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Additional morphological information on *Dipteropeltis hirundo* Calman, 1912, and a description of *Dipteropeltis campanaformis* n. sp. (Crustacea: Branchiura) from two characiform benthopelagic fish hosts from two Northern rivers of the Brazilian Amazon

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Abstract

Dipteropeltis is a monotypic genus of the Branchiura and endemic to South America. Twelve specimens of *Dipteropeltis* sp. and micrographs of a thirteenth specimen were obtained from four institutions. Measurements and light micrographs were taken of all the specimens. The specimens were compared to all known descriptions of *D. hirundo* and sorted into two groups, those that conformed to the description of *D. hirundo*; and those that differed morphologically. Two specimens, one from each group¸ were stained with lignin pink and subsequently prepared for Scanning Electron Microscopy. The differences observed in the specimens indicated that a new species exists. Thus, *Dipteropeltis campanaformis* n. sp. is described from seven specimens collected from two characiform benthopelagic fish species and compared to *D. hirundo*. *Dipteropeltis campanaformis* **n. sp.** differs from *D. hirundo* in the head shape, the length and shape of the carapace lobes, the membrane composition of the maxillules, the shape of the maxillae, the shape of the mouth, and the shape of the natatory lobes.

Key words: South America, parasite, morphology, description

Introduction

The genus *Dipteropeltis* Calman, 1912 is the only monotypic genus in the subclass Branchiura (Piasecki & Avenant-Oldewage 2008) and also the only branchiuran endemic to South America (Malta 1998).

Dipteropeltis hirundo Calman, 1912 was first described from four specimens collected in southern Brazil, in the region of Matto Grosso (Calman 1912). This paper described the species as an argulid with maxillae modified to suckers with discoidal scales on the membranous border; a preoral papilla with no spine; small antennules with a stout basal part and a subglobular terminal part separated by a constriction; small antennae that are undivided with a blunt lobe at the base bearing a short apical "tooth"; no furcal rami and elongated carapace lobes (Calman 1912). The specimens used for this description were deposited in the Crustacea collection of the British Museum of Natural History (BMNH).

However, in the same year, Moreira (1912) wrote a brief description of a new genus and species that he called *Talaus ribeiroi* Moreira, 1912, from a single specimen collected from the same region (Moreira 1912). *Talaus ribeiroi* was described as lacking antennae; maxillules as two-thirds the length of the cephalothorax; maxillae strong with the basal segment short and terminal segment digitiform; the posterior pair of lobes of the swimming legs as large, elongate and bent backwards and upwards; the carapace lobes as parallel; and finally, the abdomen as half the length of the whole specimen (Moreira 1912). In 1914, Melo-Leitão suggested that the genus *Talaus* be

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renamed *Moreiriella* because the former name was already used in the class Arachnida by Simon (Moreira 1915). Later, Moreira (1915) synonymized both *Talaus* and *Moreiriella* with *Dipteropeltis* and declared that *T. ribeiroi* is the same as *D. hirundo* primarily because they are "of the same place of origin" (Moreira 1915). This was widely accepted in later publications. In addition, Moreira (1915) added a description of the antennae and antennules of *D. hirundo* which differed significantly from the description by Calman (1912). The antennules were described as two segmented, the basal segment as oblong and the terminal segment short with four setae; the antennae being three segmented, the basal segment as oblong and quite large carrying a single thin seta, the second segment short and carries a single seta, and the third segment tapering to two setae (Moreira 1915).

Much later, Paiva Carvalho (1941) redescribed *D. hirundo* from four specimens collected in Boa Esperança, São Paulo. According to this description, specimens are three times longer than wide; the carapace lobes are shaped like wings and rarely exceed the length of the abdomen; they possess a pair of antennules and antennae; the suckers are supported by two layers of horizontal and parallel ribs along the edges of the disc; the mouth is a rounded disc with crescent-shaped mandibles; the maxillae are short and robust and have five segments, the third and fourth segments are provided with callouses; and the natatory lobes are in the infero-posterior position.

Ringuelet (1943) described two specimens collected in Argentina and compared these to Calman's (1912) description. The distinguishing features were summarized as the maxillules being transformed into a pair of suction cups without supporting rods; possession of an underdeveloped preoral sting; no "anal" papillae and the presence of a pair of respiratory areas on the "dorsal" surface of the carapace (Ringuelet 1943). He later reviewed and corrected his own description of the antennules as being two segmented with a blunt terminal hook; and the antennae as being four segmented with setae on the "back edge" of the basal segment similar to those of the genus *Argulus* (Ringuelet 1948). Furthermore, the existence of a preoral sting within a channel in the preoral papilla was confirmed, while the suction cups reportedly possessed a palisade of polygons instead of radial supporting rods (Ringuelet 1948).

Subsequently, *D. hirundo* was recorded in Brazil, Venezuela, and Argentina and the first colour micrograph of the species was provided (Weibezahn & Cobo 1964). Later, a key to the Neotropical Branchiura was published together with a brief summary of the description of the species and a drawing of *D. hirundo* taken from Paiva Carvalho's (1941) re-description (Thatcher 1991).

During a recent ecological study of three piranha species in the Pantanal wetlands of Brazil (Carvalho *et al*. 2003), a single specimen of *D. hirundo* was collected from *Pygocentrus nattereri* Kner, 1860 (piranha); while Mamani *et al*. (2004) recorded a high prevalence of *D. hirundo* on *Pseudoplatystoma fasciatum* Linnaeus, 1840 (surubim) from the Beni River in the floodplains of Bolivia. In 2006, Thatcher updated his key to the Neotropical Branchiura (Thatcher 2006), adding a colour photo of *D. hirundo*, where after Møller *et al*. (2008) and Møller (2009) discussed the taxonomic position of *D. hirundo* in relation to the other genera representing the Branchiura. In addition, Møller & Olesen (2010) used paratype specimens (including one of the specimens deposited by Calman) from the BMNH to provide a re-description of the morphology of the female *D. hirundo* based on scanning electron microscopy.

The literature on *D. hirundo* is thus sporadic and the descriptions vary greatly with only females being documented. Specimens obtained from the Instituto Nacional de Pesquisas da Amazônia (INPA), the Smithsonian Institute (USNM), and the British Museum of Natural History (BMNH) were obtained for study. These were studied with light and scanning microscopy and the results compared to that from previous studies. Based on the large number of morphological differences, a new species is described.

Material and methods

Specimens archived as *D. hirundo* were obtained from the Instituto Nacional de Pesquisas da Amazônia (INPA, 10 specimens), the Smithsonian Institute (USNM, one specimen), and the British Museum of Natural History (BMNH, one specimen). Additionally, micrographs of a single specimen at the Museo de La Plata were obtained (see Remarks and Discussion). All the specimens were egg bearing females. The specimens were from different locations and collected from different hosts (see Table 1).

TABLE 1. Collection information obtained from the 13 specimens examined during this study.

