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Redescription of two endemic Neotropical species of *Bosminopsis* Richard, 1895 (Cladocera: Bosminidae) with discussion of the genus monophyly

Переописания двух эндемичных неотропических видов рода *Bosminopsis* Richard, 1895 (Cladocera: Bosminidae) с обсуждением монофилетического статуса рода

Alexey A. Kotov*, Petr G. Garibian
Алексей А. Котов*, Петр Г. Гарибян

A.N. Severtsov Institute of Ecology and Evolution, Leninsky Prospect 33, Moscow 119071, Russia. E-mail: alexey-a-kotov@yandex.ru
Институт проблем экологии и эволюции им. А.Н. Северцова РАН, Ленинский пр-т. 33, Москва 119071, Россия.
*Corresponding author

KEY WORDS: Anomopoda, Bosminidae, morphology, taxonomy, South America.
КЛЮЧЕВЫЕ СЛОВА: Anomopoda, Bosminidae, морфология, систематика, Южная Америка.

ABSTRACT. Family Bosminidae Baird, 1845 *sensu* Sars, 1865 (Crustacea: Cladocera) is among the macrotaxa attracting attention of few recent taxonomists. The aim of this paper is to redescribe two endemic Neotropical species, *B. negrensis* Brandorff, 1976 and *B. brandorffi* Rey et Vásquez, 1989 in detail and to check the monophyly of the genus *Bosminopsis* Richard, 1895. Our study confirmed a remarkable similarity of the thoracic limbs in all known species from this genus, supporting the genus monophyly. At the same time, morphology of valves is different in different species of *Bosminopsis*, analogously to differences between taxa of the second bosminid genus, *Bosmina* Baird, 1845.

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РЕЗЮМЕ. Семейство Bosminidae Baird, 1845 *sensu* Sars, 1865 (Crustacea: Cladocera) относится к макротаксона, привлекающим внимание крайне ограниченного числа современных систематиков. Задачей данного исследования было переописать два эндемичных неотропических вида, *B. negrensis* Brandorff, 1976 и *B. brandorffi* Rey et Vásquez, 1989, и проверить монофилетичность рода *Bosminopsis* Richard, 1895. Наш исследование подтвердило примечательное сходство торакальных конечностей всех видов рода, что подтверждает его монофилетическиф статус. В то же самое время, морфология створок различается у разных видов *Bosminopsis*, что аналогично различиям между видами второго рода босминид, *Bosmina* Baird, 1845.

Introduction

The end of the 20th century was marked by a rejection of the cosmopolitanism concept in the Cladocera (Crustacea: Branchiopoda) biogeography [Frey, 1982, 1987a–b]. It was apparent that most previously established taxa were poorly described [Korovchinsky, 1996]. The general level of previous morphological descriptions was inadequate in terms of recent taxonomy. Since the end of the 20th century molecular studies commenced, and they have demonstrated that the Cladocera species diversity is strongly underestimated [Adamowicz, Purvis, 2005; Elías-Gutiérrez *et al*., 2008; Adamowicz *et al.*, 2009; Crease *et al.*, 2012; Kotov *et al.,* 2021]. But most genetic studies have concentrated on a single genus, *Daphnia* O.F. Müller, 1776 [Adamowicz *et al.*, 2009], with few exclusions [Xu *et al.*, 2010; Neretina *et al.*, 2020; Garibian *et al.*, 2021]. Many questions remain unresolved in the taxonomy of different cladoceran families.

Family Bosminidae Baird, 1845 *sensu* Sars, 1865 is among the macrotaxa attracting attention of few taxonomists, although some interesting data on it were published recently [Kotov *et al.*, 2009; Faustová *et al.*, 2010, 2011; Wang *et al.*, 2019]. The family consists of two genera only, *Bosmina* Baird, 1845 and *Bosminopsis* Richard, 1895 [Birge, 1918; Lieder, 1996].

In 1895, the famous French carcinologist Jules Richard described from the La Plata Delta (Argentna) a new, remarkable cladoceran, *Bosminopsis deitersi* Richard, 1895 (Crustacea: Branchiopoda) belonging to a separate genus *Bosminopsis* [Richard, 1895]. Subsequently this genus was recorded in the tropical and subtropical regions of all continents [Daday, 1903, 1905; Brehm, 1913, 1939; Smirnov, Timms, 1983], and all these populations were found to be basically

The paper is devoted to the memory of Vassily A. Spiridonov.

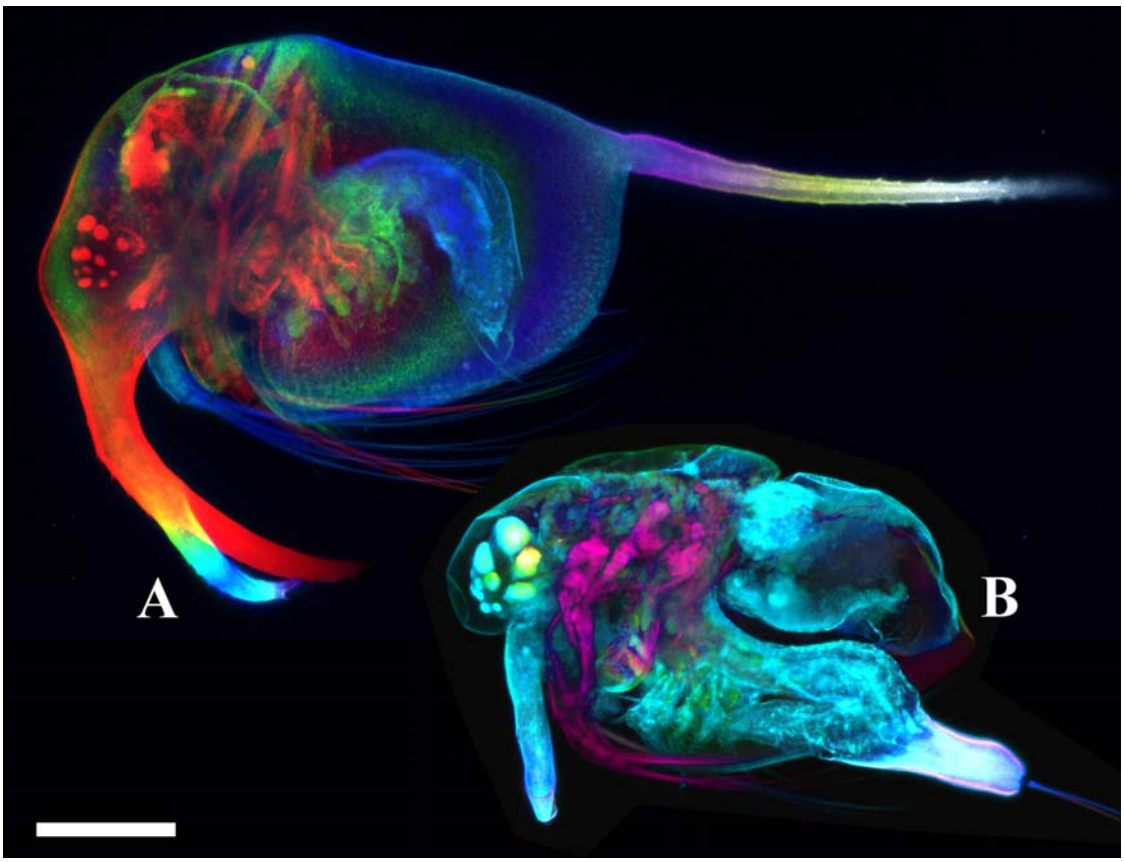

Fig. 1. Two endemic South American species of *Bosminopsis*, large parthenogenetic females from Rio Negro above Manaus, Amazonas, Brazil. A — *B. negrensis*. B — *B. brandorffi*. Photos by the confocal microscope. Scale bars 0.1 mm.

