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A List of the Recent Clam Shrimps (Crustacea: Laevicaudata, Spinicaudata, Cyclestherida) of Australia, Including a Description of a New Species of *Eocyzicus*

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ABSTRACT. Since 1855, 28 species of clam shrimps (Laevicaudata, Spinicaudata, Cyclestherida) have been described from Australia, although three have been synonymized. One new species of *Eocyzicus* is described herein. It has a distinctive rostrum that is slightly different in male and females and the clasper has a three segmented palp. With this new species the Australian fauna comprises 26 valid species of clam shrimps. We provide a list of all described species, including their known localities and a key to the genera of Australian clam shrimps.

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Large branchiopods are an important element of Australia's temporary inland waters. Knowledge about the taxonomy of the three large branchiopod groups differs, however. Among the Notostraca, both known genera, *Lepidurus* and *Triops*, are represented by a single species (Longhurst, 1955). The anostracan fauna is relatively simple, being dominated by *Branchinella* and the endemic *Parartemia*, but with three other genera (Williams, 1980; Timms, 2004). *Branchinella* is represented by 31 species (Geddes, 1981; Belk, 1995; Timms, 2001, 2003, 2004, 2005; Timms & Geddes, 2003). *Parartemia* has eight described and at least seven undescribed species (see Geddes, 1973; Remigio *et al*., 2001; Savage, 2003; Timms, 2004). Two species of *Artemia* (*A. francisciana* and *A*. near *parthenogenetica*) have been reported from Australia, though at least one, and possibly both, were introduced (Williams & Geddes, 1991; McMaster *et al*., in press). Recently, the presence of *Streptocephalus* in Australia was confirmed with the description of a new species and the detection of others (Herbert & Timms, 2000; Timms, 2004). In addition, a new branchiopodid genus has been discovered (Brendonck and Timms, unpublished data). In comparison to Notostraca and Anostraca, the taxonomic knowledge of Australian clam shrimps (conchostracans) is less complete despite having the same interest for ecologists (e.g., Bishop, 1967c; Williams, 1980; Timms, 1993, 1999; Bunn & Davies, 1999; Timms & Richter, 2002; Timms & Sanders, 2002). Because the Conchostraca is paraphyletic (Martin & Davis, 2001; Braband *et al*., 2002) this taxon name is not used and is replaced by the Laevicaudata, Spinicaudata and Cyclestherida, and the popular name of "clam shrimps" is used for all three groups.

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Since the first description of Australian clam shrimps by King (1855), 27 species belonging to the Laevicaudata and Spinicaudata have been described, all endemic to Australia. In addition, the circumtropical *Cyclestheria hislopi* is also known from Australia (e.g., Timms, 1986). The last—and unfortunately incomplete—review of the Australian clam shrimps was published about 80 years ago (Henry, 1924), and only three species have been described since then (Gurney, 1927; Webb & Bell, 1979; Olesen & Timms, 2005). In addition, Henry (1924) was not aware of important taxonomic changes introduced by the Hungarian zoologist E. Daday, who published an extended review (1914, 1923, 1925, 1926, 1927) on the clam shrimps of the world (for a complete list of Daday's somewhat confusing taxonomic works, see Forró & Brtek, 1998). Therefore, our knowledge about Australian clam shrimps is fragmented and incomplete, and a detailed revision is needed. Some of the described species are probably synonymous and many new species will have to be described. The present work is intended as a first step to facilitate future work.

In this paper, a list of the described clam shrimps (Laevicaudata, Spinicaudata, Cyclestherida) of Australia is presented. Some are transferred to different genera, based on practice for congeneric species overseas. We also describe a new species of *Eocyzicus*, a genus which to date has not been reported from Australia. A key to the genera of Australian clam shrimps is also provided.

Materials and methods

This catalogue is based mainly on published descriptions. Type materials were usually not studied as this is not a taxonomic review, but the two types conveniently located in the Australian Museum and one each in the Natural History Museum, London and Zoologisches Institut und Zoologisches Museum, Hamburg were examined. The existence of types for other species was checked with relevant museums. The acceptance of four genera within the Cyzicidae (*Caenestheria, Caenestheriella, Cyzicus*, and *Eocyzicus*—as suggested by Daday, 1914 for the world) and three Australian genera within the Limnadiidae (accepting *Limnadia* and *Eulimnadia* as valid genera, in addition to the Australian endemic *Limnadopsis*) is based on our examination of the collections of the Australian Museum, Sydney. The rationale for this approach will be discussed below. The following abbreviations are used for repositories of specimens examined: AM, Australian Museum, Sydney; NTM, Northern Territory Museum, Darwin; BMNH, Natural History Museum, London; ZMH, Zoologisches Institut und Zoologisches Museum, Hamburg.

Illustrations were prepared using a Stemi SV 6 (Zeiss) stereomicroscope with camera lucida. Specimens were prepared for scanning electron microscopy (SEM) using standard procedures, including critical-point drying, and sputter coating with gold. Type material of the new described species is deposited at the Australian Museum, Sydney.

Results

In Australia, four clam shrimp families occur: Lynceidae Baird, 1845, Cyzicidae Stebbing, 1910, Limnadiidae Baird, 1849, and Cyclestheriidae Sars, 1899. For authorities for the families we refer to Martin & Davis (2001).

Lynceidae Baird, 1845

Lynceidae Stebbing, 1902, p. 105.

Carapace globose with valves lacking growth lines and an umbo and both joined in an elongate dorsal depression. Head region bearing distinct fornix and sharp longitudinal rostral carina. Mandibles robust and serrate. Second maxilla reduced or absent. First thoracopods in male modified as prehensile subchelate claspers, second pair usually unmodified or enlarged but never with a subchelate clasper. Anal segment reduced, with delicate telsonal filaments but no caudal furca. Dorsolateral area of posterior segments lacking spiniform protuberances. Female with posterolateral lamina for holding egg mass. For further information see Martin & Belk (1988).

According to Martin & Belk (1988), the family Lynceidae comprises three genera: *Lynceus, Lynceiopsis*, and *Paralimnetis*. Martin & Belk (1988) list all described species in the world. Only *Lynceus* is known from Australia with three described species, but with only two valid species.