Accession numbers	Locality	River system	General orientation[a]	Host name	*Dipteropeltis* sp.	Specimen type	Collector	Accession date
BMNH 1892.10.24.2[bc]	Brazil, Corumbá, Mato Grosso	Paraguay River	South	"Dourado" [d]*Salminus brasiliensis* (Cuvier, 1816)	*D. hirundo*	Paratype	Spencer Moore Esq.	October 1892
USNM 41866[c]	Argentina, Buenos Aires	River de la Plata	South	Unknown ([c]*Agenor angelus)*	*D. hirundo*	Paratype	F. Silvestri	October 1899
INPA 429[c]	Brazil, Rondônia, near Costa Marques	Guaporé River	South	*Acestrorhynchus falcirostris* (Cuvier, 1819)	*D. hirundo*	Paratype	J.C.O Malta	November 1983
INPA 430 (i-ii)[cf]	Brazil, Minas Gerais	Grande River (Parana Basin River)	South	*Salminus brasiliensis* (Cuvier, 1816) [as *Salminus maxillosus* Valenciennes, 1890]	*D. hirundo*	Paratype	E. Zaniboni	September 1985
MLP Cr 26049 (M.LP., Crus.: 43)[cgh]	Argentina, Rosario	Perana River	South	*Luciopimelodus pati* (Valenciennes, 1835)	*D. hirundo*	Paratype	Mr. Luis Reyna	October 1941
INPA 1934 (ex INPA 423iii)[c]	Brazil, Amazonas, Manaus	"Igarapé" Água Branca, Reserva Florestal Ducke	North	*Brycon amazonicus* (Spix & Agassiz, 1829)	*D. campanaformis*	Holotype	A. Storti	July 1983
INPA 423 i,ii, iv,v[cf]	Brazil, Amazonas, Manaus	"Igarapé" Água Branca, Reserva Florestal Ducke	North	*Brycon amazonicus* (Spix & Agassiz, 1829)	*D. campanaformis*	Paratype	A. Storti	July 1983
INPA 1755 i-ii[c]	Brazil, Amazonas	Padauari River	North	*Acestrorhynchus* sp.	*D. campanaformis*	Paratype	G. Borges	October 1981

[a]General orientation with respect to the continent of South America.
[b]Calman, 1912, and Møller and Olesen, 2010
[c]Current article
[d]Believed to be the species name associated with this common name
[e]Given species name does not exist in any database
[f]INPA423i and INPA430i used in SEM
[g]Ringuelet (1943, 1948)
[h]Obtained photographs from the curator

TABLE 2. Measurements and ratios calculated for the 13 specimens studied. Measured in millimetres (mm)

Code	*Dipteropeltis* sp.	Measurements recorded for each specimen						Relative ratios in comparison to one another							
		Head to abdomen end (HA)*	Head to Carapace lobe end (HC)‡	Carapace Split Length (CSL)	Abdomen Length (AL)	Abdomen Split Length (ASL)	Sucker Diameter (SD)	HC/ HA	HA/ HC	CS L/H C	AS L/A L	AL/ HA	AL/ HC	SD/ HA	SD/ HC
USNM 41866	*D. hirundo*	12.0	12.0	11.1	4.0	3.4	0.48	1.00	1.00	0.93	0.85	0.33	0.33	0.04	0.04
INPA 429	*D. hirundo*	7.0	6.0	4.9	3.0	2.4	0.44	0.86	1.17	0.82	0.80	0.43	0.5	0.06	0.07
INPA 430i	*D. hirundo*	10.0	12.0	10.1	3.5	2.6	0.50	1.20	0.83	0.84	0.74	0.35	0.29	0.05	0.04
INPA 430ii	*D. hirundo*	8.0	9.5	7.8	3.0	2.2	0.05	1.19	0.84	0.82	0.73	0.38	0.32	0.01	0.01
BMNH 1892.10.24.2	*D. hirundo*	14.5	25.5	22.0	8.5	7.5	1.00	1.76	0.57	0.86	0.88	0.59	0.33	0.07	0.04
MLP Cr 26049	*D. hirundo*	16.2	21.4	17.4	7.4	6.3	1.00	1.32	0.76	0.81	0.85	0.46	0.35	0.06	0.05
INPA 423i	*D. campanaformis*	20.0	16.0	12.7	10.0	8.9	0.90	0.80	1.25	0.79	0.89	0.5	0.63	0.05	0.06
INPA 423ii	*D. campanaformis*	16.0	13.0	10.4	8.0	6.9	0.60	0.81	1.23	0.80	0.86	0.5	0.62	0.04	0.05
INPA 1934 (ex INPA 423iii)	*D. campanaformis*	15.0	13.0	10.2	7.0	6.0	0.70	0.87	1.15	0.78	0.86	0.47	0.54	0.05	0.05
INPA 423iv	*D. campanaformis*	19.0	16.0	12.6	8.0	6.8	1.25	0.84	1.19	0.79	0.85	0.42	0.5	0.07	0.08
INPA 423v	*D. campanaformis*	14.0	13.0	10.3	7.0	6.0	0.40	0.93	1.08	0.79	0.86	0.5	0.54	0.03	0.03
INPA 1755i	*D. campanaformis*	10.0	8.0	6.4	5.0	4.2	0.60	0.80	1.25	0.80	0.84	0.5	0.63	0.06	0.08
INPA 1755ii	*D. campanaformis*	12.0	10.0	7.4	5.5	4.8	0.80	0.83	1.20	0.74	0.87	0.46	0.55	0.07	0.08

* HA in *Dipteropeltis campanaformis* refers to the total length of the specimen
‡HC in *Dipteropeltis hirundo* refers to the total length of the specimen.

All the specimens were transferred to fresh 70% ethanol and studied with the aid of stereo and light microscopes, while only those from INPA and USNM were subsequently cleared in 80% lactic acid. Micrographs were taken of the specimens and drawings were made (with the aid of a drawing tube). Results obtained via both methods were used to take measurements of all 12 specimens. The following measurements (mm) were taken (see Figure 1 and Table 2): abdomen length (AL), abdomen split length (ASL), carapace split length (CSL), head to abdomen lobe end (HA), head to carapace lobe end (HC), sucker diameter (SD). The measurements were used to calculate ratios of the various body parts in relation to others (see Table 2).

The specimens were separated into two groups based on the morphological differences (i.e. specimens that matched the descriptions of *D. hirundo*, and those that differed) and the ratio differences obtained. Two specimens, one from each group (INPA 430i and INPA 423i), were stained with lignin pink for better visualization with the light microscope. The same specimens were prepared for Scanning Electron Microscopy by hydration in a descending concentration series of ethanol. The specimens were then freeze dried, sputter coated with gold and viewed with a JEOL JSM-5600 electron microscope. Appendage specific measurements were based on these two specimens used in SEM for more accurate measurements. The head shield of both specimens was removed through micro-dissection using a tungsten needle to study the antennules and antennae.