Рис. 1. Два эндемичных южноамериканских вида пода *Bosminopsis*, крупные партеногенетические самки из Рио Негро выше Манауса, Амазонас, Бразилия. A — *B. negrensis*. B — *B. brandorffi*. Фотографии выпонены при помощи конфркального микроскопа. Масштабные линейки: 0,1 мм.

similar to *B. deitersi*. Also, the *deitersi*-like populations were found in more temperate regions: the southern portion of North America [Birge, 1918], all main river basins of northern and eastern Asia, and also the Volga and Dnepr basins in Europe [Linko, 1901; Pirozhnikov, 1937; Bledzki, Rybak, 2016; Garibian *et al.*, 2021]. Several authors at the beginning of the 20th century had tried to establish new taxa from different regions of the world [Linko, 1901; Burckhardt, 1909, 1924], but finally it was accepted that there is a single widely distributed taxon in the world fauna, *B. deitersi* [Koøínek, 1984]. Then two *deitersi*-like taxa were described from tropical regions [Rane, 1984; Rey, Vásquez, 1986], but such descriptions were based on very dubious "diagnostic characters" [Kotov, 1997b]. It was also found that the thoracic limbs of the populations belonging to the *deitersi*-group from different regions are uniformly organized [Kotov, 1997a].

Several attempts were made to revise this group globally, but to date the ideas on species discrimination within it are rather rough and preliminary [Burckhardt, 1924; Kotov, 1997b], although it is known that so-called "cosmopolitan" taxa (like *B. deitersi*) are usually represented by a series of congeneric species inhabiting different continents [Frey, 1982, 1987a–b]. Finally, continental endemism of the taxa within the *deitersi*-group was demonstrated by molecular methods and independent status of the North Eurasian *B. zernowi* Linko, 1901 was confirmed [Garibian *et al.*, 2021]. But the *deitersi*-group still needs further revision.

At the same time, two species with strong morphological differences from *B. deitersi* were found in tropical South America, *B. negrensis* Brandorff, 1976 and *B. brandorffi* Rey et Vásquez, 1989 [Brandorff, 1976; Rey, Vásquez, 1989]. They apparently do not belong to the *deitersi*-group and were placed into the genus *Bosminopsis* based on: (1) postabdomen narrowing distally, with a basal spine comparable to size with the postabdominal claw itself; (2) fused basal portions of the antennae I; (3) both exopod and endopod of the antenna I being three-segmented. But both taxa were described rather superficially, i.e. their thoracic limbs were not studied, and we cannot exclude independent origin of the aforementioned traits and, as a result, the genus polyphyly/paraphyly.

Therefore, the aim of this paper is to redescribe *B. negrensis* and *B. brandorffi* in detail and to check the monophyly of the genus *Bosminopsis*.

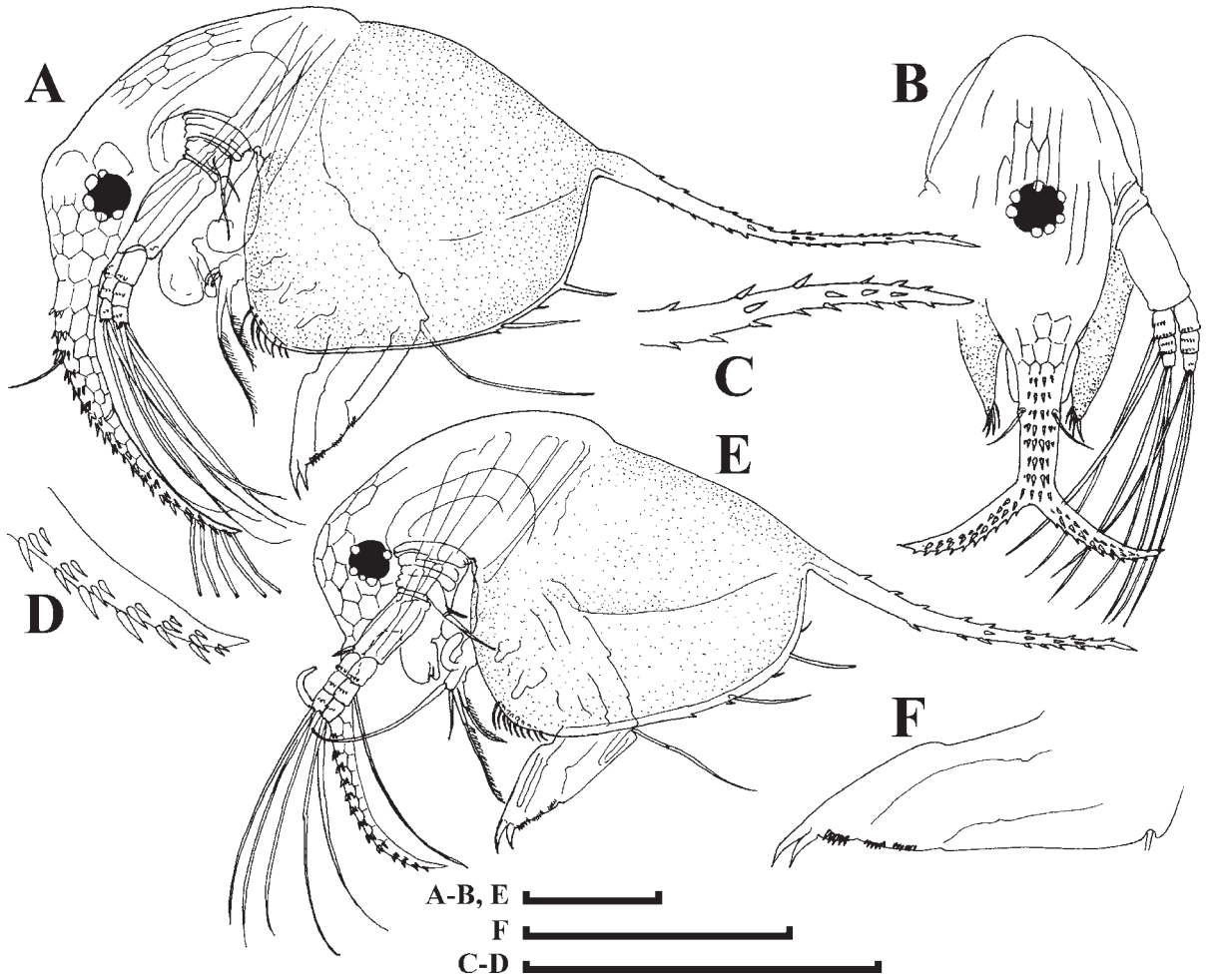

Fig. 2. *Bosminopsis negrensis*, parthenogenetic female and juvenile male from Rio Tarumã-mirim, left affluent of the Rio Negro, region of Boa Vista, Amazonas, Brazil. A — lateral view of large parthenogenetic female; B — its anterior view; C — tip of caudal spine; D — tip of antenna I; E — juvenile male; F — its postabdomen. Scale bar: 0.1 mm.

Рис. 2. *Bosminopsis negrensis*, партеногенетическая самка и ювенитьный самец их реки Тарума-Мирим, правого притока Рио Негро, регион Боа Вишты, Амазонас, Бразилия. A — партеногенетическая самка, вид сбоку; B — вид спереди; C — кончик каудального шипа; D — кончик антенны I; E — ювенильный самец; F — его постабдомен. Масштабные линейки: 0,1 мм.

Material and Methods

Formalin samples from Brazil which are kept in the collection of A.A. Kotov (abbreviated as AAK) for a long time, they were collected before the time when Brazil introduced very strict regulations for sampling. Samples were received from colleagues who collected them by plankton nets (with mesh size of 0.25–0.3 mm) of different constructions and immediately fixed by 2–4% formaldehyde. Samples were initially examined under a stereoscopic dissecting microscope Leica MZ9.5. For morphological analysis, samples were placed in small Petri dishes; specimens were picked from them by pipettes, placed on slides in drops of glycerol, covered by cover slips and examined under a high-power microscope Olympus CX41. Four-two parthenogenetic females from each locality were dissected for analysis of fine morphological details including the appendages. Drawings were made by *camera lucida*.

A single adult female of each taxon was transferred to 50% glycerol solution and observed under Zeiss LSM 880 confocal laser scanning microscope with a Plan Apochromat 20×/0.8 NA M 27 objective lens. UV diode laser in single track channel mode imaging, excitation wavelengths of 405 nm and emission wavelengths of 410–550 nm were used as a set up for imaging; 50 slices at 2.5 ìm optical section depth were done for generating the z-stack from top to bottom of the specimen with 2048 x 2048 px image resolution. The image files were edited by Zen 3.8 (Carl Zeiss) and then by ImajeJ ver.1.53i.