Lynceus tatei (Brady, 1886)

Limnetis tatei Brady, 1886a: 84–85, fig. A; Sars, 1895: 43–46, pl. 8; Henry, 1924: 121–122 (list), 135–136 (text).
Lynceus tatei.–Sayce, 1903: 258–259, pl. 36, fig. E, 1–3; Wolf, 1911: 255 (list); Dakin, 1914: 295 (list), 303 (text); Daday, 1927: 6 (key), 45–49, fig. 155; Glauert, 1924: 59–60; Martin & Belk, 1988: 452 (list); Brtek, 1997: 61 (list).
Limnetis eremia.–Spencer & Hall, 1896: 244, pl. 23, figs. 30–32.
Lynceus eremia.–Sayce, 1903: 258–259, pl. 36, fig. F, 1–3; Wolf, 1911: 255 (list); Dakin, 1914: 295 (list); Chilton, 1917: 481.

Type material. None known.

Comments. Martin & Belk (1988) accepted the synonymy of *Lynceus eremia* with *L. tatei*, as suggested by Daday (1927) although Sayce (1903) described a few differences. These include: the carapace with a posterior extremity more narrowly rounded and the rostral expansion in both sexes shorter and more constricted in the middle than in either of the other two species.

Distribution. Rivoli Bay (South Australia); Sydney, Botany, Maroubra (New South Wales); Rostown and Elwood (Victoria); pools at Busselton, Cannington (Western Australia) (all refer to *L. tatei*); Cooper Creek, rock hole at Carmeena in the Everard Ranges, flat rock holes 30 miles (= 48 km) east of Musgrave Ranges (South Australia) (refer to *L. eremia*). Additional distribution records (from Timms & Richter, 2002): Bloodwood Station and localities near Bloodwood Station (New South Wales); Currawinya National Park, Rockwell and Wombah Stations (southwest Queensland).

Lynceus macleayanus (King, 1855)

Limnetis macleayana King, 1855: 70; King, 1864: 162–164, pl. 11, fig. without number; Brady, 1886a: 83 (list); Whitelegge, 1889: 318 (list); Sars, 1895: 35–43, pl. 6,7; Henry, 1924: 121–122 (list), 135 (text).
Lynceus macleayana.–Sayce, 1903: 258–259, 25 pl. 36, fig. D, 1–3; Dakin, 1914: 295 (list); Chilton, 1917: 481.
Lynceus macleayanus.–Wolf, 1911: 255 (list); Daday, 1927: 6 (key), 53–57, fig. 157; Martin & Belk, 1988: 452 (list); Brtek, 1997: 60 (list).

Type material. None known.

Distribution. Denham Court, Botany Swamps, Parramatta, shallow pools in Moore Park, Liverpool, Hay, Myall Lakes, Paroo River (New South Wales); Elwood, St. Arnaud (Victoria); between Todmorden and Wantapella Swamp, rockhole west of Carmeena–Everard Ranges (South Australia).

Cyzicidae Stebbing, 1910

Cyzicidae Stebbing, 1910.
Caenestheriidae Daday, 1913.
Isauridae Bock, 1953.
Bairdestheriidae Novojilov, 1954, in part.

Spinicaudata with valves thick and swollen, more or less oval, with growth rings. Umbo well developed. Body of 20–28 segments. No rostral spine. Limbs 9 and 10 of female with ovigerous flagellum. Telson with strong dorsal teeth, denticulated and often irregular in shape. End-claws of telson with fine spines along their inner rim.

With the recognition of the presence of a new species of *Eocyzicus* in Australia, three genera are now known to occur in Australia: *Caenestheria, Caenestheriella* and *Eocyzicus*. Daday (1914) transferred the species described before 1910 into his new genera, but three species were described later. One of these three species, *Estheria rufa* Dakin, 1914, cannot be referred to one of Daday's genera based on the original description. The alternative unsubstantiated scheme of Brtek (1997) of placing all Australian Cyzicidae into the genera *Cyzicus* and *Eocyzicus*, which he defines differently from Daday, has not been followed here.

We believe that *Eocyzicus* is distinctive in having a posterior margin to its rostrum (which gives the entire rostrum a hatchet-like shape) that leads to the origin of the first antenna, and the occipital condylus short and rounded. *Cyzicus, Caenestheria* and *Caenestheriella* do not have this combination of characters.

Eocyzicus parooensis n.sp.

Figs. 1–3

Eocyzicus sp. a, Timms & Richter, 2002.
Limnadia sp. b, Timms, 1993.

Type material. HOLOTYPE ♂, formalin-fixed AM P68156, carapace 7.8 × 4.5 mm. PARATYPES formalin-fixed: 1♂ slide AM P68157, 1♀ slide AM P68158; 8♂♂, 9♀♀, AM P68159, all collected by B.V. Timms from Gidgee Lake, 17 November 1999.

Type locality. Gidgee Lake on Bells Creek, Bloodwood Station, 130 km NW of Bourke, NSW, Australia, 29°33'S 144°52'E.

Etymology. This species is named after the Paroo area where it occurs commonly in hyposaline waters.

Description. Male carapace 7.2 to 7.8 mm length, 4.2 to 4.5 mm height (n = 10). Female carapace 6.4 to 6.7 mm length, 3.9. to 4.1 mm height, smallest and largest female both ovigerous (n = 10). Carapace in both sexes oval, with 10 to 11 growth lines in males, and 9 to 10 in females. Dorsal margin of carapace with prominent umbo, posterior of umbo straight. Male head region with prominent rectangular (hatchet-like) rostrum in lateral view (Fig. 2A), including bilateral anterior margins, a ventral margin and a posterior margin. Anterior margins together form a V-shape in the dorsal view, continuing into the fornices of both sides (Fig. 2B). Nauplius eye triangular shaped, with sharp end pointing to the compound eye. Central dorsal part of the head defined anteriorly by prominent compound eye chamber and posteriorly by rounded occipital condylus. Compound eye chamber opening via a small pore anteriorly, slightly above anterior margins of rostrum (Fig. 2A, arrowhead). Central head region filled by mid-gut diverticula. Dorsal organ located close to posterior margin of occipital condyle (Fig. 2B, arrowhead). Female head region differing in particular by shape of rostrum which is more triangular because of less distinct posterior margin (Fig. 3A). Antennule extending to about fourth (females) or sixth (males) segment of posterior antennal flagellum, and distinctly lobate with each lobe bearing short sensilla (Fig. 2C). Antenna with peduncle of about eight segments, anterior densely covered with setae (Fig. 3C), and with about 11 to 14 segments on both anterior and posterior flagellum. Each flagellum segment bearing about six short spines on anterior side, and a number of longer natatory setae at the posterior side. Trunk consisting of 22 (in a few cases 23) leg-bearing segments, the last (two) segments not entirely separated from telson (Figs. 2G, 3B). More posterior trunk segments (between 10 and 15) carrying single dorsal spine at posterior end of segment (Fig. 2F). First and second thoracopod of male modified as claspers, not differing general characters from each other. Movable finger smoothly curving to the apical club (i.e. expanded apex). Surface of movable finger adjacent to apical club covered with scales; apical club with stout flat-tipped spines opposite to scales of movable finger (Fig. 2D). Tip of movable finger with about six (specimen studied might be broken in this area) more elongated "hairy" scales, directed away from apical club (Fig. 2E). Two palps originating from palm, the larger (three-segmented) palp behind movable finger, smaller (one-segmented) palp at apical club base. In females, eggs carried by projections of exopod of the ninth and tenth pairs of thoracopods (Fig. 3D). Telson covered dorsally by numerous spines, with caudal furcae originating at its posterior end. Dorsal part of telson formed like a "U", with connecting part anteriorly and the two parallel margins ending in strong, upwards curved apexes (Fig. 2G,H,K). Margins carrying about 10 to 13 spines each in males and about 15 to 20 in females, excluding the apex (Figs. 2G, 3B). Two telsonal setae originating from a common plate at anterior end, at inner side of "U" (Fig. 2K). Caudal furcae articulated with telson; each carrying many (about 15) long plumose setae on inner margin (Fig. 2G,K). Tips of caudal furcae covered by very small spinules (Fig. 2 I). Eggs round and smooth, not showing any specialized surface structures (Fig. 3D).