Results

Family Argulidae Leach, 1819

Dipteropeltis Calman, 1912

(Figure 1, 2, and 3A)

Dipteropeltis hirundo Calman, 1912

Material examined. *Paratypes.* 6 egg-bearing ♀: 1 egg-bearing ♀ (BMNH 1892.10.24.2) collected from *Salminus brasiliensis* (Cuvier, 1816) from Corumbá, Mato Grosso, Brazil during October 1892; 1 egg-bearing ♀ (USNM 41866) collected from an unknown host caught in Buenos Aires, Argentina during October 1899; 1 egg-bearing ♀ (INPA 429) collected from *Acestrorhynchus falcirostris* (Cuvier, 1819) from Rondônia, near Costa Marques, Brazil during November 1983; 2 egg-bearing ♀ (INPA 430i, ii) collected from *Salminus brasiliensis* (Cuvier, 1816) from Minas Gerais, Brazil during September 1985; 1 egg-bearing ♀ (MLP Cr 26049) collected from *Luciopimelodus pati* (Valenciennes, 1835) from Rosario, Argentina during October 1941 (see Table 1).

Description. In dorsal view (Fig. 1A), *D. hirundo* has a wide, rounded head shield. A pair of separate inter-ocular rods (ir) originates between the compound eyes (ce) and extend towards the nauplius eye (ne). The carapace lobes exceed the length of the abdomen and thus form the total length of the species (HC, Fig. 1A, 1B, Table 2) with a range of 6–25.5 mm (average of 14.4 mm), and the average split length (CSL) of the carapace (i.e. the depth of the sinus of the carapace) is at 84.67 % of the length of the carapace (CSL/HC, Table 2). The network of branching ducts of the midgut is visible in both light microscopy and scanning electron microscopy, and reaches the external margins of the carapace. The carapace lobes shield the abdomen from view dorsally.

In ventral view (Fig. 1B, 3A), the head shield is round and folds in towards the appendages of the cephalon. These folds exceed the outer margins of the maxillules (mx). If the head shield were to be folded open, the folds would invariably form a square-shape. Respiratory areas were not visible in light microscopy but a large respiratory area was visible in scanning electron microscopy (Fig. 2A).

The antennules and antennae were not observed as these structures were obscured by both the head shield and the maxillules; and furthermore did not survive the micro-dissection during the scanning electron microscopy study. However, Møller & Olesen (2010) provided micrographs and a schematic drawing in Figures 2B–D.

The maxillule (mx, Fig. 1B) rim is divided into three zones; zone 1 (interior margin) bears folds in an erratic pattern (Fig. 2B); zone 2 (middle zone) is the widest zone and bears round sclerites with minute setules arranged within it (Fig. 2C, D); zone 3 (exterior margin) bears a single border of setules. The maxillules have a diameter that ranges between 0.05–1.00 mm (Figure 1B, Table 2), and occupy an average of 4.10 % of the total length of the specimens (SD/HC, Table 2).

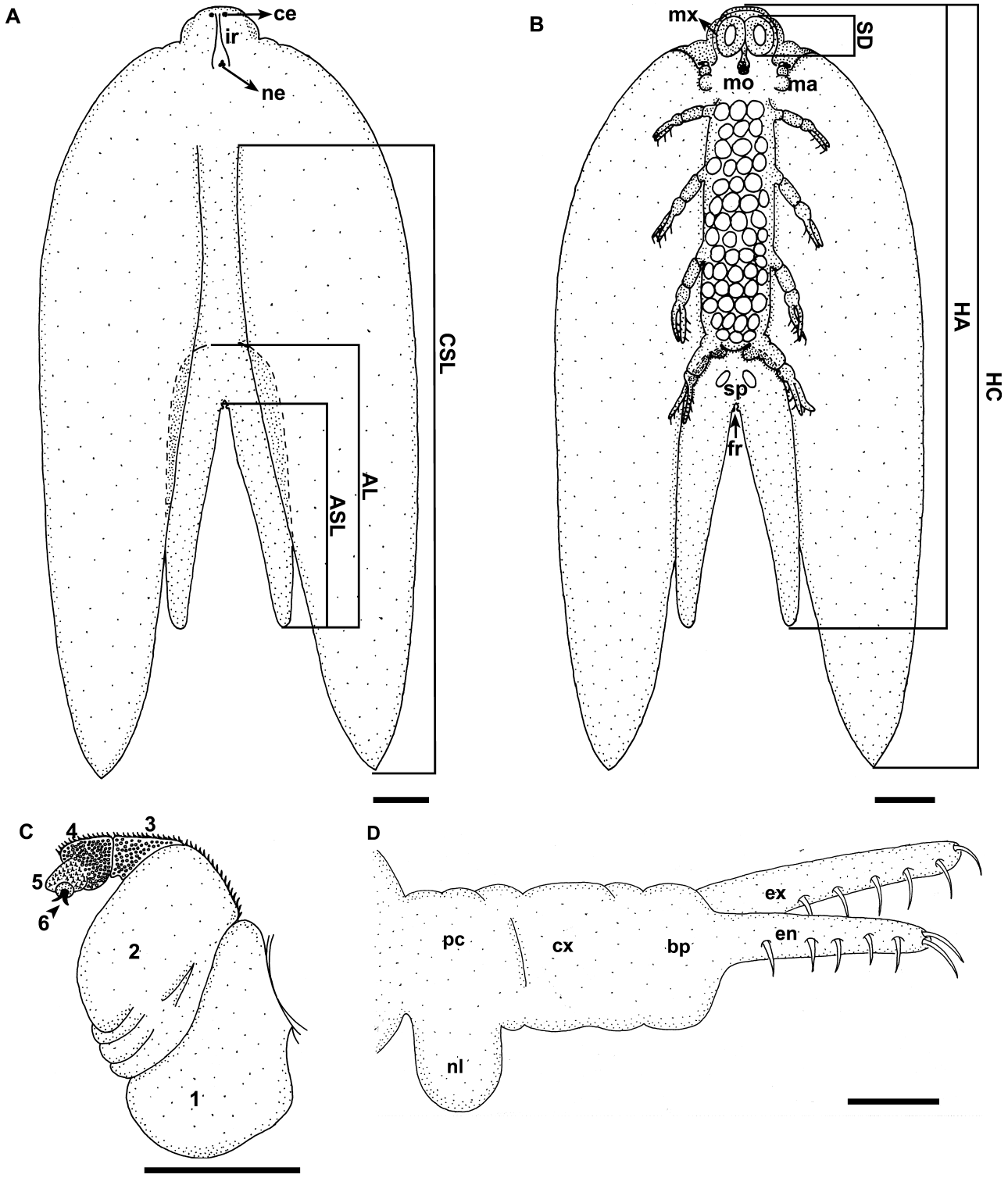

FIGURE 1. *Dipteropeltis hirundo.* Paratype female BMNH 1892.10. 24. 2. (A) Dorsal view. AL = abdomen length, ASL = abdomen split length, ce = compound eye, CSL = carapace split length, ir = inter-ocular rods, ne = nauplius eye. (B) Ventral view. fr = furcal rami, HC = head to carapace lobe end, ma = maxilla, mo = mouth, mx = maxillule, SD = sucker diameter, sp = spermatheca. (C) The right maxillae. 1 = first segment, 2 = second segment, 3 = third segment, 4 = fourth segment, 5 = fifth segment, 6 = sixth segment. (D) The fourth left leg showing the natatory lobe. bp = basopodite, cx = coxa, en = endopodite, ex = exopodite, pc = precoxa, nl = natatory lobe. Scale bars: A, B, 2 mm; C, 400 µm; D, 200 µm.

