oxygen between 0.14 and 8.3 mg L^{-1}. The predominant type of substrate in which this species was found was *Eichhornia crassipes*.

Pseudocandona agostinhoi sp. nov. occurred in both types of substrate, namely littoral and *Eichhornia crassipes*, with pH values ranging between 5.4 and 6.9, electrical conductivity between 28.1 and 64.1 µS cm^{-1} and dissolved oxygen between 0.9 and 7.2 mg L^{-1}. Finally, *P. cillisi* sp. nov. was found in environments with pH values ranging between 4.9 and 6.1, electrical conductivity between 27.0 and 41.8 µS cm^{-1} and low values of dissolved oxygen, between 1.0 and 4.5 mg L^{-1}. Also this species was predominant in *Eichhornia crassipes*.

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