For morphological descriptions, we used terminology as proposed for Anomopoda by Kotov [2013].

ABBREVIATIONS IN THE TEXT AND FIGURES: a–g — posterior setae on limb III corm; dag — distal armature of gnathobase; ejh — ejector hooks on limb I; epp — epipodite; ext — exopodite; fpl — filter plate of gnathobase; mxp — maxillar process of limb I; odl — outer distal lobe of limb I; pep — preepipodite; pos — posterior setae on limb II corm; sdl — inner subdistal lobe of limb I.

Taxonomy

Order Anomopoda Sars, 1865
Family Bosminidae Baird, 1845 *sensu* Sars, 1865
Genus *Bosminopsis* Richard, 1895
Bosminopsis negrensis Brandorff, 1976
Figs 1A, 2–4.

Bosminopsis negrensis Brandorff, 1976: 109–144, figs 1–6; Weibezahn *et al.*, 1990: 46, 48, fig. 2.

TYPE LOCALITY. The mouthlake of the lower Rio Negro some kilometers upstream of Manaus, Amazonas, Brazil [Brandorff, 1976].

TYPE MATERIAL. Lectotype. Female from "Rio Negro, 24.09.59, leg. H. Sioli" in slide in the collection of the Instituto Nacional de Pesquisas da Amazônia, Manaus, Brazil, (collection no. CRUST-031 [Hardy *et al*., 1984; Magalhães *et al.*, 1988].

MATERIAL EXAMINED. Brazil (Amazonas): 4 parthenogenetic females from Rio Negro, left margin above Manaus (3.117°S; 60.05°W), collected on 15.09.1959 by H. Sioli, AAK 1999-063; 12 parthenogenetic females from Rio Negro near Manaus, Ponta Negra (3.05°S; 60.12°W), collected on 26.03.1974 by G.-O. Brandorff, AAK 2002-134 and AAK 2002-136; 2 parthenogenetic females from Rio Negro above Manaus (3.23°S; 60.08°W), collected on 21.09.1975 by G.-O. Brandorff, AAK 1999-064; 3 parthenogenetic females and 1 juvenile male from Rio Tarumã-mirim (3.02°S; 60.18°W), left affluent of the Rio Negro, region of Boa Vista, collected on 19.06.1975 by G.-O. Brandorff, AAK 1999-065; 10 parthenogenetic females from Rio Negro near Anavilhanas Archipelago (2.7°S; 60.8°W), collected on 04.1997 by L. Alves, AAK 2002-149 and AAK 2002-153.

SHORT DIAGNOSIS. Dorsal margin slightly convex to almost straight. Postero-dorsal angle well-expressed, with a long, straight or slightly curved, caudal spine bearing small denticles. Head in lateral view with a low ocular dome. A thin seta (*seta Kurzi*), thin mucro and two minute spines at postero-ventral angle. Antennae I with long fused proximal portion, their istal portions with numerous denticles along its length. Limb I with outer dislal lobe bearing two large setae of different size, feathered by sparse, long, setules. Seta on subdistal lobe relatively long. Seven soft setae on posterior face of limb III. Setae 3–8 of exopodite III increasing in size proximally. Size up to 0.45 mm.

ADULT PARTHENOGENETIC FEMALE. Body brownish, in general subovoid, dorsal margin slightly convex to almost straight, with a slight depression at posterior head portion (Fig. 1A, 2A, 3A). Body moderately compressed laterally (Fig. 2B). Reticulation prominent on head, valves with minute dots (Fig. 2A–B). Posterior margin straight to slightly convex, with height less than half of total body height, postero-dorsal angle well-expressed, with a long, straight or slightly curved, caudal spine bearing small denticles (Fig. 2C). Head in lateral view with a low ocular dome, body contour between head and proboscis rostral part (fused bases of antennae I) somewhat depressed (Fig. 3B), reticulation well-expressed on head anterior face (Figs 2B, 3C). Any head pores not found. Compound eye of moderate size. Ocellus absent. Labrum as a fleshy appendage with a small distal labral plate. Antero-ventral portion of valves with setulated setae (Fig. 3D–E), middle of ventral margin lacking any armature. A thin seta (*seta Kurzi*), thin mucro and two minute spines at postero-ventral angle (Fig. 3F–H).

Postabdomen compressed laterally, dorsal and ventral margins parallel in its proximal (preanal) portion, distal (anal and postanal) portion regularly narrowing distally (Fig. 3I). No proximal projection for postabdominal setae. Preanal margin long, straight to slightly concave, without setules. Anal margin slightly convex, preanal angle expressed, postanal angle smooth. Anal and postanal portion with groups of small denticles. Postabdominal claw terminally supplied with a strong basal spine, almost as large as claw, both claw and basal spine slightly curved (Fig. 3J). Postabdominal seta bisegmented, shorter than postabdomen (Figs 2A, 3A).

Antennae I with proximal portions fused together and with rostrum (Figs 2B, 3C), and this portion significantly longer than in *B. deitersi*. Both lateral portions directed downwards and posteriorly and slightly curved laterally. Antennular sensory setae located on fused portion of antennae I. Distal portion with numerous denticles along its length (Figs 2D, 3K–L) and a row of nine aesthetascs subequal in size distally.

Antenna II (Fig. 3M–N) with a very short coxal portion bearing a long seta and a short seta on a conical elevation, thick basal segment and short three-segmented exopod and endopod, antennal formula: setae 0-0-3/1-1-3, no spines on segments, apical spines reduced. All apical and lateral (on endopod first and second segment) setae subequal in size, covered by sparsely located setules proximally.

Limb I large, with a globular corm. Epipodite (Fig. 4A: epp) with two long finger-like projections. Outer distal lobe (Fig. 4A: odl) with two large setae of different size, feathered by sparse, long, setules. Inner subdistal lobe (in terms of Kotov, 1997a) (Fig. 4A: sdl) fused with outer distal lobe, with a single thin, long seta (longer that distal segment of large seta), bearing delicate setules distally. On inner limb edge, three soft setae, no bunch of long setules near these setae. Two robust ejector hooks (Fig. 4A: ejh) somewhat different in size, armed with short denticles. The maxillar process (Fig. 4A: mxp), a derivative of gnathobase I, with a single short, densely setulated seta.

Limb II relatively small, with epipodite supplied with a short finger-like projection. Inner limb portion with an anterior row of six stiff setae (Fig. 4B: 1–6), seta 1 specially long, and disjuncted posterior row two setae (Fig. 4B: pos): a seta near gnathobase and another one near the proximal end of the limb. Gnathobase II with distal armature (Fig. 4C: dag) of three setae of different armature. Filter plate consists of five long setulated setae (Fig. 4B: fpl).

Limb III with epipodite (Fig. 4D: epp) supplied with a short finger-like projection. Exopodite rectangular, with five distal (Fig. 4D: 1–5, dis) two lateral (Fig. 4D: 6–7, lat) and setae, seta 2 longest. All these setae covered by long setules. Distal endite with two anterior setae (Fig. 4D: 1–2), seta 3 reduced. Proximal endite with two long anterior setae (Fig. 4F: 4–5). Seven soft setae on posterior face of limb (Fig. 3E: a–g), plus a seta of unclear homology (Fig. 4D). Distal armature of gnathobase (Fig. 4F: dag) with four setae. Filter plate (Fig. 4D: fpl) with five setae of subequal size.

Limb IV with small ovoid setulated pre-epipodite (Fig. 4G: pep) and an epipodite bearing a long finger-like projection (Fig. 4G: epp). Exopodite (Fig. 4G: ext) circular, with eight soft setae, no subdivision into lateral and distal setae, seta 2 longest, covered by fine stiff setulae, others with long setules; setae 3–8 increasing in size proximally. Inner distal portion with four anterior setae (Fig. 4G: 1–4). Four thin long setae on posterior limb face. Distal armature of gnathobase with two elements. Filter plate with four setae subequal in size.

