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A new species of *Lynceus* (Crustacea: Branchiopoda: Laevicaudata) from Patagonia, with comments on laevicaudatan systematics

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Abstract

Lynceus mallinensis, a new species of laevicaudatan clam shrimp is described from a single temporary pool in Chubut province, Patagonia, Argentina. The form of the male rostrum necessitates a reevaluation of rostral characters for the genus. This species differs from *L. rotundirostris*, the only known *Lynceus* from Patagonia, by the absence of a distinct umbo. *L. mallinensis* is the fourth species of this genus and the fifth laevicaudatan to be reported from South America. The systematical position of the Laevicaudata is discussed in the Introduction.

Key words: Clam Shrimp, Lynceidae, Argentina

Resumen

Lynceus mallinensis, una nueva especie de Laevicaudata, es descrita a partir de material recolectado en un mallín temporal en la provincia de Chubut, Patagonia, Argentina. Esta especie difiere de *L. rotundirostris*, la única especie descrita en Patagonia, por la ausencia de umbo. *L. mallinensis* es la cuarta especie del género y el quinto Laevicaudata registrado en América del Sur.

Introduction

Laevicaudata Linder, 1945 are sometimes treated as a suborder of the Diplostraca Gerstaecker, 1866, along with the suborders Spinicaudata Linder, 1941, Cyclestherida Sars, 1899 and the Cladocera Latreille, 1829 (Martin & Davis 2001) although Linder (1945), Tasch (1969), Fryer (1987), Martin and Belk (1988), Olsen (2003; 2005) and Richter (2004) presented ample evidence that the group represents a unique order, distinct from the Diplostraca. Laevicaudata, Spinicaudata and Cyclestherida are commonly referred to as 'clam shrimp' and often as the 'Conchostraca' although this term has lost all taxonomic meaning, and is no longer considered valid (e.g. Fryer 1987; Martin & Belk 1988; Martin & Davis 2001). Laevicaudata share the large, bivalved carapace and the modified male first thoracopods with the two diplostracan clam shrimp suborders. However, these characters are convergent between Laevicaudata and Diplostraca, having different origins (Gurney 1926; Botnariuc 1947; Fryer 1987; Martin & Belk 1988). Bivalved carapaces are also shared with other classes (e.g. Ostracoda, some Maxillopoda).

The laevicaudatan carapace begins in the early instars as a shield-like carapace as in Notostraca Sars, 1867, and then splits to form two separate valves, hinged together in a groove (Tasch 1969; Dumont & Negrea 2002; Olesen 2003), whereas the diplostracan carapace begins as a folded structure and continues to grow without developing a true hinge (Tasch 1969; Martin *et al.* 1986; Walossek 1993; Olesen 2003). The laevicaudatan carapace does not develop growth lines (there may be one unspecified exception (Fryer 1987)) as does the diplostracan carapace.

The shape of the laevicaudatan head and the mouthpart morphology are different in form from any diplostracan (Sars 1896; Linder 1945; Tasch 1969; Martin *et al.* 1986; Fryer 1987; Dumont & Negrea 2002; Olesen 2003; Rich-

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ter 2004). Contrary to Tasch (1969), Pennak (1989), Smith (2001) and Dumont and Negrea (2002), the head as well as the body are encompassed by the carapace (in all the species examined for this study). However, the head can be projected outside the carapace and withdrawn again, unlike the diplostracan clam shrimp.

The male claspers are different also. In Laevicaudata the movable "finger is endite VI, opposing against endite III, with endites IV and V as lateral "palps. In Spinicaudata the movable "finger is endite V opposing against endite IV, with VI and a lateral "palp, and endite III is removed from the clasper, positioned further down the face of the limb. According to Walossek (1993) the segmentation and number of the thoracomeres (12) in Laevicaudata is similar to Anostraca Sars, 1867, while the other clam shrimp suborders and Cladocera have a similar segmentation. Internally, Laevicaudata have a heart with three ostia, the diplostracans have four, and Laevicaudata have the vas deferens terminating in the 'postabdomen', while in Diplostraca they terminate in thoracic segment 11 (Linder 1945; Dumont & Negrea 2002).