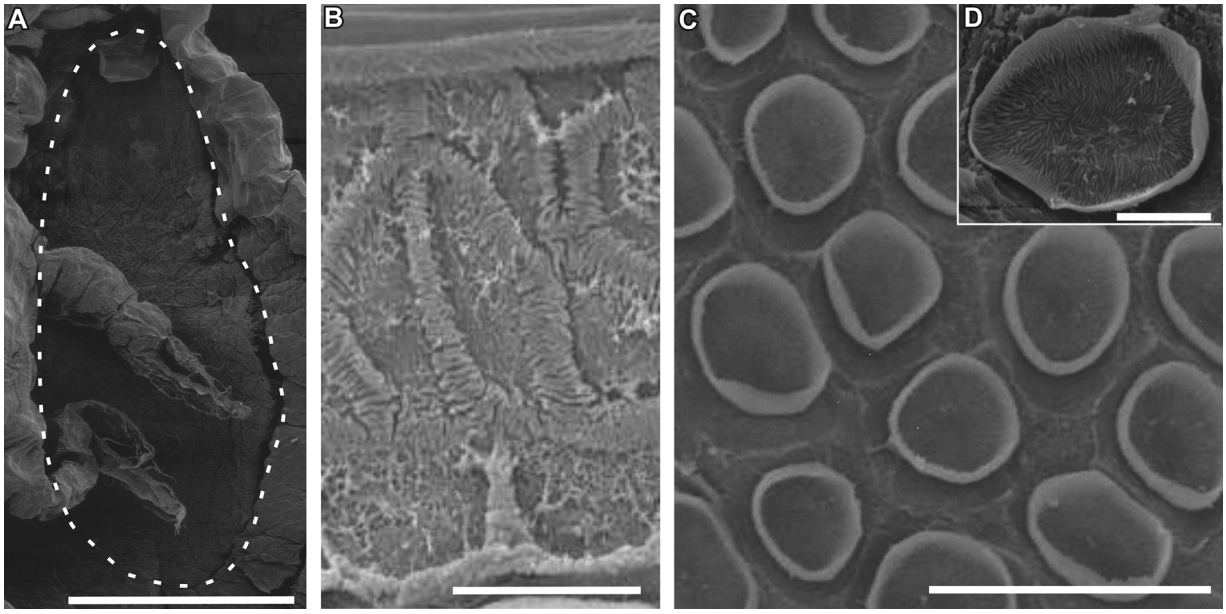

FIGURE 2. Scanning electron micrographs of an egg bearing female *Dipteropeltis hirundo* (Paratype INPA 430i). (A) Ovoid respiratory area located on the ventral surface of the carapace. Dashed line drawn slightly outside of the structure, indicates the outline of the respiratory area. (B) Maxillule zone 1 (z1) consisting of folds in an erratic pattern. (C) Maxillule zone 2 (z2) round sclerites. (D) Sclerite of zone 2 with finite setules arranged on the surface. Scale bars: A, 500 µm; B, 10 µm; C, 20 µm; D, 5 µm.

The mouth (mo, Fig. 1B) is borne on a long and slender siphon-like cone. The labrum (labr, upper lip) has an inverted U-shape, and is joined laterally with the labium (labi, lower lip). The labium therefore does not exceed the limits of the labrum, and forms the posterior limit of the mouth (see Møller & Olesen 2010, Figure 3A–E). Neither the labial spines, nor the mandibles with their denticles or the preoral papilla and sting were discernible during the light microscopy study but these are shown in Møller & Olesen (2010) Figure 2E and 3.

The maxillae (ma, Fig. 1B, 1C) are uniramous, six segmented, with the last three segments at an angle to the basal three segments. The maxillae appear hooked and are adorned with scales and setules as is shown in Møller & Olesen's (2010) Figure 5A.

The natatory lobe (nl, Fig. 1D) of the fourth pair of swimming legs is elongate and rounded, almost tongue-shaped, with a small protrusion at the base of the lobe that in some specimens resembles a fold of exoskeleton.

The abdomen lobes (AL, Fig. 1B) range between 3.0–8.5 mm in length (see Table 2) with blunt tips that lie in an inverted V. The abdomen length (AL) forms an average of 35.33 % of the total length (HC) of the species (AL/HC, Table 2). The abdomen split length (ASL), that is the depth of the sinus of the abdomen, is an average of 81.0 % of the length of the abdomen (ASL/AL, Table 2). Two minute round furcal rami (fr, Fig. 1B) are situated on the abdomen in the angular split. The spermathecae (sp, Fig. 1B) are oval and the area is raised and adorned with scales.

***Dipteropeltis campanaformis* n. sp.**
(Figure 3B, 4–6)

Etymology. The species name *campanaformis* refers to the bell shape that the carapace lobes resemble.

Type locality. In an unnamed forest stream ("Igarapé", Água Branca) in Reserva Florestal Ducke, in the Amazonas River basin in Manaus, Amazonas, Brazil.

Type host. *Brycon amazonicus* (Spix and Agassiz, 1829)

Material examined. *Holotype.* Egg-bearing ♀ (INPA1934, former INPA 423iii, see Table 1) here designated. *Paratypes.* 6 egg-bearing ♀: 4 egg-bearing ♀ (INPA 423i, ii, iv, v, see Table 1) collected from *Brycon amazonicus* (Spix and Agassiz, 1829) from an unnamed forest stream ("Igarapé", Água Branca) in Reserva Florestal Ducke, in the Amazonas River basin in Manaus, Amazonas, Brazil, during July 1983; 2 egg-bearing ♀ (INPA 1755i, ii, see

Table 1) collected from an *Acestrorhynchus* sp.(Acestrorhynchidae) from the Padauari River, a left bank tributary of the upper Negro River, Amazonas, Brazil during October 1981.

Description. In dorsal view (Fig. 4A), this species has a narrow, square-shaped head shield that does not have folds nor does its width exceed the outer margins of the maxillules. Two compound eyes (ce) are visible. A pair of separate inter-ocular rods (ir) originates between the eyes, extends towards the nauplius eye (ne) and continues around it. The carapace lobes (HC, Fig. 3B, 4A–B, Table 2) are 13 mm long (range 8–16 mm, average 12.7 mm) with the split length of the carapace (CSL) at 78.46 % of the length of the carapace (CSL/HC, average 78.55 %, Table 2). The elliptical lobes give the parasite a bell shape and the lobes only shield the anterior part of the abdomen. The central duct of the midgut on the central axis of the lobes is visible in light microscopy with a network of tubules branching out.