Limb V with a small, ovoid setulated pre-epipodite (Fig. 4H: pep) and an epipodite (epp) supplied with a long finger-like projection. Exopodite with five soft setae covered by

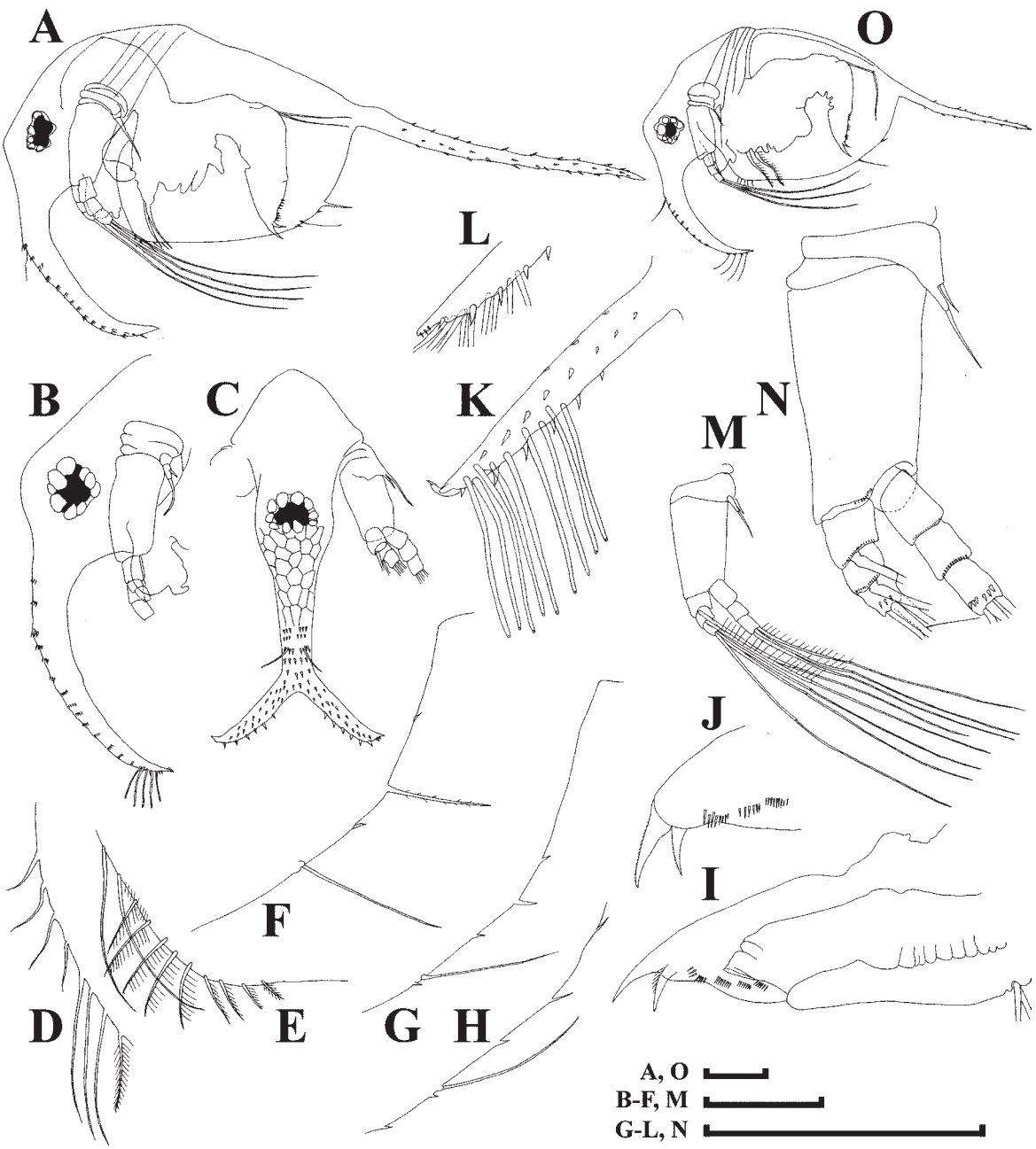

Fig. 3. *Bosminopsis negrensis*, parthenogenetic female from Rio Negro above Manaus, Amazonas. Brazil. A — large parthenogenetic female, lateral view; B — head, lateral view; C — head, anterior view; D–E — antero-ventral valve portion; F–H — postero-ventral valve portion; I–J — postabdomen and its distal portion; K–L — tip of antenna I; M–N — antenna II; O — juvenile female. Scale bar: 0.1 mm.

Рис. 3. *Bosminopsis negrensis*, партеногенетическая самка из Рио Негро выше Манауса, Амазонас, Бразилия. A — крупная партеногенетическая самка, вид сбоку; B — голова, вид сбоку; C — голова, вид спереди; D–E — береднебрюшная часть створки; F–H — заднебрюшная часть створки; I–J — постабдомен и его дистальная часть; K–L — кончик антенны I; M–N — антенна II; O — ювенильная самка. Масштабная линейка: 0,1 мм.

long setules (Fig. 4H: 1–5). The distalmost portion of limb as a densely setulated flat lobe, two soft setae near it, two setulated setae of subequal length near gnathobase. Filter plate with two long setae.

JUVENILE FEMALE. Body more round, with shorter caudal spine supplied by less developed denticles (Fig. 3O).

EPHIPPIAL FEMALE. Not found in our material and not described by Brandorff [1976].

JUVENILE MALE. Body somewhat lower than in adult female elongated, anteriormost head portion projected (Fig. 2E). Armature of valve as in female. Postabdomen as in female, gonopores not visible (Fig. 2F). Antennae I fused to rostrum. Limb I with a short, thick copulatory hook.

ADULT MALE. Not found in our material, description is given according to Brandorff [1976]. Body low, dorsal contour of head humped, dorsal contour of carapace straight