Molecular analyses (Spears & Abele 2000; Brabrand *et al.* 2002) and morphological cladistic analysis (Richter 2004) demonstrate polyphyly in the traditional 'Conchostraca'. In fact both molecular analyses place the Laevicaudata as a lineage older than the diplostracans, more closely allied to the Notostraca. Maintaining the Laevicaudata as a suborder of the Diplostraca obscures the obvious independence of this lineage within Branchiopoda. Therefore, following Fryer (1987) we treat Laevicaudata as an order of the Branchiopoda, separate and distinct from Diplostraca.

Laevicaudata contains the single family Lynceidae Stebbing, 1902, which is nearly cosmopolitan, being reported from all continents except Antarctica (Martin & Belk 1988; Brendonck *et al.* 2008; Rogers 2009). Lynceidae is comprised of three genera: *Lynceus* Müller, 1776, *Lynceiopsis* Daday, 1912 and *Paralimnetis* Gurney, 1931. Martin and Belk (1988) and Brendock *et al.* (2008) report 36 described species worldwide, although the fauna of Australia is in need of revision (B. V. Timms, pers. comm.) and at least one undescribed species occurs in Canada (Rogers & Martin in prep.). The genus *Lynceus* is known from seasonally astatic wetlands, streams and lakes (Retallack & Clifford 1980; Martin & Belk 1988; Yoon & Kim 2000; Brendock *et al.* 2008; Rogers 2009). Five species are recorded from the Neotropical region to date (Martin & Belk 1988; Roessler 1995; Brendock *et al.* 2008). Only four laevicaudatan species have been reported from South America: *Lynceus aequatorialis* Daday, 1927, *L. rotundirostris* Daday, 1902 from Argentina, *L. tropicus* Daday, 1927 from Colombia and Venezuela and *Paralimnetis rapax* Gurney, 1931 from Paraguay.

We report a new species of *Lynceus* from Argentinean Patagonia. This represents the fourth *Lynceus* species from South America, the eighth for the Americas and the 32nd species for the world.

Materials and methods

This species was discovered by the first two authors and M.L. Miserendino collecting in Patagonia. Collections were made with a D-frame type dip net (1 mm in mesh size). Specimens were fixed in 10% formalin and preserved in 70% ethanol. The specimens were examined under a Leica stereomicroscope. Whole bodies were dissected and temporary mounted in glycerol. Drawings were made with the aid of a camera lucida coupled to a Leica DMLB microscope and a Leica MZ6 stereomicroscope. Body lengths of the animals were measured with a linear eyepiece micrometer inserted in a Zeiss Stemi DV 4 stereomicroscope. Biogeographical areas are according to Morrone (2006).

All specimens are deposited in the collections of the Museo de La Plata (La Plata, Buenos Aires, Argentina) and D. Christopher Rogers (Lawrence, Kansas, United States) collections.

Comparative material: the descriptions and figures of many species were compared with our material, as specimens were not available or the types have been damaged or lost. These species include: *Lynceus simiaefacies* Harding, 1941, *L. rotundirostris* (Daday, 1902), *L. aequatorialis* Daday, 1927, and *L. tropicus* Daday, 1927. The following species were examined directly for this study:

Lynceus biformis (Ishikawa, 1895). JAPAN: SHIGA PREFECTURE: Kusatsu – Shi, Kataoka – Cho, rice paddy, 26 May 2004, M. J. Grygier, DCR- 611. TAIWAN: Yangmingshan National Park, Siangtian Pond, N 25°10'26'', E 121°29' 56'', S.-L. Huang, C.-C. Wang, W.-P. Wang, & L.-S. Chou; Det. D.C. Rogers, DCR-723