Remarks. This species has been recorded from several other localities in the Paroo area (Timms & Richter, 2002). Some of the characters differ from those described herein, e.g., the number of growth lines, number of telson spines, and the carapace length and height. Nevertheless, we believe that all these records (referred to in Timms & Richter, 2002 as *Eocyzicus* sp. a) are of *E. parooensis* n.sp. Most remarkable from an ecological point of view is that all these records are from hyposaline water bodies (see Timms & Richter, 2002 for more details). There is probably a second undescribed *Eocyzicus* species common in the Paroo area, which prefers turbid fresh water habitats (referred to *Eocyzicus* sp. b by Timms & Richter, 2002).

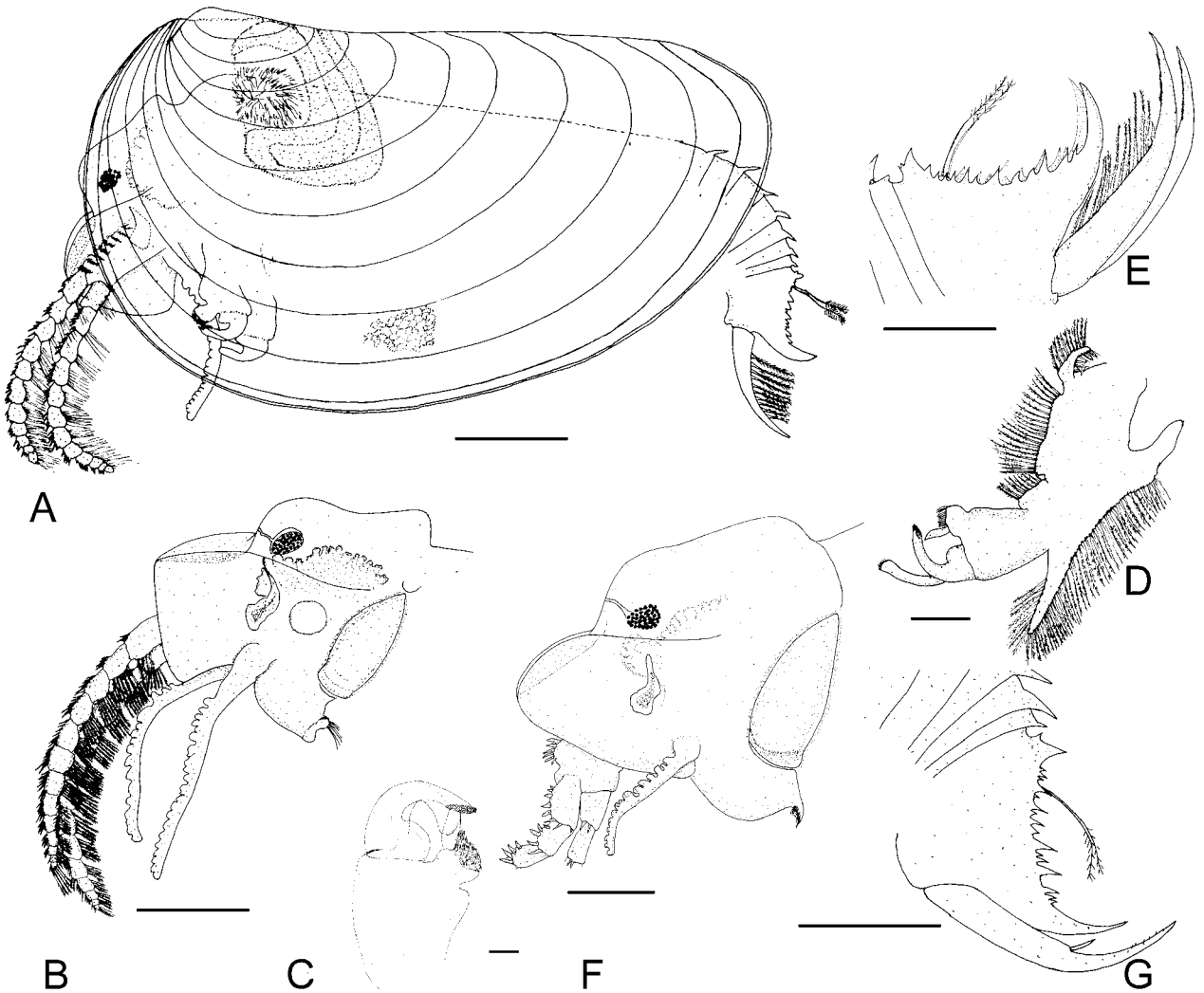


Fig. 1. *Eocyzicus parooensis* n.sp. (*A*) holotype (AM P68156) thoracopods, except the first two pairs (claspers), not drawn. (*B–E*) Paratype male (AM P68157): (*B*) head, left antennae removed; (*C*) first left clasper; (*D*) second left clasper; (*E*) telson. (*F–G*) Paratype female (AM P68158); (*F*) head, left antenna removed; (*G*) telson. Scales: 1 mm (*A,B*), 0.2 mm (*C*), 0.5 mm (*D–G*).