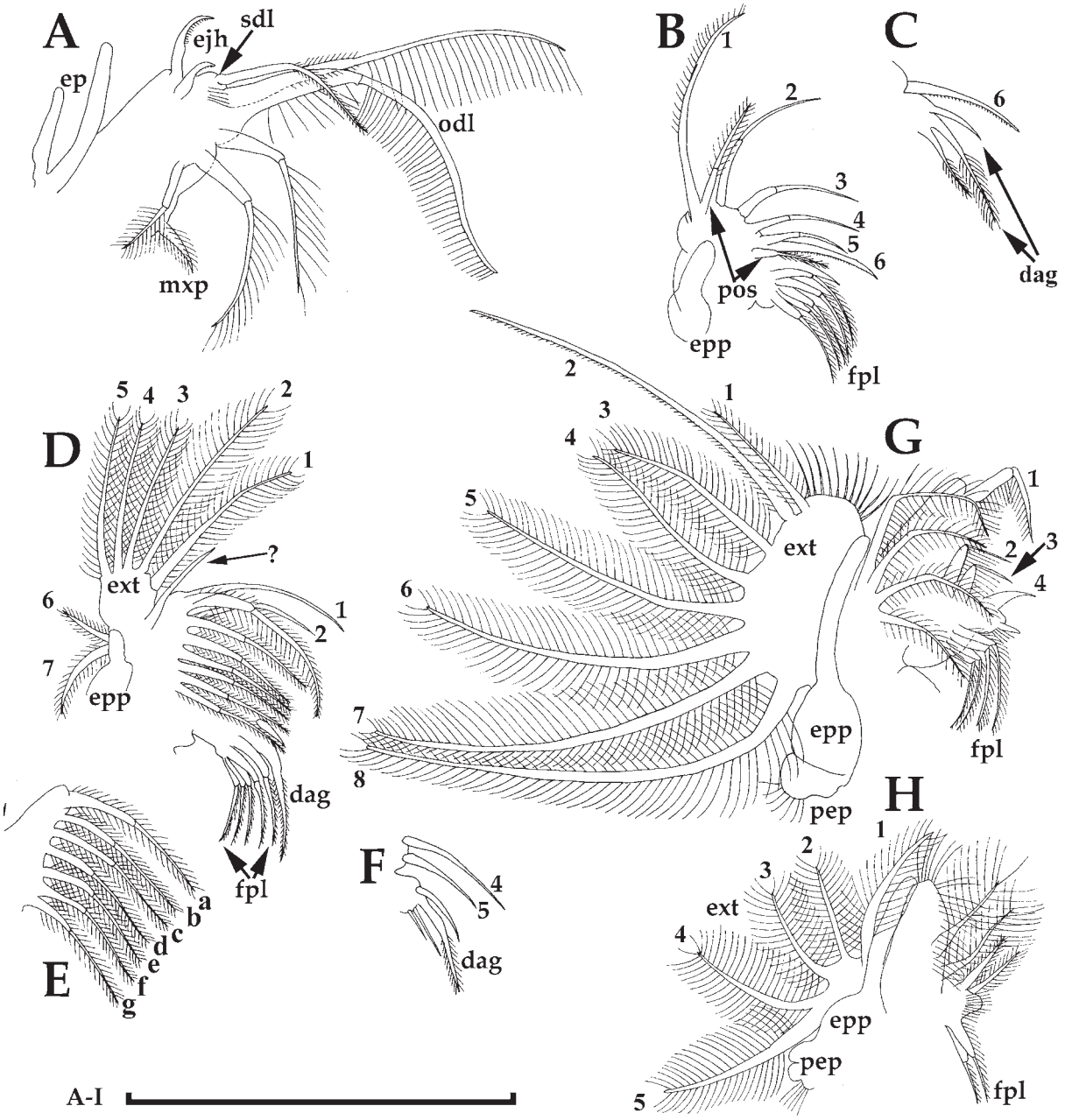

Fig. 4. *Bosminopsis negrensis*, thoracic limbs of parthenogenetic female from Rio Negro above Manaus, Amazonas. Brazil. A — limb I, inner view; B — limb II; C — distal armature of its gnathobase; D — limb III; E — posterior setae on inner limb portion; F — distal armature of gnathobase; G — limb IV; H — limb V. Scale bar: 0.1 mm.

Рис. 4. *Bosminopsis negrensis*, торакальные конечности партеногенетической самки из Рио Негро выше Манауса, Амазонас, Бразилия. A — конечность I пары, вид изнутри; B — конечность II пары; C — дистальное вооружение ее гнатобазы; D — конечность III пары; E — задние щетинки на внутренней части конечности; F — дистальное вооружение гнатобазы; G — конечность IV пары; H — конечность V пары. Масштабные линейки: 0,1 мм.

[Brandorff, 1976: fig. 3: 1]. Head large, with a projected anteriormost point making ocular dome, compound eye very large [Brandorff, 1976: fig. 3: 1]. Valve armature as in female. Postabdomen similar with that in female, but with stronger marginal denticles [Brandorff, 1976: fig. 3: 3]. Position of gonopores unclear. Postabdominal claw bears a basal spine shorter than claw itself. Antenna I free, remarkably curved distally. Frontal sensory seta long, located proximally to antenna I middle, male seta undescribed, a row of setules in middle. Limb I with outer distal lobe bearing two setae of subequal size, and inner distal lobe (which is fully absent in female) with a long and a short seta and relatively large copulatory hook [Brandorff, 1976: fig. 3: 4].

SIZE. Length of females (without mucro) 0.35–0.45 mm in our material, 0.28–0.41 mm according to Brandorff [1976], 0.23–0.40 according to Weibezahn *et al.* [1990].

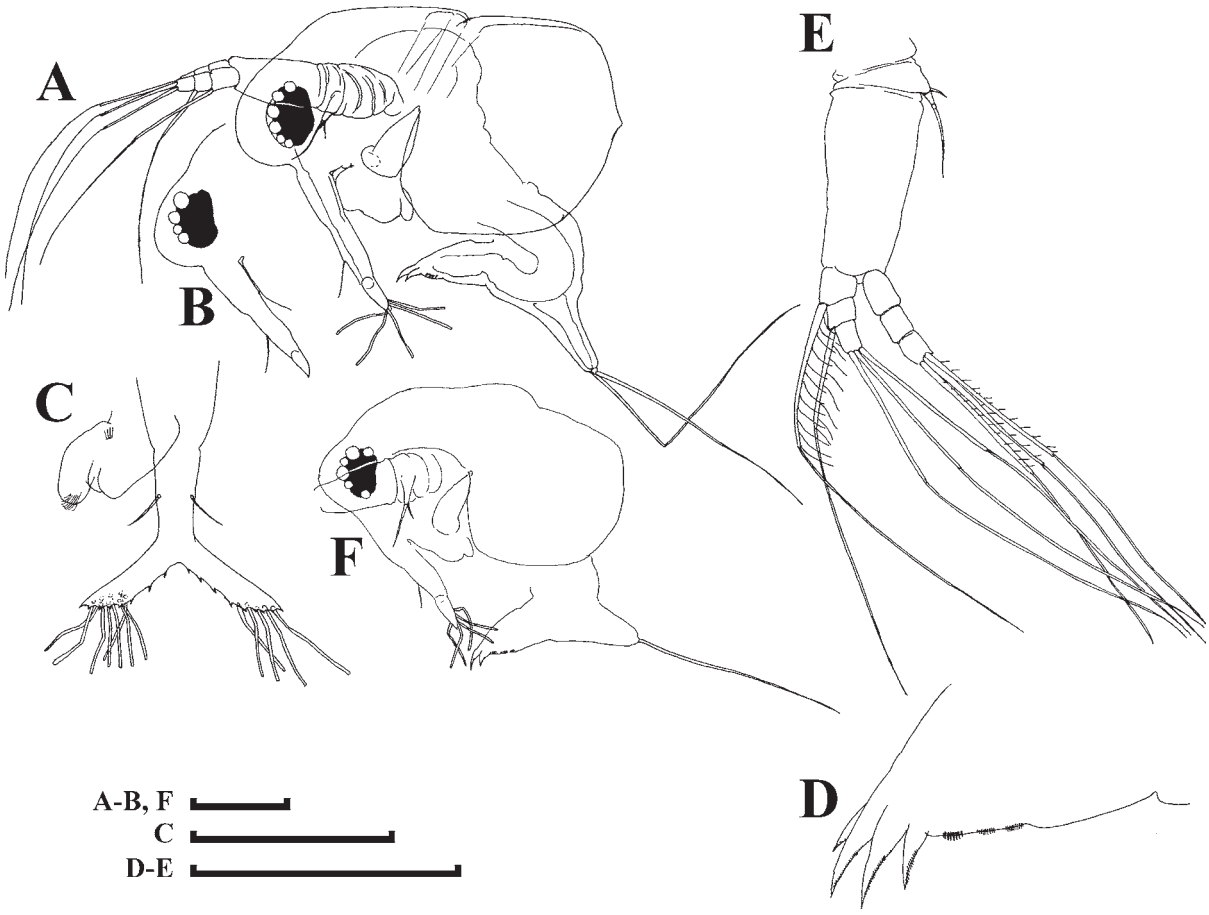

Fig. 5. *Bosminopsis brandorffi*, parthenogenetic female from Lago Chamaleão, Ihla da Marchantaria, Rio Solimões 2–3 km from the mouth of Rio Negro, Amazonas. Brazil. A — adult parthenogenetic female, lateral view; B — its head, lateral view; C — head, anterior view; D — postabdomen; E — antenna II; F — juvenile female. Scale bar: 0.1 mm.

Рис. 5. *Bosminopsis brandorffi*, партеногенетическая самка из Озера Чамалеао, Остров Марчантария, Амазонка 2–3 км от устья Рио Негро, Амазонас, Бразилия. А — взрослая партеногенетическая самка, вид сбоку; В — голова, вид сбоку. Масштабная линейка: 0,1 мм.

DIFFERENTIAL DIAGNOSIS. This taxon differs from any other taxa of the genus in a long ("*Daphnia*-like") caudal spine and only six posterior setae on inner portion of limb III.

DISTRIBUTION. Lower Rio Negro in the region of Manaus, and also lakes in this area [Brandorff, 1976; Hardy, 1980; Ghidini, Santos-Silva, 2011, 2018], several localities in High Orinoco basin in South Venezuela [Weibezahn *et al.*, 1990; Zoppi de Roa, López, 2008]. The species clearly prefer humid "black waters" with a low pH and a low ion concentration.