Lynceus brachyurus (Müller, 1776)**.** CANADA: ONTARIO: King Twp., 79˚ 38' 02''W 43˚ 55' 96''N, 22 April 2000, 4 males, 6 females, K. A. L. Reading, Det. D. C. Rogers, DCR-364. SASKATCHEWAN: On road from

Prince Albert to La Ronge to Yellow Knife, 28 June 1994, 23 males, 31 females. K. A. L. Reading, Det. D. C. Rogers, DCR-345. USA: CALIFORNIA: Lassen County: Sage flat pool, ~8 miles north of Termo, on west side of Highway 395, 27 March 1998, 4 males, 4 females, D.C. Rogers. Modoc County: Rail-road bed pool at intersection of rail-road and Clear Lake Road, east of Highway 139, south of Tule Lake City, 27 March 1998, 2 males, 1 female, D.C. Rogers, R.E. Hill. San Joaquin County: Large vernal pool south of Buena Vista Road, 7 males, 4 females, D.C. Rogers, DCR-103. Shasta County: Redding, Shasta Bible College Pond, Winter Lake between HWY 44 and Hartnell Avenue, March 1987, 9 males, 13 females, D.C. Rogers, DCR-13. MONTANA: Deer Lodge County: Pinter Lake pool, 23 July 1995, two females, D. L. Gustafson, Det. D. C. Rogers, DCR- 574. Glacier County: Cut Bank Creek Road, Pond #9, 7 July 1956, 7 males, 11 females, R. Brunson. OREGON: Lake County: Squaw Buttes Lake, 24 May 1999, 1 male, D.C. Rogers, DCR-175. Sycan Marsh, 23 June 2001, 1 male, W. Fields, Det. D. C. Rogers, DCR-416.

Lynceus brevifrons (Packard, 1877). USA: NEW MEXICO: Cibola County: N35˚ 03’ 06.70”, W107˚ 59’ 48.96”, 1 male, B. K. Lang, DCR-459. Harding County: Rock Lake Playa, 7 males, 5 females, D. Garcia de la Cadena, Det. D. C. Rogers, DCR- 618. Hidalgo County: Schoolhouse Tank, Gray Ranch, Animas Valley, 21 September 2000, 1 male, 1 female, D.C. Rogers, B. K. Lang, DCR-238.

Lynceus gracilicornis (Packard, 1871). USA: FLORIDA: Leon County: Leon City, Lake Manson area, past intersection of Road 305 and 303, in small pool, 28 August 2001, 3 males, 3 females, T. Spears, Det. D. C. Rogers, DCR-393. GEORGIA: Baker County: Ichauway Plantation, George Sand Pond, 20 March 2003, 2 males, 5 females, J. Jensen, Det. D. C. Rogers, DCR-521. Early County: Shackleford-William’s Bluff Preserve (TNC), 21 March 2003, 2 males, J. Jensen & T. Floyd, Det. D. C. Rogers, DCR-516. Newton County: 2 April 1998, 3 males, 3 females, J. Battle, Det. D. C. Rogers, DCR-389. NORTH CAROLINA: Craven County: Cherry Point Marine Air Station, 20 April 1993, 2 females, A. L. Broswell, Det. D. Belk, DCR-415.

Lynceus macleayanus (King, 1855). AUSTRALIA: WESTERN AUSTRALIA: The Humps rock gnammas, north of Hyden, 21 August 2004, 4 males, 3 females, D. C. Rogers, E. C. L. Rogers, B. V. Timms, DCR - 626.

Lynceus mucronatus (Packard, 1875). USA: MONTANA: Madison County: Hidden Lake pool, 30 June 1990, 5 males, 7 females, D. L. Gustafson, Det. D. C. Rogers, DCR- 576.

Lynceus tatei (?) (Brady, 1886). AUSTRALIA: WESTERN AUSTRALIA: Mundijong – Serpentine, south of Perth, pools along railroad tracks south of town, 16 August 2004, 9 males, 11 females, D. C. Rogers, E. C. L. Rogers, DCR - 630.