Caenestheria sarsii (Sayce, 1903)

Estheria sarsii Sayce, 1903: 252–253, 256 (synopsis), pl. 35 fig. 1a–f.
Cyzicus sarsi.–Wolf, 1911: 254 (list).
Cyzicus sarsii.–Dakin, 1914: 295 (list).
Caenestheria sarsi.–Daday, 1914: 55 (key), 57–59, fig. 2.
Estheria sarsii.–Henry, 1924: 122 (list), 134 (key).
Eocyzicus sarsii.–Brtek, 1997: 50 (list).

Type material. None designated.

Distribution. Lake Aurean, Murchison (Western Australia) (Sayce, 1903).

Caenestheria lutraria (Brady, 1886)

Estheria lutraria Brady, 1886a: 85, fig. B; Simon, 1886: 453 (list); Spencer & Hall, 1896: 234–235, pl. 20, figs. 4–5; Sayce, 1903: 254, 256 (synopsis), pl. 35, fig. 2a–e; Henry, 1924: 121–122 (list), 134 (text and key).
Cyzicus lutraria.–Wolf, 1911: 254 (list); Dakin, 1914: 295 (list).
Caenestheria lutraria.–Daday, 1914: 56 (key), 90–92, fig. 11.
Eocyzicus lutrarius.–Brtek, 1997: 49 (list).

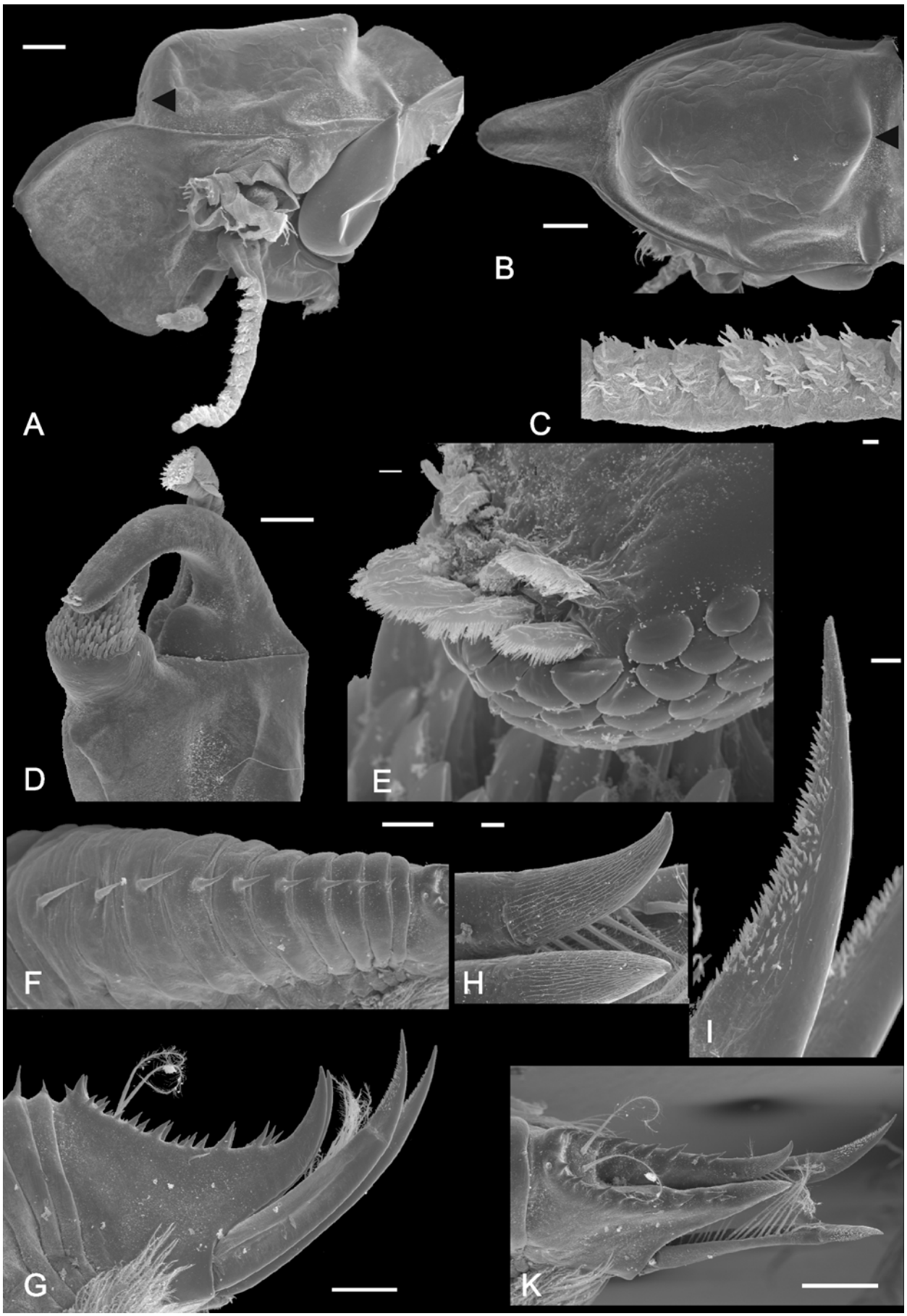
Type material. None designated.

Distribution. Innamincka, Cooper Creek, valley of Stevenson River, head of Anna Creek (South Australia); Dubbo, Broken Hill (New South Wales). Additional distribution records from Timms & Richter, 2002: Bloodwood Station and localities near Bloodwood Station (New South Wales); Currawinya National Park, Rockwell and Wombah Stations (Queensland).

Caenestheria elliptica (Sars, 1897)

Estheria elliptica Sars, 1897: 12–17, pl. 2; Sayce, 1903: 252, 255 (synopsis), pl. 36, fig. B; Henry, 1924: 122 (list), 134 (key); Gurney, 1927: 63–64.
Cyzicus ellipticus.–Wolf, 1911: 254 (list); Dakin, 1914: 295 (list).
Caenestheria elliptica.–Daday, 1914: 56 (key), 96–98, fig. 14.