Bosminopsis brandorffi Rey et Vásquez, 1989
Figs 1B, 5–7.

Bosminopsis spec. in Brandorff *et al.*, 1982: 93, figs 65–66.

Bosminopsis brandorffi Rey et Vásquez, 1989: 215–218, figs 1–13.

TYPE LOCALITY. Not specified accurately in the paper of Rey & Vásquez [1989].

TYPE MATERIAL. Holotype. A mature parthenogenetic female in 4% formaldehyde solution, tube NE-SI-63a. Paratypes. 3 specimens from "Rio Negro, près Tapuruquara", NE-HS-1-63, NE-HS-2-63, NE-HS-3-63; 1 specimen from "Rio Nhamundá", NH-GOB-19-75; 2 females from "l"Orénoque, près Samariapo", 1 CHE-OR-SA-85, 1 BHE-OR-SA-85; 1 specimen from "l"Orénoque près Puerto-Ayacucho", 2 BHE-OR-PA-85. Holotype and paratypes are kept at the collection of l'Instituto Nacional de Pesquisas da Amazônia, Manaus, Brazil.

MATERIAL EXAMINED. Brazil (Amazonas):1 parthenogenetic female from Rio Negro, left margin above Manaus (3.12°S; 60.05°W), collected on 15.09.1959 by H. Sioli, AAK 1999-063; 5 parthenogenetic females from Rio Negro above Manaus (3.23°S; 60.08°W), collected on 21.09.1975 by G.-O. Brandorff, AAK 1999-064; 10 parthenogenetic females from Lago Chamaleão (3.25°S; 60.0°W), Ihla da Marchantaria, Rio Solimões 2–3 km from the mouth of Rio Negro, collected on 8.08.1996 by E.R. Hardy, AAK 2002-133.

SHORT DIAGNOSIS. Dorsal margin slightly convex. Postero-dorsal angle as a rounded projection, without a spine. Head in lateral view with a strong ocular dome. A very small seta (possibly, reduced *seta Kurzi*), at postero-ventral valve margin. Antennae I with short fused proximal portion, their distal portions without denticles. On proximal segment of the seta on outer distal lobe of limb I, setules strong and additionally feathered. Subdistal seta short. Six soft setae on posterior face of limb III. Setae 3–8 of exopodite III subequal in size. Size up to 0.48 mm.

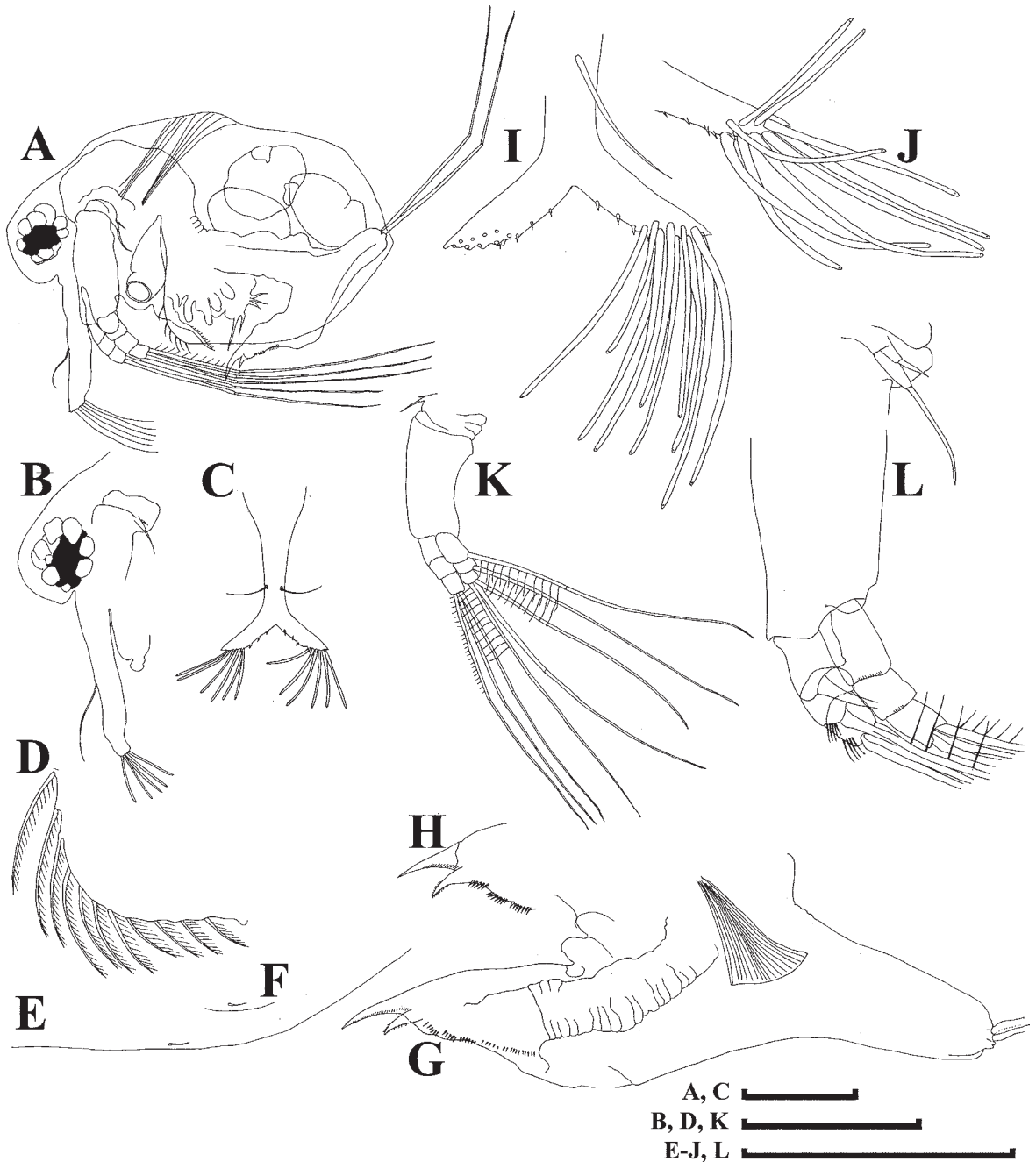

Fig. 6. *Bosminopsis brandorffi*, parthenogenetic female from Rio Negro above Manaus, Amazonas. Brazil. A — large adult, lateral view; B — its head, lateral view; C — head, anterior view; D — antero-ventral vavle portion; E–F — postero-ventral valve portion; G–H — postabdomen and its distal portion; I — antennae I; J — tip of antenna I; K–L — antenna II. Scale bar: 0.1 mm.

Рис. 6. *Bosminopsis brandorffi*, партеногенетическая самка из Рио Негро выше Манауса, Амазонас, Бразилия. A — крупная самка, вид сбоку; B — голова, вид сбоку; C — голова, вид спереди; D — переднебрюшная часть створки; E–F — заднебрюшная часть створки; G–H — постабдомен и его дистальная часть; I — антенны I; J — кончик антенны I; K–L — антенна II. Масштабные линейки: 0,1 мм.

ADULT PARTHENOGENETIC FEMALE. Body transparent, in general ovoid, dorsal margin convex, with a slight depression at posterior head portion (Figs 1B, 5A, 6A). Reticulation not visible. Postero-dorsal angle as a rounded projection, postero-ventral angle widely rounded. Head in lateral view with a strong ocular dome, body contour between head and long proboscis rostral part remarkably depressed (Figs 5B, 6B–C). Any head pores not found. Compound eye large as compared to any other species of the genus. Ocellus absent. Labrum as a fleshy appendage with a small distal labral plate (Fig. 5C). Antero-ventral portion of valves with setulated setae (Fig. 6D), middle of ventral margin lacking any armature. A very small seta (possibly, reduced *seta Kurzi*), at postero-ventral valve margin.