Taxonomy

Laevicaudata Linder, 1945

Lynceidae Stebbing, 1902

Lynceus, Müller, 1776

Lynceus mallinensis sp. nov.

(figs 1–2)

Etymology. “mallín” is the original inhabitants (the Mapuche people) word to designate the typical Patagonian wetlands.

Type locality. ARGENTINA: Chubut province: State Route 15, 28 km east of Cholila town, wetland by the side of road, (42º21’43.3” S, 71º08’59.8” W)

Type material. Holotype, male deposited in Museo de La Plata. Accession number 26.724. Data of collection: December 2006; Epele, Miserendino and Pessacq leg.,.

Allotype, female; same data as holotype, deposited: Museo de La Plata. Accession number 26.725.

Paratypes: same data as holotype, 11 females, 5 males, deposited: Museo de La Plata, Accession number e no. 26.726. 1 male and 2 females, same data as holotype, deposited: Collection of D. Christopher Rogers, Accession number #DCR-782.

Diagnosis. *Male L. mallinensis* is separated from all known American *Lynceus* species except *L. brevifrons* by

the bifurcate rostral carina and the angulate rostrum in lateral view, rather than evenly curved. Male *L. mallinensis* also have four dorsal plumose setae on endite III of thoracopod I. The posterior margin of the male rostrum is covered with minute setae, a character only shared with *L. brevifrons* (Martin & Belk 1988) within the American species. Male *L. mallinensis* is most readily separated from *L. brevifrons* by the length of the bifurcate region of the rostral keel, which is approximately 50% the rostral length in *L. mallinensis* and approximately 25% in *L. brevifrons*. The presence of a row of short thick spines near clasping edge in the third endite is shared with *L. brachyurus*.