Fig. 2 (facing page). *Eocyzicus parooensis* n.sp. SEM images of male characters: (*A*) head, left antenna removed; (*B*) head, dorsal view; (*C*) antennule; (*D*) clasper of 2nd thoracopod; (*E*) close up of D, movable finger; (*F*) thorax, dorsal view; (*G*) telson; (*H*) apex of telson; (*I*) tip of furca; (*K*) telson, dorsal view. Scales: 200 µm (*A,B,F,G,K*), 100 µm (*D*), 20µm (*C,H,I*), 4 µm (*E*).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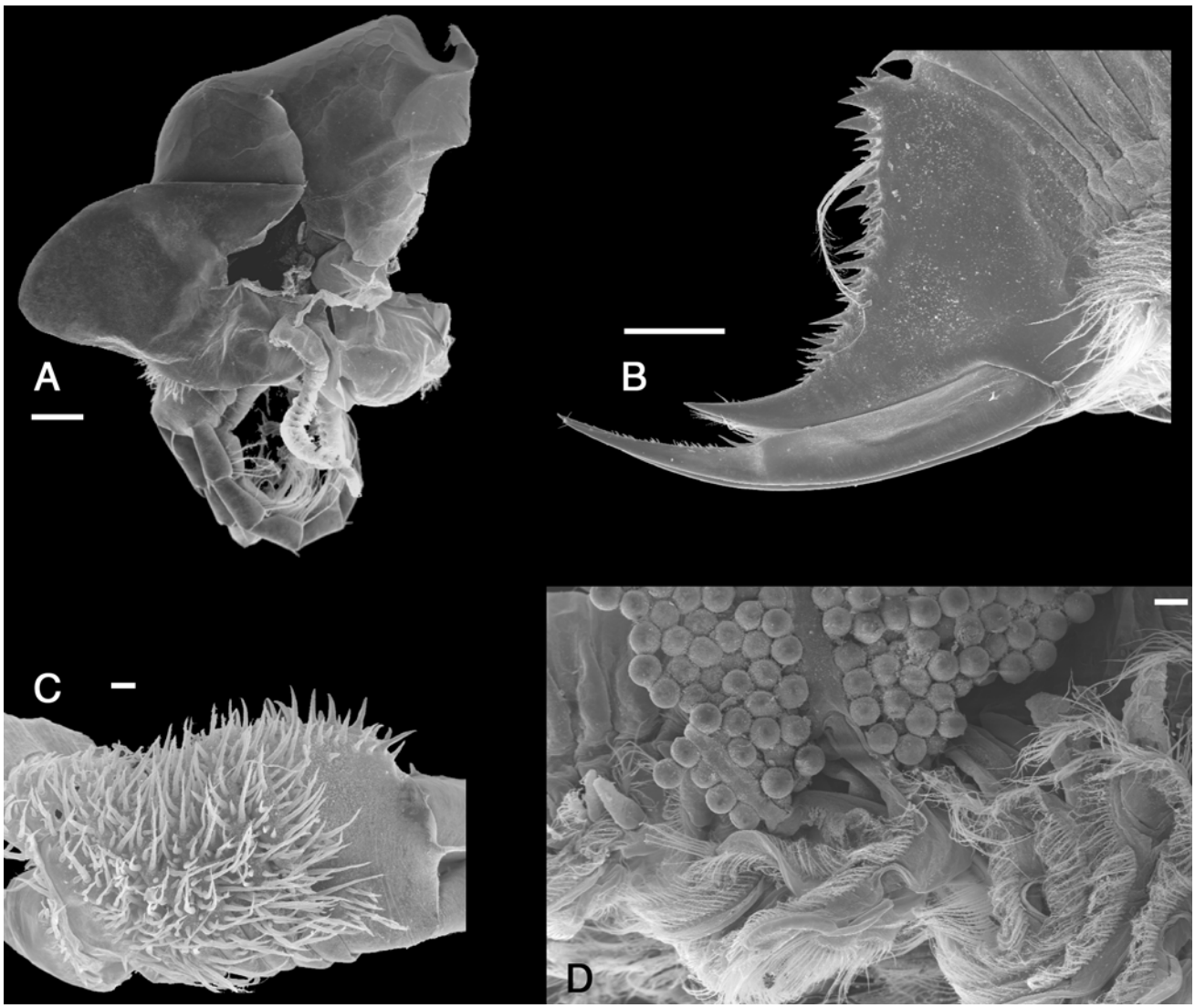

Fig. 3. *Eocyzicus parooensis* n.sp. SEM images of female characters: (*A*) head, left antenna reduced; (*B*) telson; (*C*) antenna base; (*D*) cysts. Scales: 200 μm (*A, B*), 100 μm (*D*), 40 μm (*C*).

Eocyzicus ellipticus.–Brtek, 1997: 49 (list).

Type material. Zoological Museum, Oslo, has possible syntype material.

Distribution. near Roebuck Bay (Western Australia) (Sars, 1897).

Caenestheria dictyon (Spencer & Hall, 1896)

Estheria dictyon Spencer & Hall, 1896: 236, pl. 20, figs. 6–8; Sayce, 1903: 255, 256 (synopsis), pl. 36, fig A; Henry, 1924: 122 (list), 134 (key).
Cyzicus dictyon.–Wolf, 1911: 254 (list); Dakin, 1914: 295 (list).
?*Caenestheria dictyon*.–Daday, 1914: 105.
Eocyzicus lutrarius (in partem).–Brtek, 1997: 44 (list).

Type Material. None designated.

Distribution. Palm Creek, in the James Range (Northern Territory) (Spencer & Hall, 1896).

Remarks. Sayce (1903) discussed a possible synonymy with *C. lutraria*: "I am inclined to regard this as but a young form of *E. lutraria*." For Daday (1914) transferred of this species to the genus *Caenestheria*, based on the descriptions by Spencer & Hall (1896) and Sayce (1903) The question whether this species is synonymous with *C. lutraria* cannot be answered here (but see Brtek, 1997: 44).

Caenestheria rubra (Henry, 1924)

Estheria rubra Henry, 1924: 121 (list), 134–135, pl. 32, figs. 8–9.

Type material. Australian Museum, Sydney, P6773, 1 female syntypes (body and carapace in two different vials). The study of this single female shows that this species belongs to the genus *Caenestheria*. Brtek (1997: 52) noted "*Estheria rubra* Henry, 1924 = probably *Cyzicus* sp.", but he has not examined the type specimen.

Distribution. Marra and Budda Stations on the Darling River, Goorimpa Station on the Paroo (New South Wales).