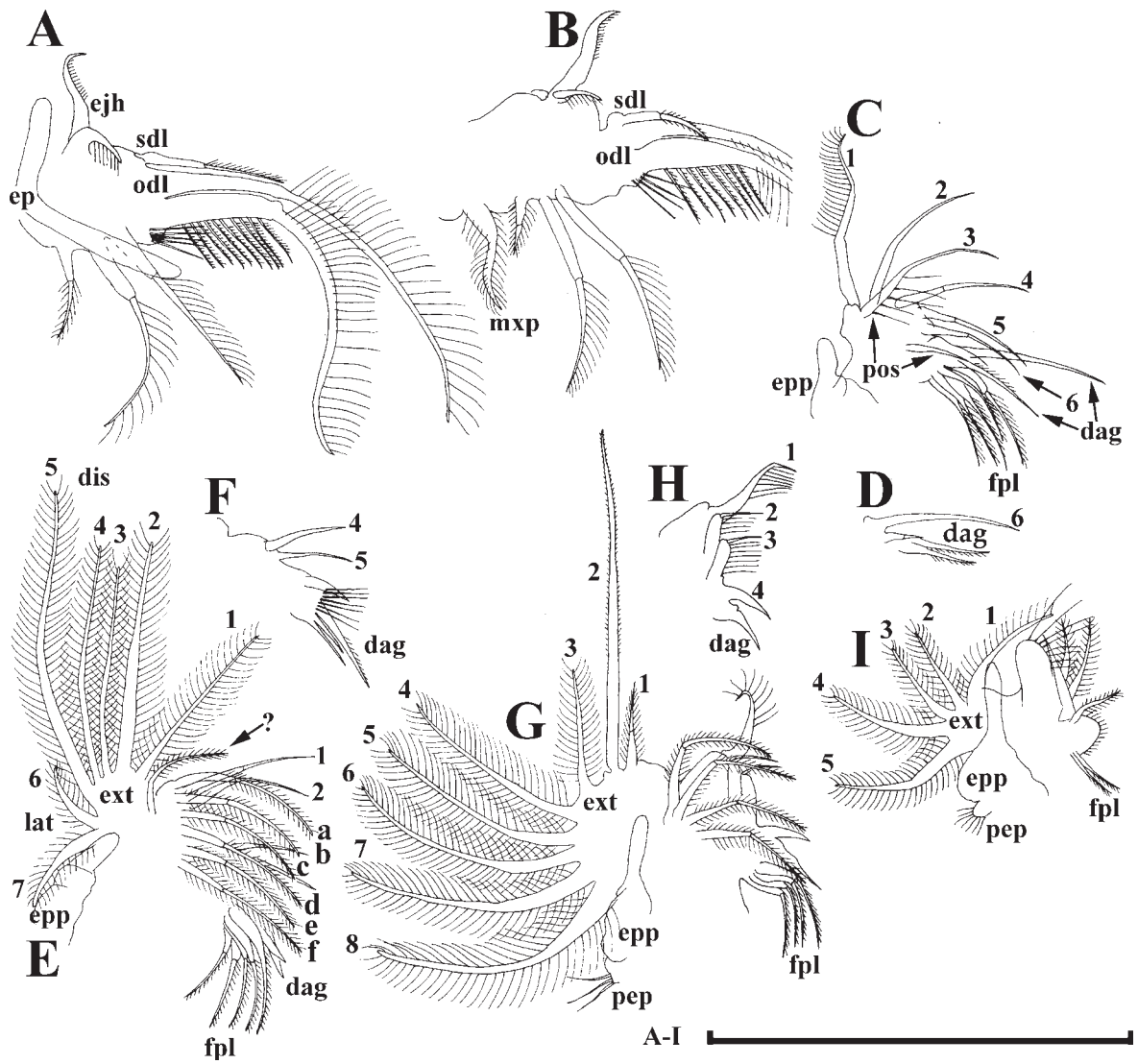

Fig. 7. *Bosminopsis brandorffi*, thoracic limbs of parthenogenetic female from Rio Negro above Manaus, Amazonas. Brazil. A — limb I, outer view; B — its inner view; C — limb II; D — distal armature of its gnathobase; E — limb III; F — distal armature of its gnathobase; G — limb IV; H — its inner portion; I — limb V. Scale bar: 0.1 mm.

Рис. 7. *Bosminopsis brandorffi*, торакальные конечности партеногенетической самки из Рио Негро выше Манауса, Амазонас, Бразилия. A — конечность I пары, вид снаружи; B — вид изнутри; C — конечность II пары; D — дистальное вооружение гнатобазы; E — конечность III пары; F — дистальное вооружение гнатобазы; G — конечность IV пары; H — ее внутренняя часть; I — конечность V пары. Масштабные линейки: 0,1 мм.

Postabdomen with a very large proximal projection for postabdominal setae (Figs 5A, 6A, G). Preanal margin long, concave, without setules. Anal margin slightly convex, preanal angle smooth, postanal angle smooth. Anal and postanal portion with groups of small denticles. Postabdominal claw terminally supplied with a strong basal spine (with length of 0.5–0.7 of claw length), both claw and basal spine slightly curved (Fig. 5D). Postabdominal seta bisegmented, remarkably longer than postabdomen (Fig. 6A).

Antennae I with proximal portions fused together and with rostrum. Both lateral portions directed downwards and posteriorly laterally. Antennular sensory setae located on fused portion of antennae I. Distal portions with few marginal denticles (Figs 5C, 6I–J) and a row of nine aesthetascs unequal in size distally.

Antenna II (Fig. 6K–L) with a very short coxal portion bearing a long seta and a short seta on a conical elevation, thick basal segment and short three-segmented exopod and endopod, antennal formula: setae 0-0-3/1-1-3, no any spines on segments, apical spines reduced. All apical and lateral (on endopod first and second segment) setae subequal in size, covered by sparsely located setules proximally.

Thoracic limbs in general as in previous species, but some obvious differences were found. On proximal segment of the seta on outer distal lobe, setules strong and additionally feathered, subdistal seta short (its tip reaches distal end of large ODL seta) and proximalmost seta on limb corm very short (Fig. 7A–B). On limb II, distalmost posterior seta armed with long, sparse setules (Fig. 7C), and shortest seta in distal armature of gnathobase very short (Fig. 7D). On