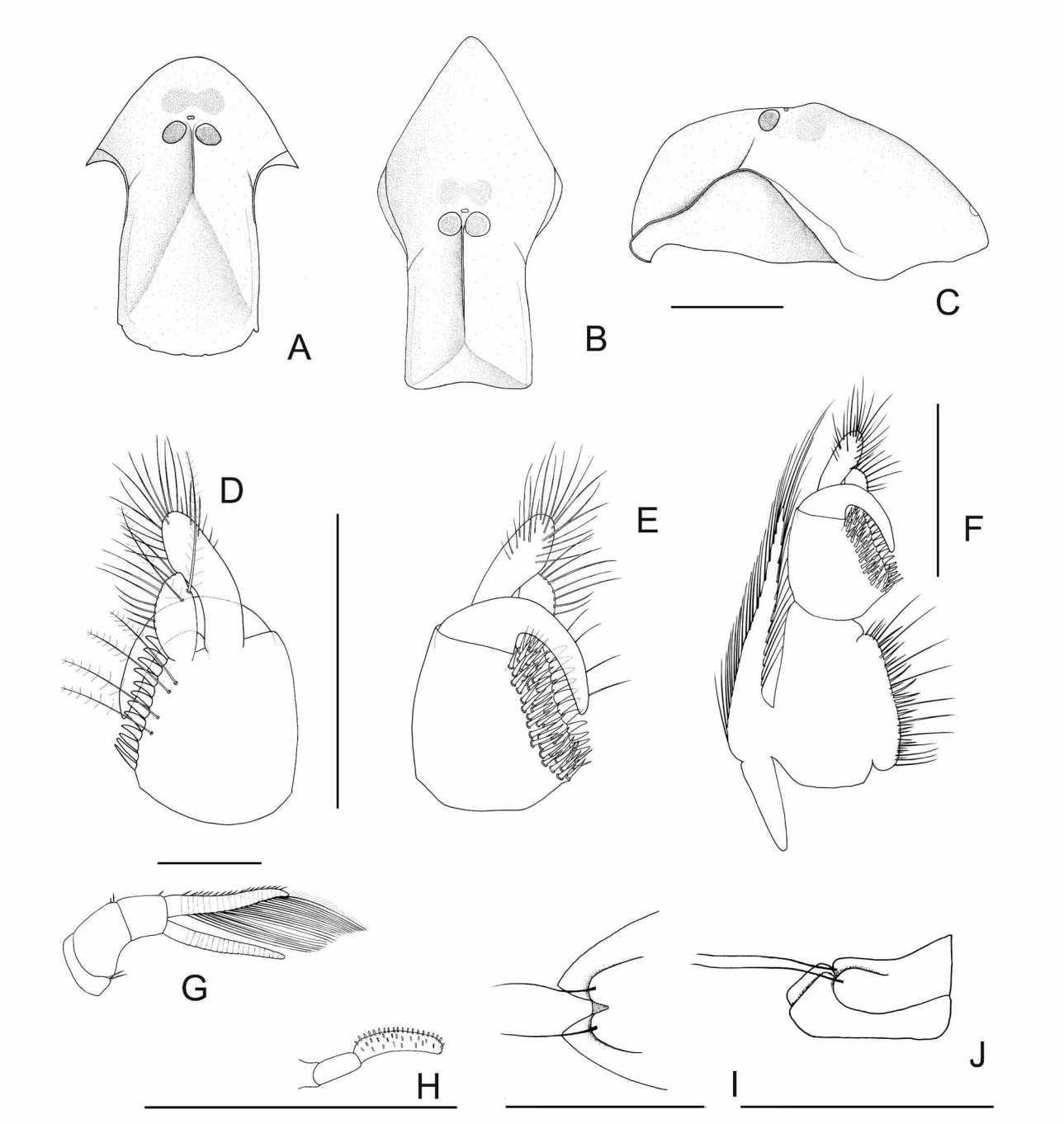

FIGURE 1. *Lynceus mallinensis* male. A, Head, antero-ventral view. B, Head, frontal view. C, Head, lateral view. D, Clasper of first thoracopod, inner view. E, Clasper of first thoracopod, outer view. F, First thoracopod, outer view. G, Second antennae. H, First antennae . I, Anal somite, dorsal view. J, Anal somite, lateral view. Scale bars: 1 mm.