Caenestheria berneyi (Gurney, 1927)

Estheria berneyi Gurney, 1927: 61–64, fig. 2a–b, fig. 3a–f.
Eocyzicus berneyi.–Brtek, 1997: 49 (list).

Type material examined. The holotype male, Natural History Museum London, 1929.3.14.2. This single

specimen might not be fully grown. Head and trunk are separated so it belongs to the genus *Caenestheria*. Gurney's (1927) fig. 3a,b shows this separation and he discussed the possibility his species belongs to the genus *Caenestheria*. Gurney, however, did not accept the splitting of the genus *Estheria* by Daday (1914), consequently he placed the new species in the genus *Estheria*.

Distribution. Vicinity of Longreach (Queensland)

Caenestheriella packardi (Brady, 1886)

Estheria packardi Brady, 1886a: 85–86, fig. C; Simon, 1886: 453 (list); Sars, 1895: 28–29, pl. 4 & 5; Sars, 1896a: 1–27, pl. 1–4; Spencer & Hall, 1896: 236–238, figs. 9–14; Sayce, 1903: 250–252, 255 (synopsis), pl. 34, fig. 3, a–c; Chilton, 1917: 480–481; Henry, 1924: 121–122 (list), 134 (text and key).
Cyzicus (Estheria) packardi.–Wolf, 1911 (list); Dakin, 1914: 295 (list).
Caenestheriella packardi.–Daday, 1914: 108 (key), 116–120, fig. 20.
Cyzicus packardi.–Bishop, 1967c: fig. D, 1; Brtek, 1997: 48 (list).
Estheria packardi var. *typica* Spencer & Hall, 1896: 237, pl. 21, figs. 9–10; Sayce, 1903: 251; Chilton, 1917: 481.
Caenestheriella packardi var. *typica*.–Daday, 1914: 120.
Cyzicus packardi var. *typica*.–Brtek, 1997: 48 (list).
Estheria packardi var. *cancellata* Spencer & Hall, 1896: 237–238, pl. 21, figs. 11–12; Sayce, 1903: 251.
Caenestheriella packardi var. *cancellata*.–Daday, 1914: 120–121.
Cyzicus packardi var. *cancellata*.–Brtek, 1997: 48 (list).
Estheria packardi var. *minor* Spencer & Hall, 1896: 238, pl. 21, figs. 13–14; Sayce, 1903: 251–252.
Caenestheriella packardi var. *minor*.–Daday, 1914: 121–122.
Cyzicus packardi var. *minor*.–Brtek, 1997: 48 (list).

Remarks. Spencer & Hall (1896: 237) described three "varieties" in *Estheria packardi*: "We have found it convenient to separate the species into three varieties, the extreme forms of which are clearly distinct from one another, but the occurrence of intermediate forms renders it impossible to place them in separate species." According to ICZN rule 45.6.4 these varieties described before 1961 would have to be considered as subspecies, although the written text suggests a level below subspecific status. We think the latter could be applied here. Spencer & Hall (1896) gave no separate distribution records for the three varieties, which probably implies that different varieties were found at the same localities, and "intermediate forms" were also present. We think these two arguments in favour the "varieties" of *Caenestheriella packardi* being not considered as subspecies, and therefore we do not list them separately.

Distribution. Lake Bonney, near River Murray, Fowlers Bay, Cooper Creek, Macumba River and Stevenson River (South Australia); waterholes along the Finke and its tributaries (Northern Territory); Botany, Hay, Dubbo, Trangie (New South Wales).

Caenestheriella mariae Olesen & Timms, 2005

Caenestheriella mariae Olesen & Timms, 2005: 1–8, figs. 1–4.

Type material. Australian Museum.

Remarks. This species differs from *Caenestheriella packardi* in having (*a*) small hump anterior to the occipital condyle, (*b*) a 90° pointed angle between the eye lobe and the rostrum, (*c*) a more prominent eye lobe, and (*d*) no distinct sculpturing between the growth lines of the carapace (Olesen & Timms, 2005).

Distribution. *Caenestheriella mariae* lives in gnammas (rock pools) in southwestern Western Australia (Olesen & Timms, 2005; Timms, in press)

Cyzicus (Estheria) rufa Dakin, 1914

Cyzicus (Estheria) rufa Dakin, 1914: 295 (list), 301–302, pl. 2, figs. 19–21.

Type material. None designated.

Remarks. Using the description by Dakin (1914) of two females, whether this species belongs to *Caenestheria* or *Caenestheriella* is uncertain. According to Brtek (1997), it is conspecific with *Caenestheria sarsii* (Sayce, 1903), which he calls *Eocyzicus sarsii* (Sayce, 1903), a possibility that was discussed by Dakin (1914) but rejected. Its rostral characteristic of lacking a posterior margin shows it is neither *Eocyzicus* or *Cyzicus*.

Distribution. Pools at Lakeside, Boulder City (Western Australia).

Limnadiidae Baird, 1849

Limnadiidae Baird, 1849.
Limnadiidae in Simon, 1886, in part.

Spinicaudata with valves rounded, often thin and transparent, with growth lines in the peripheral zone only (except in *Limnadopsis*). Umbo absent or weakly developed. Head with a pear-shaped organ behind the eye. First three pairs of limbs of both sexes with an endopodial palp. Limbs 9 and 10 of female with ovigerous flagellum.

Seven species of *Limnadia* and two of *Eulimnadia* are described from Australia. The genus *Limnadopsis* Spencer & Hall, 1896 can be distinguished from the genus *Limnadia* by growth lines that cover the entire carapace and by the absence of the typical sucker-like projection on the movable fingers of the male claspers. *Limnadia* is distinguished from *Eulimnadia* by the absence of the spine on the lower distal angle of the telson. The status of *Limnadopsis* is confused. Novojilov (1958) erected a new genus, *Limnadiopsium* for *Limnadopsis tatei*, and a new family, the Limnadopseidae, for both genera. This approach has been accepted by Naganawa (2001). Dumont & Negrea (2002) place this group as a subfamily Limnadopsinae within the Limnadiidae, while Martin & Davis (2001) do not recognize either family or subfamily rank for this group. We follow Martin & Davis, but recognize the problem is not resolved. We see no reason for the transfer of *Limnadoposis tatei* to a different genus, *Limnadiopsium* (see Brtek, 1997). *Limnadopsis* is endemic to Australia, with four described species.