FIGURE 3. Light micrographs of *Dipteropeltis sp*. (A) *Dipteropeltis hirundo* (Paratype, BMNH 1892.10.24.2). (B) *Dipteropeltis campanaformis* **n. sp.** (Holotype INPA 1934). Scale bars: A, B, 5 mm.

In ventral view (Fig. 3B, 4B); the head shield is cucullate and visible above the anterior margin of the maxillules (mx). There are two respiratory areas on the ventral side of each carapace lobe visible in scanning electron microscopy; the anterior area (ar, Fig. 4B, 6B) is a small (0.27 mm x 0.35 mm) triangular oval, while the posterior area (pr, Fig. 4B, 6C) is large and oval (1.31 mm x 2.97 mm). There are no hooks or spines. The total length of the specimen (HA) is 15 mm, with range between 10.00–20.00 mm (average 15.14 mm, see Table 2).

The antennules and antennae (Fig. 5A, 6A) are obscured by the suckers. The antennule (ant) is small (64 µm) and two segmented; the base is narrow and oval, the terminal segment cylindrical, with a blunt tip that carries five setae. The antenna (a, 135 µm) is two segmented; the base is bulbous and oval; the terminal segment cylindrical, carrying four setae.

The maxillules (mx, Fig. 4B, 6D) are cylindrical stalks with oval membranous suction discs that lack supportive rods (characteristic of *Argulus* and *Chonopeltis*). The cup rim is divided into three zones (Fig. 6D); zone

1 (interior margin) bears prominent radiating rows of micro papillae (Fig. 6E); zone 2 (middle) with suctorial plates (Fig. 6F); zone 3 (exterior margin) with two rows of concentric elongated discoidal scales (Fig. 6G). The sucker diameter (SD, Table 2) is 0.70 mm and constitutes a ratio of 0.05 (4.67 %) of the total length (SD/HA) of the specimen (range 0.03–0.07 mm, average 5.0 %).

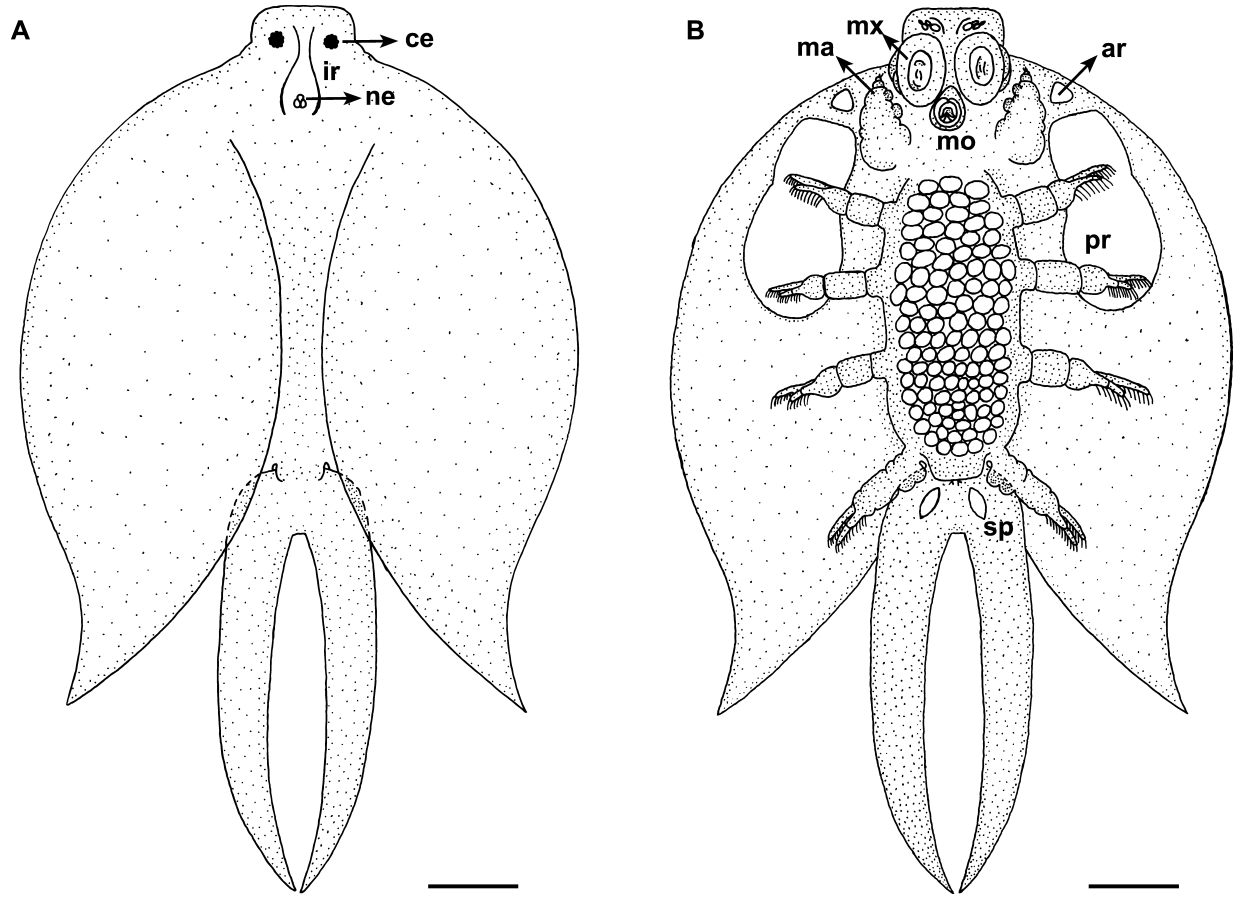

FIGURE 4. *Dipteropeltis campanaformis* **n. sp.** Paratype female INPA 423i. (A) Dorsal view. ce = compound eye, ir = inter-ocular rods, ne = nauplius eye. (B) Ventral view. ar = anterior respiratory area, ma = maxilla, mo = mouth, mx = maxillule, pr = posterior respiratory area, sp = spermatheca, Scale bars: A, B, 2 mm.

In the mouth (mo, Fig. 4B, 6H), the labrum (labr, upper lip) is an inverted U-shape with lateral protrusions (lp) and a single row of short setules (s, Fig. 6I). The lateral protrusions form the base of the mandibles (m) which are sickle-shaped with 3 or 4 slim and sharp denticles at the distal end (Fig. 6J). The labium (labi, lower lip) encircles the upper lip, making the mouth opening circular in shape. There are two short tubular labial spines (ls, 54 μm) at the entrance to the mouth (Fig. 6K). The internal dorsal surface of the mouth is densely packed with long setae (Fig. 6L). The pre-oral structure (ps) is diminutive and triangular in shape, without a duct or spine (Fig. 6M).