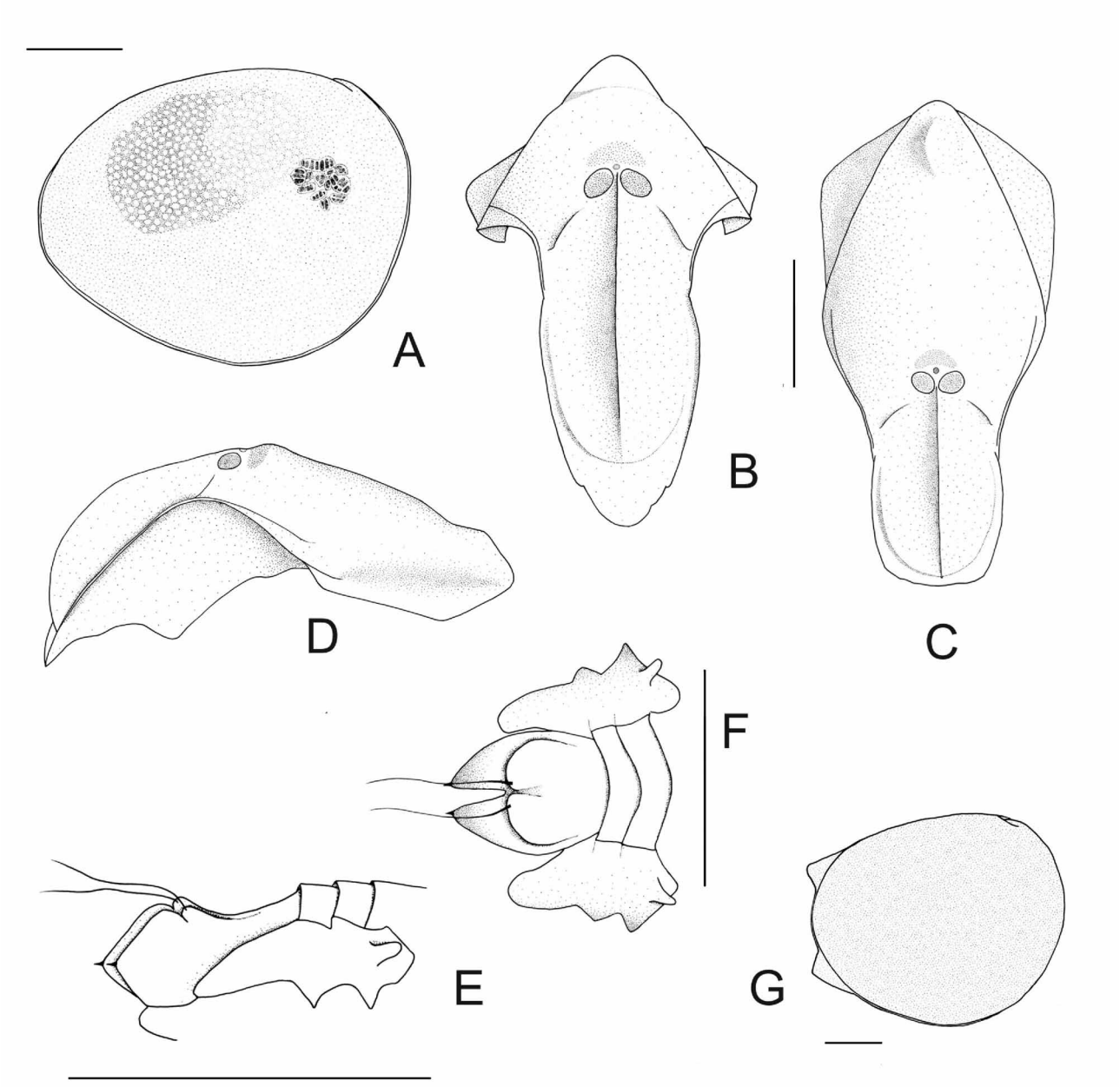

FIGURE 2. *Lynceus mallinensis* female. A, Lateral view. B, Head, antero-ventral view. C, Head, frontal view. D, head, lateral view. E, Anal somite, lateral view. F, Anal somite, dorsal view. G, Lateral view of anomalous specimen with triangular flanges on carapace. Scale bars: 1 mm.

Female L. mallinensis is separated from all known American female *Lynceus* except *L. mucronatus* by the rounded rostral apex, which is either apically acute or emarginated. Female *L. mallinensis* is separated from female *L. rotundirostris* by the lack of an umbo. Both *L. mallinensis* and *L. mucronatus* have a rounded rostral apex, which is narrowly rounded, with rounded lateral spines in *L. mallinensis*, and broadly rounded with subacute lateral and medial spines in *L. mucronatus*. Insufficient information is available concerning the female of *L. tropicus* Daday, 1927 to properly separate it from *L. mallinensis*.

Coloration: Heavily melanised. Carapace very dark brown, body nearly black with dark brown highlights.

Description. Male: *Head* (figs. 1A–C): subequal in size to body, finely punctate. Fornices broad, angulated. Setal fields closely spaced, subequal in size to compound eye. Compound eyes larger than adjoining setal fields, close set and just posterior of setal fields. Frontal pore centered between setal fields and compound eyes. Rostrum twice as wide as long, anteriorly angulate in lateral view. Lateral margins subparallel. Distal margin slightly convex