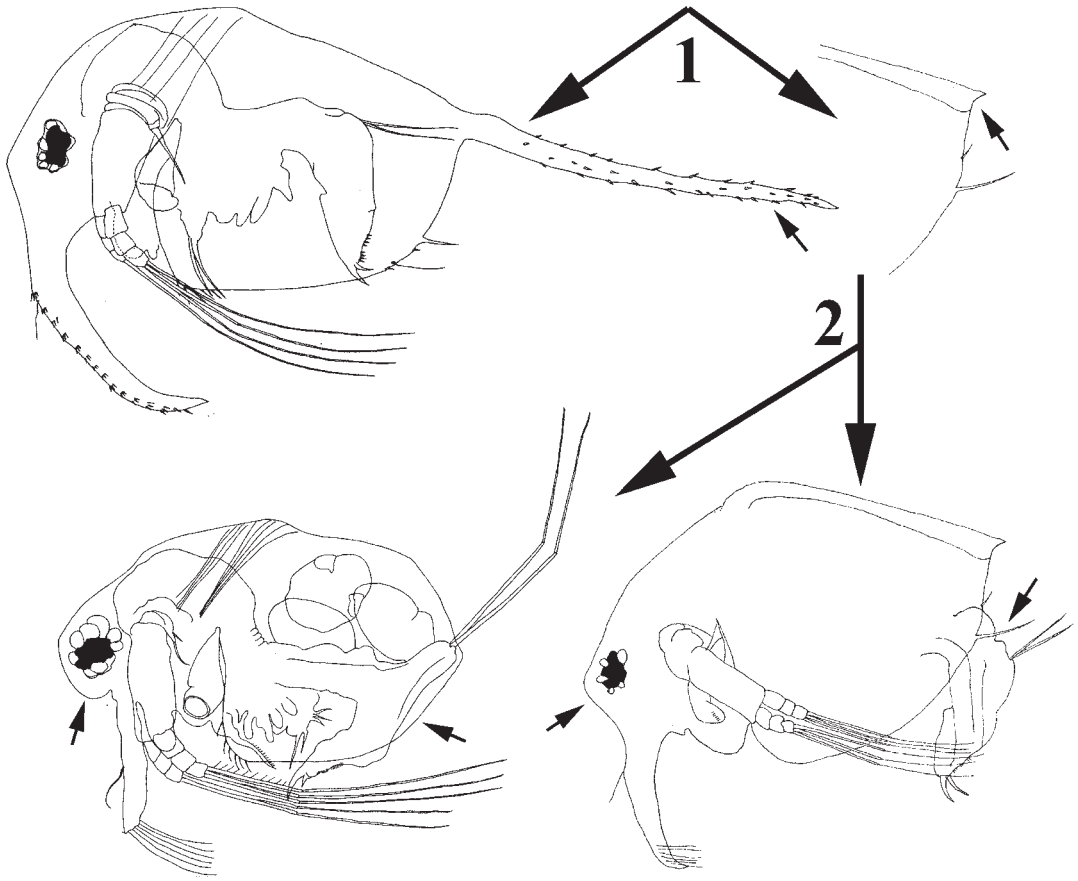

Fig. 8. Pictorial key for South American species of *Bosminopsis*.
Рис. 8. Пиктографический ключ для южноамериканских видов рода *Bosminopsis*.

exopodite III, seta 4 longest, six posterior setae on limb corm (Fig. 7E: a–f), distalmost seta in distal armature of gnathobase short (Fig. 7F). Lateral setae of exopodite IV subequal in size (Fig. 7G), while setae at inner limb margin as in previous species (Fig. 7H). In inner margin of limb V, two proximal setae strongly unequal in size (Fig. 7I).

JUVENILE FEMALE. Body more elongated, with larger head and less developed brood pouch (Fig. 6F).

EPHIPPIAL FEMALE, MALE. Unknown.

Size. Length of females 0.30–0.41 mm in our material, 0.26–0.48 mm according to Rey, Vásquez [1989].

DIFFERENTIAL DIAGNOSIS. It differs from any other species in a very large compound eye and ocular dome in female, strong depression between head and proboscis rostral part and a strong proximal projection on postabdomen.

DISTRIBUTION. Rio Negro and its affluents (Jauaperi, Jufaris), Rio Nhamundá in Amazonas; Rio Aripuana in Mato Grosso; Moju River and Curûa-Una Reservoir in Para in Brazil; Rio Xingu in Pará [Matsumura-Tundisi *et al.* 2015], Cuniã Lake in Rondônia [Negreiros, 2014]; Tupé Lake in Amazonas [Ghidini, Santos-Silva, 2011]; Orinoco basin (Samariapo, Puerto-Ayacucho, El Burro, Ciudad Bolivar) in Venezuela [Rey, Vásquez, 1989].

KEY FOR IDENTIFICATION OF SPECIES IN THE GENUS *BOSMINOPSIS* IN SOUTH AMERICA (FIG. 8):

1. Postero-dorsal angle with a long caudal spine .... *Bosminopsis negrensis* Brandorff, 1976
– Postero-ventral angle with a short triangular projection, or smooth 2
2. Postero-ventral angle of valve in juvenile females and males with mucro; ocular dome slightly projected .... *Bosminopsis deitersi* Richard, 1895
– Postero-ventral angle of valve in juvenile females and males without mucro; ocular dome strongly projected .. .. *B. brandorffi* Rey et Vasquez, 1989

Discussion

Kotov [1997a] demonstrated that the thoracic limbs in different populations of *B.* cf. *deitersi* are uniformly organized: the set of setae is exactly the same in different limb portions in all studied females (males are still poorly studied). Recently it was found that there are no differences in limb morphology between *B. deitersi* and *B. zernowi* (a single species from the B. *deitersi* group occurring in Northern Eurasia), see Garibian *et al.* [2021]. Here, our new study confirmed a remarkable similarity of the thoracic limbs in all known species from this genus. The only difference in the set of setae is six posterior setae on limb III in *B. negrensis* vs. seven setae in *B. deitersi* [Kotov, 1997a], *B. zernowi* [Garibian *et al.*, 2021] and *B. brandorffi* (this study). The situation in *Bosminopsis* therefore is simi-

lar to *Bosmina* with a full uniformity of the limb morphology [Kotov, 1995, 1997a; Kotov *et al.*, 2009] having also the exactly identical set of the setae in each limb portion, although this set in *Bosmina* is remarkably different from that in *Bosminopsis*.

Kotov [1997a] listed sharing traits of the bosminid limbs and confirmed monophyly of the Bosminidae in contrast to the opinion on necessity to separate a special family Bosminopsidae Meissner, 1903 for a single genus *Bosminopsis* [Meissner, 1903]. Then Kotov [2013] re-analysed the bosminid limb peculiarities based on previous data on *Bosmina* spp. and *Bosminopsis deitersi* limbs, and confirmed the previous opinion. Here we demonstrated that two other species of *Bosminopsis* have no serious differences in the set of setae from *B. deitersi*, and we can also confirm the eligibility of the previous conclusions. Family Bosminidae belongs to the suborder Radopoda Dumont et Silva-Briano, 1998 *sensu* Kotov [2013]. Most probably, bosminids were originated from a littoral chydorid-like ancestor [Woltereck, 1920]. They apparently penetrated the plankton independently of the daphniids, and in different geological epoch [Kotov, 2013]. Their limbs are more similar to the chydorid-macrothricid rather than daphniid limbs. Unfortunately, functional morphology of *Bosminopsis* is not studied, but presumably feeding mode of the former is relatively similar to that in *Bosmina* (see Graf [1930]). In tropical-subtropical water bodies the two genera frequently co-occur, and their ecological niches seem to be similar or, at least, strongly overlapping.

At the same time, morphology of valves is different in different species of *Bosminopsis*, analogously to differences between the *Bosmina* taxa. In the latter genus, just aforementioned characters were discussed in the context of adaptation to the planktonic mode of life [Woltereck, 1920; Dodson, 1974, 1989; Kerfoot, 1988]. These valve projections in *Bosminopsis* are antipredator protective structures [Kotov, 1997b], well-known in other cladoceran plankters, *Daphnia* and *Bosmina* [Dodson, 1974; Kerfoot, 1978, 1988]. These structures are known as a subject of a strong instar, seasonal and inter-populational variability. Analogous valve projections are known in other planktonic and neustonic daphniids: mucro in *Scapholeberis* Schödler, 1858 and *Megafenestra* Dumont et Pensaert, 1983 [Dumont, Pensaert, 1983; Alonso, 1996] and or short caudal spine in some *Ceriodaphnia* Dana, 1853 [Alonso, 1996].

In *Bosminopsis* their presence/absence is a species-specific character. In all taxa of the *B. deitersi* group, mucro is longest in smallest juveniles and then is decreasing with age sometimes up to full disappearance [Kotov, 1997b]. But the mucro length in small juveniles is moderately varying among the populations of *B. deitersi*, differences between populations of the same species are small as compared to such variability in daphniids. Here we can see differences in the evolution of convergent structures in two different evolutionary branches of the plankters, the bosminids and daphniids.

Unfortunately, ephippial females and males of aforementioned two taxa are unknown or not studied in detail, although they usually bear characters which are valuable for species discrimination as compared to parthenogenetic females [Goulden, 1966; Kotov *et al.*, 2009; Smirnov, Kotov, 2018].

The plankton is studied more thoroughly than the littoral microfauna in all regions of the world, including the tropics of different continents. Most probably, any specific taxa of *Bosminopsis* other than those belonging to the large *deitersi*-group are present only in tropical South America together with other endemic cladoceran taxa [Daday, 1905; Van Damme *et al.*, 2005; Sousa *et al.*, 2017; Sousa, Elmoor-Loureiro, 2018]. Recently Brazilian cladocerans are under intensive revision [Sousa *et al.*, 2014; Sousa, Elmoor-Loureiro, 2019; Sousa *et al.*, 2018], but still new records are possible. Such studies need to be continued.

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This paper is dedicated to the memory of renown Russian carcinologist V.A. Spiridonov.

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