The maxillae (ma, Fig. 4B, 5B) are prominent, conical, and directed vertically, forming a cubic shape in the head region. It is six-segmented; with a wide (segment 1, 727 μm) base, tapering to the distal segment. Segments three and four bear round protrusions on their medial surfaces with pectinate scales (Fig. 6N). Segment six bears two stout setule-like claws (Fig. 5C). All the segments are sparsely covered by setae.

The swimming legs are biramous. Leg 1 (Fig. 5D), the precoxa (pc) is short (200 μm), the coxa (cx) longer (488 μm), the basopodite (bp, 250 μm) bears the endopodite (en, 350 μm) and the exopodite (ex, 600 μm). Leg 2 (Fig. 5E), the precoxa (pc) is short (166 μm), the coxa (cx) longer (452 μm), the basopodite (bp, 286 μm) bears the two-segmented endopodite (en, 242 μm) and the exopodite (ex, 362 μm). Leg 3 (Fig. 5F), the precoxa (pc) is short (182 μm), the coxa (cx) is longer (484 μm), the basopodite (bp. 348 μm) bears the two-segmented endopodite (en, 302 μm) and the exopodite (ex, 664 μm). Leg 4 (Fig. 5G), the precoxa (pc, 384 μm) bears the bilobed natatory lobe (nl, 203 μm) on the posterior surface, the coxa (cx) is longer (400 μm); the basopodite (bp, 150 μm) bears the two-segmented endopodite (en, 566 μm) and the exopodite (ex, 566 μm). All 4 legs bear round scales on the coxa and basopodite, with a denser concentration on the anterior surface.

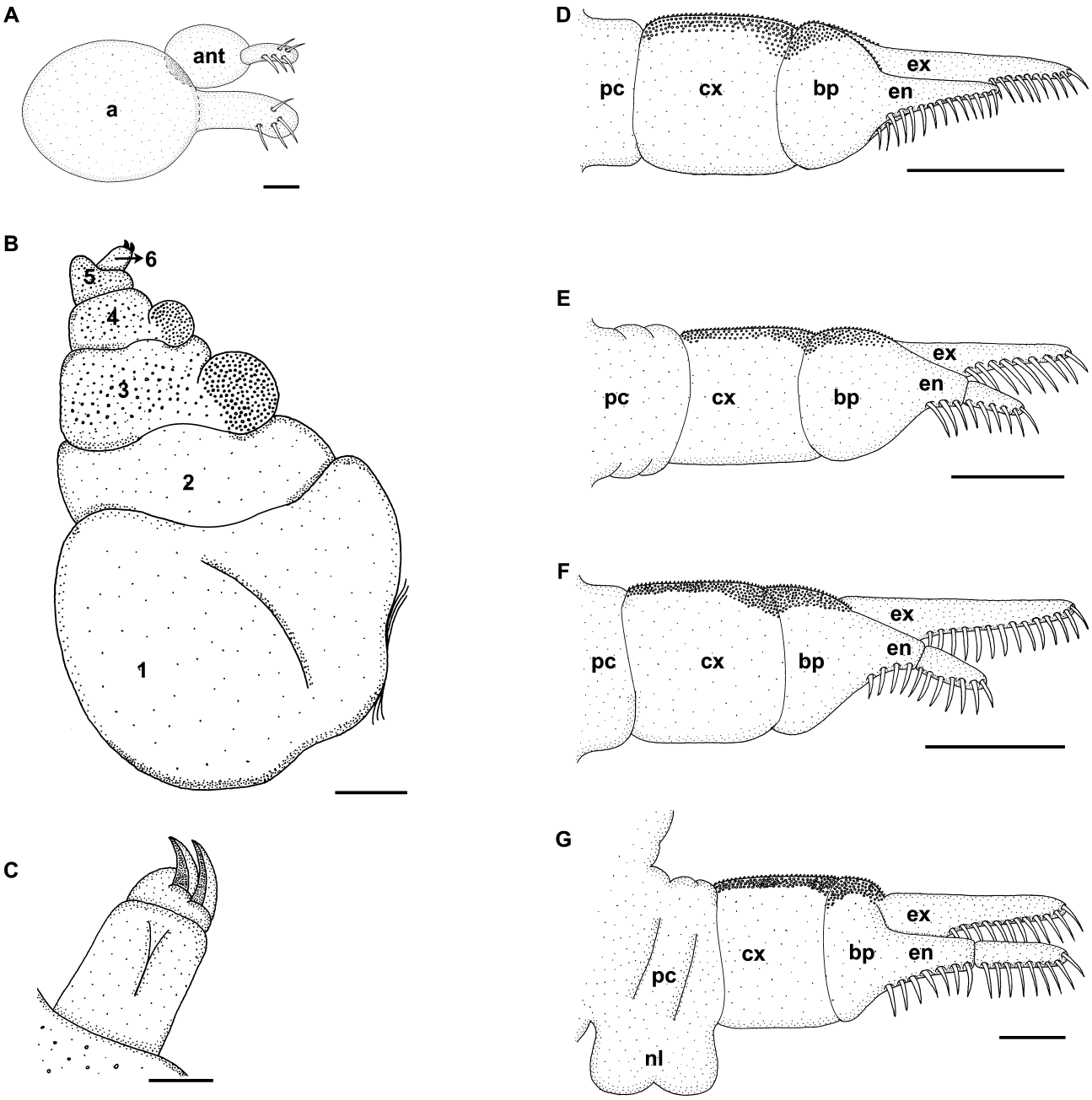

FIGURE 5. *Dipteropeltis campanaformis* **n. sp.** Paratype female INPA 423i. (A) The left antenna and antennule. a = antenna, ant = antennule. (B) The right maxillae. 1 = first segment, 2 = second segment, 3 = third segment, 4 = fourth segment, 5 = fifth segment, 6 = sixth segment. (C) The sixth segment of the right maxillae bearing 2 claws. (D) The first left leg. (E) The second left leg. (F) The third left leg. (G) The fourth left leg showing the natatory lobe. bp = basopodite, cx = coxa, en = endopodite, ex = exopodite, pc = precoxa, nl = natatory lobe. Scale bars: A, 20 µm; B, 200 µm; C, 10 µm; D–F, 500 µm; G, 200 µm.

The abdomen (Fig. 3B, 4A, 4B) has an angular base. Lobes (AL, Table 2) are 7 mm long (range 5–10 mm, average 7.21 mm) and lanceolate, with tips that bend slightly inwards. The abdomen has a ratio of 0.47 (46.67 %) of the length of the specimen (AL/HA, Table 2) with the species average at 47.80 %. Furcal rami were not observed at the position of the split. The average abdominal sinus (ASL) is 86.14 % of the length of the abdomen (ASL/AL, see Table 2). The spermathecae (sp, Fig. 4B) are oval with angular anterior and posterior apices; the area is flattened and sparsely scattered with stout pectinate scales interspersed with setules (Fig. 6O).