and irregularly crenulate. Anteriolateral apical corners with short, narrow lobes. Rostral carina extending from between setal fields to distolateral lobes, bifurcate, with bifurcation beginning at rostrum midlength. Rostral disc distad of the carinal bifurcation covered by minute setae. Rostrum finely punctate posterior to rostral branches. *First antenna* (fig. 1H) with two antennomeres. Proximal antennomere short, cylindrical. Distal antennomere approximately twice the length of proximal and bearing numerous olfactory papillae, each with apical pore and cylindrical base. *Second antennae* (fig. 1G) biramous, large, well developed, exceeding length of rostrum by one fourth their length. Second antennal peduncle of first antennomere with few simple distal setae, peduncle of second antennomere with row of simple distal setae on anterior side. Posterior and anterior flagellae bearing shorter simple setae along anterior surfaces and much longer, plumose setae along posterior surfaces. *Labrum large*, well developed, dependent, clothed apically and posteriorly in fine setae. *Mandible* broadly spatulate, molar surface with 12 to 16 transverse ridges becoming larger in size posteriorly. Posterior most ridge prolonged into spine. *First maxilla* typical for genus. *Second maxilla* absent.

Carapace: with hinge line straight, flat, umbo lacking. Anterior margin broadly arcuate, curving evenly to ventral surface, then back to the posterior end. Posterior end with post hinge dorsal margin and posterior margin, slightly convergent and rounded apically. Valves roundly inflated laterally. Carapace surface completely smooth, lacking growth lines or punctae.

Thorax: *thoracopod I* (figs. 1D–F) modified as clasping appendage, right and left claspers equal in shape and size. Endite VI thin, arcuate, tapering to rounded apex, slightly curved, most of length closing against endite III. Endite V larger than endite IV, extending distally beyond base of endite VI, distal end covered with simple setae. Endite IV distally and anteriorly covered with simple setae, with two large dorsal plumose setae. Endite III a broad longitudinal plateau, margined with numerous short, stout spines, and four dorsal plumose setae. *Thoracopod II* unmodified. Remaining thoracopods, body and anal somite (figs. 1I–J) typical for genus (see Martin & Belk 1989). Posterior sclerotized hook-like process absent.

Measurements (mm, n=7): length: 4.6–5.0 (4.8 ± 0.18); height: 3.75–4.1 (3.93 ± 0.15); width 2.8–3.5 (3.11 ± 0.26).

Female: *Head* (figs. 2B–D): similar to male. Rostrum comparatively narrower than in male, gently curved in lateral view. Apical margin rounded with obscured lateral lobes. Carina long, not bifurcated, ending close to rostrum margin. Eyes widely joining on middle line, sensory fields and frontal pore same as male.

Carapace (figs. 2A, 2G): as in male, umbo lacking. Egg mass visible through the carapace.

Thoracopods: thoracopods XI and XII with exopod dorsal lobes cylindrical and extending dorsally beyond thoracic dorsum. Last three thoracic segments (figs. 2E–F) with a conjoined lateral lamellar process, with three subacute, conical, lateral lobes and one posterior flange.

Measurements (mm, n=10): length: 4.2–5.15 (4.85 ± 0.28); height: 3.4–4.2 (3.88 ± 0.22); width 2.85–3.4 (3.22 ± 0.16).

Variation. One female specimen possesses low, rounded flanges on the carapace margin (fig. 1G). One at the posteriodorsal angle and one at the posterioventral angle. These flanges are triangular in shape and apically rounded.

Egg: Spherical and smooth. 150 µm in diameter.

Characteristics of type locality. A temporary pool of about 50 m wide 100 m long and 0.2 m average depth. At the time of collection, the water temperature was 14.3 ºC, pH 8,08, water conductivity 170,8 µS cm^{-1}, salinity 0.1 $^{o}/_{oo}$, dissolved O_2 10,5 mg/l (102 % saturation), TN (total nitrogen) 419 µg.l^{-1}, NO_3 140 µg.l^{-1}, NH_4 4 µg.l^{-1}, TP (total phosphorus) 36 µg.l^{-1}, and SRP (soluble reactive phosphorus) 3 µg.l^{-1}.