Limnadia badia (Wolf, 1911)

Eulimnadia badia Wolf, 1911: 270–275, figs. 14–24; Dakin, 1914: 295 (list), 301 (text).
Limnadia badia.–Daday, 1925: 149 (key), 151–155, fig. 115; Brtek, 1997: 56 (list).

Type material. Types are present in the Zoologisches Institut und Zoologisches Museum Hamburg. We examined the paratypes (4 males, 8♀♀, 1 juvenile; ZMH, K-19624). The specimens possess no spine on the lower distal angle of the telson. This species therefore belongs to the genus *Limnadia*. A characteristic feature of this species is the very pronounced

and elongated process close to the apical club of the claspers in fully grown males (see also Wolf, 1911: fig. 24).

Distribution. Boorabbin; rock pool near Burracoppin (Western Australia) (Wolf, 1911). Timms (in press) records it from gnammas (rock pools) throughout the wheatbelt of southwestern Western Australia.

Limnadia stanleyana King, 1855

Limnadia stanleyana King, 1855: 70; King, 1864, pl. 11, 3 figs. without number; Claus, 1872: 355–364, pl. 6, 29–30; Brady, 1886a: 83 (list); Simon, 1886: 456 (list); Whitelegge, 1889: 318 (list); Daday, 1925: 150 (key), 163–166, fig. 118; Bishop, 1967c: figs. D, 2, 3, 4b; Bishop, 1968a: figs. 4, 7; Webb & Bell, 1979: 243; Brtek, 1997: 58 (list).
Eulimnadia stanleyana.–Sars, 1895: 16–28, pl. 2–3.
Paralimnadia stanleyana.–Sars, 1896b: 15; Sayce, 1903: 248–249, pl. 34, fig. 2, a–b; Wolf, 1911: 254 (list), 270 (text); Dakin, 1914: 295 (list); Henry, 1924: 121(list), 133 (text).

Type material. None designated.

Remarks. Several aspects of the biology and development of *Limnadia stanleyana* have been extensively studied by Anderson (1967) and Bishop (1967a,b, 1968a,b, 1969).

Distribution. Coogee near Port Jackson, Moore Park, Maroubra, Sydney (New South Wales). Also North Head, Sydney and Kanangra Walls, via Oberon, NSW (Bishop, 1967a)

Limnadia grobbeni Daday, 1925

Limnadia grobbeni Daday, 1925: 150 (key), 167–170: fig. 119; Webb & Bell, 1979: 243; Brtek, 1997: 57 (list).

Type material. None designated.

Distribution. New South Wales (Daday, 1925).

Limnadia victoriensis (Sayce, 1903)

Eulimnadia victoriensis Sayce, 1903: 246–247 (text), 248 (synopsis), pl. 33; Wolf, 1911: 254 (list); Dakin, 1914: 295 (list); Henry, 1924: 122 (list).
Limnadia victoriensis.–Daday, 1925: 150 (key), 171–172, fig. 120; Brtek, 1997: 58 (list).

Type material. National Museum of Victoria.

Distribution. Elwood (Victoria) (Sayce, 1903).

Limnadia sordida King, 1855

Limnadia sordida King, 1855: 70; King, 1864: pl. 11, 3 figs. without numbers; Brady, 1886: 83 (list); Whitelegge, 1889: 318; Brtek, 1997: 58 (list).
Eulimnadia rivolensis.–Brady, 1886a: 86–87, fig. D; Simon, 1886: 456 (list); Spencer & Hall, 1896: 238; Sayce, 1903: 245–246 (text), 248 (synopsis), pl. 32; Wolf, 1911 (list); Dakin, 1914: 295 (list), 300 (text); Gurney, 1927: 60–61, fig. 1, A.
Eulimnadia sordida.–Wolf, 1911 (list); Dakin, 1914: 295 (list); Henry, 1924: 121–122 (list), 133–134.
Limnadia rivolensis.–Daday, 1925: 150 (key), 173–175, fig. 121; Webb & Bell, 1979: 243 (text), table 1.

Type material. None designated.

Remarks. The synonymy of *Eulimnadia rivolensis* with *Limnadia sordida* was first suggested by Sayce (1903) and supported by Henry (1924). Sayce's (1903) and Gurney's (1927) figures show that this species belongs to the genus *Limnadia* (no spine on the lower distal angle of the telson) and not *Eulimnadia*.

Distribution. Vicinity of Rivoli Bay, Upper Onkaringa Creek (Northern Territory); Cheltenham (Victoria); small ponds near Busselton (Western Australia); vicinity of Longreach (Queensland); Botany Bay, Moore Park, Nelson Bay, Myall Lakes, Lismore (all New South Wales) (all refer to *L. rivolensis*); Pond near Bondi Bay, Botany Swamps, off Bunnerong Road, Moore Park near Sydney (New South Wales) (refer to *L. sordida*).

Limnadia cygnorum (Dakin, 1914)

Eulimnadia cygnorum Dakin, 1914: 295 (list), 299, pl. 1, figs. 9–13; Glauert, 1924: 59.
Limnadia cygnorum.–Webb & Bell, 1979: 243, table 1; Brtek, 1997: 57 (list).

Type material. None designated.

Remarks. In consideration of Dakin's (1914) plate 1, fig. 12 that shows no spine on the lower distal angle of the telson, this species belongs to the genus *Limnadia*.

Distribution. Cannington, near the Swan River (Western Australia) (Dakin, 1914).

Limnadia urukhai Webb & Bell, 1979

Limnadia urukhai Webb & Bell, 1979: 239–244; Brtek, 1997: 58 (list).

Type material. Queensland Museum.

Distribution. Sow and Pigs, near Stanthorpe; Mt. Norman, near Stanthorpe, Stanthorpe (Queensland); Bald Rock, near Tenterfield (New South Wales) (Webb & Bell, 1979).

Eulimnadia dahli Sars, 1896

Eulimnadia dahli Sars, 1896b: 14–30, pl. 2–6; Sayce, 1903: 244 (text), 247–248 (synopsis), pl. 34, fig. 1, a–c; Wolf, 1911: 254 (list), 270 (text); Dakin, 1914: 295 (list); Henry, 1924: 122 (list); Daday, 1926: 4 (key), 16–20, figs. 128–129.
Limnadia dahli.–Brtek, 1997: 57 (list).

Type material. Zoological Museum, Oslo has possible syntype material.

Distribution. Shallow pool Mount Showbridge, near Darwin; Charlotte Waters (both Northern Territory) (Sars, 1896b).