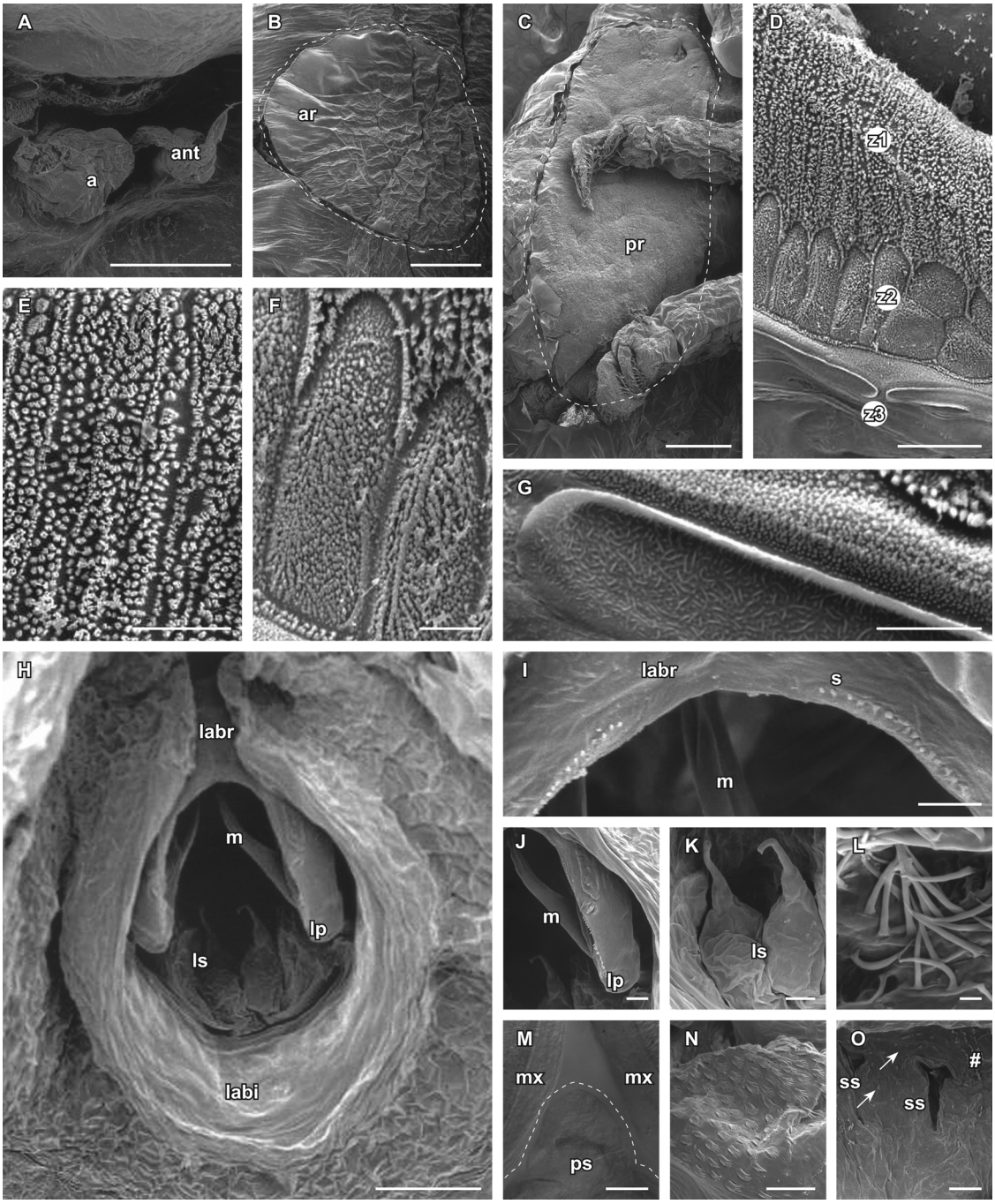

FIGURE 6. Micrographs of an egg bearing female *Dipteropeltis campanaformis* **n. sp.** (Paratype, INPA 423i). Scanning electron micrographs. (A) Antennule and antenna. a = antenna, ant = antennule. (B) Triangular oval anterior respiratory area located on the ventral surface of the carapace. ar = anterior respiratory area. Dashed line drawn slightly outside of the structure, indicates the outline of the respiratory area. (C) Ovoid posterior respiratory area located on the ventral surface of the carapace. pr = posterior respiratory area. Dashed line drawn slightly outside of the structure, indicates the outline of the respiratory area. (D) Section of the membrane of the maxillule. z1 = zone 1, z2 = zone 2, z3 = zone 3. (E) Sucker zone 1 (z1) consisting of lineated rows of micro papillae. (F) Sucker zone 2 (z2) consisting of suctorial plates. (G) Sucker zone 3 (z3) consisting of a single ovoid, elongated discoidal scale. (H) Mouth. labi = labium, labr = labrum, lp = lateral protrusion, ls = labial spines, m = mandible. (I) Upper lip bearing the setules. labr = labrum, m = mandible, s = setules. (J) Left lateral protrusion of the upper lip bearing the left mandible. lp = lateral protrusion, m = mandible. (K) Tubular labial spines. ls = labial spines. (L) Setae of the internal dorsal surface of the mouth. (M) Light micrograph of the diminutive preoral structure. Dashed line drawn slightly outside of the structure, indicates the outline of the preoral structure, mx = maxillules, ps = preoral structure. Scanning electron micrographs. (N) Pectinate scales of the protrusion on the third segment of the maxillae. (O) Flattened spermathecal spine area sparsely scattered with coarse pectinate scales interspersed with setules. arrows = setules, ss = spermathecal spines, # = course pectinate scales. Scale bars: A, B, 100 µm; C, 500 µm; D, O, 20 µm; E, J, K, M, 10 µm; F, G, I, 5 µm; H, N, 50 µm; L, 2 µm.

TABLE 3. Direct comparison between *D. campanaformis* and *D. hirundo.*

Feature	*D. campanaformis*	*D. hirundo*
Head shield	Square	Round
	Narrower than maxillules	Wider than maxillules
	No folds	Folded
Carapace lobes	Elliptical	Straight
	Bell shaped	Swallow shaped
	Covers anterior portion of abdomen dorsally	Covers length of abdomen dorsally
	Average ratio 84.05 % of body length (HA)	Average ratio 122.07 % of body length (HA)
Respiratory areas	Anterior triangular oval	[a]Anterior oval
	Posterior ovoid	[a]Posterior ovoid with concave ridge on anterior edge
Mouth	Round, labium encircles labrum	Labium and labrum joined laterally
	Recessed on cephalon	Projected on a siphon-like cone
Pre-oral structure	Diminutive and triangular, no duct or spine	[b]Elongated eversible sheath, spine present
Maxillules	Zone 1-lineated radiating rows of micro-papillae	Zone 1-folds in an erratic pattern
	Zone 2-suctorial plates	Zone 2-rounded sclerites with minute setules arranged within
	Zone 3-2 rows of elongate concentric parallel discoidal scales	[b]Zone 3-thin cuticle and a brush-border.
	Average ratio 5.0 % of total length (HA)	Average ratio 4.1 % of total length (HC)
Maxillae	Conical	Hooked, distal three segments folded at an angle to basal three segments
	Two round protrusions covered by pectinate scales medially on segment three and four	No protrusions
Natatory lobes	Equally bilobed	Elongate and rounded with a small basal protrusion
Abdomen	Furcal rami not observed	Furcal rami present
	Lanceolate tips	Blunt tips
	Average ratio 47.8 % of total length (HA)	Average ratio 35.33 % of total length (HC)
Spermathecal area	Sparsely scattered with course pectinate scales	Numerous course pectinate scales