Distribution. Central steppe of Central Patagonia, close to the ecotone with the Subandean Patagonia (Andean Region, Patagonian Subregion, Chubut province, Argentina).

Discussion

The laevicaudatan genera are poorly defined. Martin and Belk (1988) provided the most recent diagnoses for the three genera. The only consistent character to separate the three genera is the form of the male thoracopod II. The thoracopod II of *Paralimnetis* has a “protopodal complex” with a “hook like” process (Martin & Belk 1988, Fig. 3d and e, 11h, 12i and j, 13i and j). The thoracopod II of *Lynceiopsis* has what is speculated to be endites IV and V

fused into a "distal lobed process" with possibly endite VI as a palp subtending this structure distally. The genus *Lynceus* has thoracopod II lacking these structures, and is unmodified except in rare instances (Martin & Belk 1988) and the modifications are not similar to those found in the other genera. The fact that *L. mallinensis* males have an unmodified thoracopod II, lacking the structures present in the other two genera necessitates its placement in the genus *Lynceus* at least until the generic definitions can be further clarified. As in most other members of the genus, the claspers are equal in size and shape, and endite VI is slender and arcuate.

Martin and Belk (1988) state that no American *Lynceus* species have a bifurcate rostrum. However, we interpret the rostrum of *L. brevifrons* males as being bifurcate. The typical laevicaudatan rostrum has a broad, flat distal margin. The rostrum of *L. brevifrons* is the same, however it is strongly angulate (in lateral view) at the point where the bifurcation occurs. The rostrum surface distad of the bifurcation is densely setose as in *L. mallinensis*. This same arrangement is present in the material we examined of *L. tatei*(?) and *L. macleayanus* from Australia, *L. biformis* from Japan and Taiwan, and the figures of *L. simiaefacies* in Harding (1941) and Fryer and Boxshall (2009). The bifurcated form of the male rostral carina is generally consistent with the male rostrum morphology of *Paralimnetis* and *Lynceiopsis*. However, the female rostrum appears not be bifurcate in American *Lynceus* and was not in the Australian and Eurasian material examined.

The unique female bearing "flanges" on the dorsal and ventral posterior carapace angles was surprising to us. These flanges are unique in Branchiopoda and their origin is unknown. Only the one specimen possessing these flanges was observed.

Three *Lynceus* species have been reported from South America: *L. tropicus*, *L. aequatorialis* and *L. rotundirostris*. Both *L. tropicus* and *L. aequatorialis* are reported from tropical northern South America (Martin & Belk 1988; Roessler 1995), with *L. tropicus* only known from a single female specimen, now all except the carapace missing (Martin & Belk 1988). *Lynceus aequatorialis* is widespread, but not common, between the equator and the Tropic of Cancer in Venezuela and Colombia (Martin & Belk 1988; Roessler 1995). *Lynceus rotundirostris* is the only laevicaudatan reported as possessing a dorsal umbo (Daday 1902; 1927). This species is only known from the holotype: a single female specimen collected from Amenkelt in Argentinean Patagonia. The holotype is in very poor condition, with the rostrum damaged and the dorsal carapace border (including the umbo) missing (Martin & Belk 1988). Martin and Belk (1988) assumed that the type locality for *L. rotundirostris* is in Chubut province (45º S, 70º W), however Lopretto (1998) verified Daday's (1902) data, that the type locality (Amenkelt) is in Santa Cruz province (50º 3'16" S, 69º 0'49" W). The fact that this species has not been found since its original description may be attributable to the lack of freshwater crustacean collections in Patagonia and to the confusion surrounding the type locality location.

Lynceus mallinensis has only been collected from the type locality (42º 21' 43.3" S, 71º 08' 59.8" W), which is relatively close to *L. rotundirostris* type locality (Amenkelt, 50º3'16" S, 69º0'49" W) (Lopretto 1998). However, given the lack of systematic surveys in the Patagonian steppe, we expect more undescribed branchiopod species to be discovered.

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