[a]taken from Ringuelet (1943)
[b]taken from Møller and Olesen (2010)

Remarks and discussion

The most distinguishing feature between the females of *D. campanaformis* **n. sp.** and the females of *D. hirundo* is the difference seen in habitus (Figure 3), with the carapace lobes of *D. hirundo* extending beyond the abdomen (HC/HA, average 122.07 %) and thus forming the total length of the specimen (HC, Figure 1A, B, 3A, Table 2), while that of *D. campanaformis* **n. sp.** only extends to approximately half the length of the abdomen (HC/HA, average 84.05 %, Table 2), therefore making the length to the abdomen tip (HA, Figure 3B, 4A, B) the total length of the specimen (HA/HC, average 119.27 %). Additionally, the carapace lobes of *D. hirundo* are swallow shaped, with a deep sinus (average 84.67 %, CSL/HC, Table 2); while those of *D. campanaformis* **n. sp.** are bell shaped, and the sinus is not as deep (average 78.55 %, Table 2). *Dipteropeltis campanaformis* **n. sp.** females can also be distinguished from *D. hirundo* females by the differences in head shape, with that of *D. hirundo* being round, and that of *D. campanaformis* **n. sp.** being square in shape; the shape and morphology of the maxillae, with those of *D. hirundo* having the last three segments folded at an angle to the basal three segments and without any projections, while those of *D. campanaformis* **n. sp.** being prominent, conical, and directed vertically, with two medial projections on the third and fourth segments; as well as the shape of the natatory lobes on the fourth pair of legs, with those of *D. hirundo* being almost tongue-shaped, with a small protrusion at the base of the lobe, while those of *D. campanaformis* **n. sp.** are equally bilobed. Additionally, there are differences in the membrane zonation of the maxillules, the configuration of the lips in the mouth, and the length of the abdomen as a ratio of the total length of each specimen differs, as it is an average of 35.33 % (AL/HC, Table 2) in *D. hirundo* but 47.80 % (AL/HA, Table 2) in *D. campanaformis* **n. sp.**, the details of which are provided in Table 3.

In order to verify the identification of *D. campanaformis*, the specimens described by Calman (1912) and Møller & Olesen (2010) as well as micrographs of one of the specimens described by Ringuelet (1943, 1948) were obtained (See Table 1). Unfortunately, the specimens described by Moreira (1912, 1915) and Paiva Carvalho (1941) could not be examined as they could not be found; the former due to no museum allocation, and the latter due to incorrect accession number. Also, only micrographs were obtainable for the specimens described by Ringuelet (1943, 1948) because two of the three specimens have been misplaced. Furthermore, the specimen used in Møller (2009), BMNH 1974-839, was the same specimen used for SEM in Møller & Olesen (2010). This specimen was therefore unobtainable but both BMNH 1974-839 and BMNH 92.10.24.2-4 (deposited by Calman) were studied and confirmed to be *D. hirundo*.

In the present study, a new species of *Dipteropeltis* is described based on seven specimens deposited in the Instituto Nacional de Pesquisas da Amazônia (INPA) in Brazil.

When comparing the specimens of the two species, there are morphological characteristics that require further attention. That is, the morphology of the antennules and antennae. These appendages are obscured by the head shield and maxillules and the current descriptions for these structures in *D. hirundo* (Calman 1912; Moreira 1915; Møller & Olesen 2010; Ringuelet 1943, 1948) differ considerably; furthermore, these structures were inadvertently destroyed during the dissection of the head shield in the scanning electron microscopy study and thus no contribution could be made in clarifying the structure of these appendages.

Additionally, the preoral papilla was not visible in any of the *D. hirundo* specimens studied and was only visible in one of the specimens of *D. campanaformis* **n. sp.** as these structures are also obscured by the maxillules. In *D. campanaformis* **n. sp.** the preoral papilla is diminutive and triangular in shape with no duct or spine visible. However, it was described in *D. hirundo* as a papilla continuous with the mouth cone from the base that has a duct at its tip but no spine (Calman 1912), while Ringuelet (1943, 1948) described it as an underdeveloped spine within an eversible sheath (also see Figure 2E in Møller & Olesen 2010).

Even though the absence of furcal rami is considered to be a genus specific feature of *Dipteropeltis* representatives (Calman 1912; Ringuelet 1943, 1948), this structure was observed in three of the *D. hirundo* specimens studied. However, they were not observed in any of the *D. campanaformis* **n. sp.** specimens.

One of the previous studies that requires further attention is the detailed description of *D. hirundo* by Paiva Carvalho (1941). The characteristics that stand out are that the carapace rarely exceeds the length of the abdomen; the suckers are large and supported by two layers of horizontal ribs and that the abdominal lobes lack caudal rami (Paiva Carvalho 1941). The specimens described in Paiva Carvalho (1941) could not be examined, however, based on the description and drawings provided (Paiva Carvalho 1941), it is believed that the specimens described are in fact *D. campanaformis* **n. sp.** Paiva Carvalho (1941) therefore inadvertently provided the first description of *D.*

campanaformis **n. sp.** Thus, the drawing used in Thatcher (1991, 2006), which is referenced as being redrawn from Paiva Carvalho (1941), is in fact a drawing of *D. campanaformis* **n. sp.**

Regarding the distribution and hosts of *Dipteropeltis* species in Brazil; *D. hirundo* specimens were collected from *Acestrorhynchus falcirostris* in the Gauporé River, one of the main tributaries of the Madeira River, a southern tributary of the Amazonas River (southern Amazon basin); however, this fish species is also distributed within the Amazon and Orinoco River basins. Furthermore, *D. hirundo* has also been found to parasitize *Salminus brasiliensis* in the rio Grande which forms part of the rio Paraná basin. While *Dipteropeltis campanaformis* n. sp was only recorded from the tributaries of the Amazonas River basin, the largest tributary of the Amazon River basin and limited to the distribution of its host, *Brycon amazonicus*. The distribution patterns of *B. amazonicus* and *A. falcirostris* are similar and thus, they may coexist in the same river systems which may result in the two *Dipteropeltis* species coexisting. Additionally, if the remainder of South America is considered, records of *D. hirundo* exist as far north as Venezuela in tributaries of the Orinoco River, Tiznado River and Caño Guariquito (Weibezahn & Cobo 1963) and as far south as Argentina in the Paraná River (Ringuelet 1943, 1948). The distribution appears disjunct but may be a result of incomplete sampling or even misidentification.

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