Eulimnadia feriensis Dakin, 1914

Eulimnadia feriensis Dakin, 1914: 300, pl. 2, figs. 14–18.
Limnadia feriensis.–Brtek, 1997: 57 (list).

Type material. None designated.

Remarks. In consideration of Dakin's figure 17, this species possesses a small spine on the lower distal angle of the telson, and therefore, belongs to the genus *Eulimnadia*.

Distribution. Flooded bushland at Northam (Western Australia) (Dakin, 1914).

Limnadopsis birchii (Baird, 1860)

Estheria birchii Baird, 1860: 392–393, pl. 72, fig. 1 a–e; Grube, 1865: 234 (list); Simon, 1886: 453 (list).
Limnadopsis squirei.–Spencer & Hall, 1896: 239–241, pl. 21, fig. 15, pl. 22, figs. 16–19; Wolf, 1911: 254 (list); Dakin, 1914: 295 (listed with a question mark); Henry, 1924: 132 (key).
Limnadopsis birchii.–Sayce, 1903: 249–250; Wolf, 1911: 254 (list); Dakin, 1914: 295 (list); Henry, 1924: 121–122 (list), 132; Brtek, 1997: 58 (list).
Limnadiopsis brichii.–Daday, 1925: 177–181, fig. 122 (misspelling).

Type material. None designated.

Distribution. Namoi River, Broken Hill (New South Wales); Colon's Lagoon near Alice Springs (Northern Territory); Macumba Creek, country between Oodnadatta (South Australia) and Charlotte Waters (Northern Territory). Additional distribution records from Timms & Richter, 2002: Bloodwood Station and localities near Bloodwood Station (New South Wales); Currawinya National Park, Rockwell and Wombah Stations (Queensland).

Limnadopsis tatei Spencer & Hall, 1896

Limnadopsis tatei Spencer & Hall, 1896: 241, figs. 20–27; Sayce, 1903: 250; Wolf, 1911: 254 (list); Dakin, 1914: 295 (list); Henry, 1924: 122 (list), 132 (key).
Limnadiopsis tatei.–Daday, 1925: 181–183, fig. 123 (misspelling of the genus name).
Limnadiopsium tatei.–Brtek, 1997: 58 (list).

Type material. None designated.

Distribution. Macumba Creek, country between Oodnadatta (South Australia) and Charlotte Waters (Northern Territory); Wintinorina, near Lake Eyre (South Australia). Additional distribution records from Timms & Richter, 2002: Bloodwood Station (New South Wales).

Limnadopsis brunneus Spencer & Hall, 1896

Limnadopsis brunneus Spencer & Hall, 1896: 243, pl. 23, figs. 28–29; Sayce, 1903: 250; Wolf, 1911: 254 (list); Dakin, 1914: 295 (list); Henry, 1924: 122 (list), 132 (key); Brtek, 1997: 58 (list).
Limnadiopsis brunneus.–Daday, 1925: 183–184, fig. 124 (misspelling of the genus name); Schneider & Sissom, 1982: 72–73 (misspelling of the genus name).

Type material. None designated.

Remarks. Specimens from the Mitchell Plateau (28 males, 32 ♀ ♀) have an "average number of carapace lines of 18 in both sexes" according to Schneider & Sissom (1982). This is very different from the 30 to 34 described by Spencer & Hall (1896), especially considering the similar size of the specimens from the two localities. Although the exact number of growth lines is certainly not a character to distinguish species (Belk, 1989), such a large difference makes it questionable that the specimens from the Mitchell Plateau belong to *L. brunneus*. The number of pairs of legs is unknown in the Darwin specimens (compare with the description by Spencer & Hall [1896]). Given this, we do not know the basis for Henry (1924: 132) giving 26 pairs of legs for *L. brunneus*.

Distribution. Knuckey's Lagoon, near Darwin (Northern Territory); ?Mitchell Plateau (Western Australia).

Limnadopsis parvispinus Henry, 1924

Limnadopsis parvispinus Henry, 1924: 121 (list), 132 (key), 132–133, pl. 32, figs. 1–7; Brtek, 1997: 58 (list).

Type material examined. 3 ♂ ♂, 10 ♀ ♀ (AM G5224, AM G5226, syntypes): the three males possess 24–25 pairs of legs, five females 24–26 pairs of legs; the legs of the other five females could not be counted. Although the exact number of pairs of legs is difficult to determine, we conclude that *L. parvispinus* has no more than 26 pairs of legs. This implies that one important character—"about 30 pairs of legs"—in Henry's description and in her key is imprecise

Distribution. Lake Cowal (Bland district), Mossgiel (New South Wales).

Additional distribution records in Timms & Richter (2002): Bloodwood Station and localities near Bloodwood Station (New South Wales); Currawinya National Park, Rockwell and Wombah Stations (Queensland).

Cyclestheriidae Sars, 1899

Cyclestheriidae Sars, 1899

Valves flattened by circular in profile, clear, and with few (<5) growth lines. Body short, trunk of 16 segments, each with a pair of foliaceous appendages, all similar except for decreasing size posteriorly. Telson sclerified, dorsally adorned with strong spines and with two strong claws. Eyes sessile, fused.

The family Cyclestheriidae is monotypic, with *Cyclestheria hislopi* as the only species. *Paracyclestheria sinensis* Shen & Dai, 1987 is, according to Olesen *et al*. (1996), probably a juvenile of *C. hislopi*. An overview of the distribution of *Cyclestheria hislopi* in Australia is given by Timms (1986). A complete list of references is given by Olesen *et al*. (1996). New records from South East Asia including new drawings of the species were provided by Martin *et al*. (2003). Consequently, the present list is restricted to the first two descriptions and the Australian records.

Cyclestheria hislopi (Baird, 1859)

Estheria hislopi Baird, 1859: 232, pl. 63, fig. 1.
Limnadia hislopi.–Brady, 1886b: 294, pl. 37, figs. 1–3.
Cyclestheria hislopi.–Sars, 1887; Sayce, 1903: 256–257, pl. 36, fig. C, 1–2; Henry, 1924: 122 (list); Daday, 1926: 76–81, fig. 146; Timms, 1979: 57; Timms, 1986: 302–305, fig. 1; Brtek, 1997: 46 (list).

Type material. British Museum, London.

Distribution in Australia. *Cyclestheria hislopi* is restricted to the far north of Western Australia, Northern Territory and western Queensland, but in eastern Queensland it extends southwards to the limit of the tropics (see Timms, 1986: fig. 2 for further details).

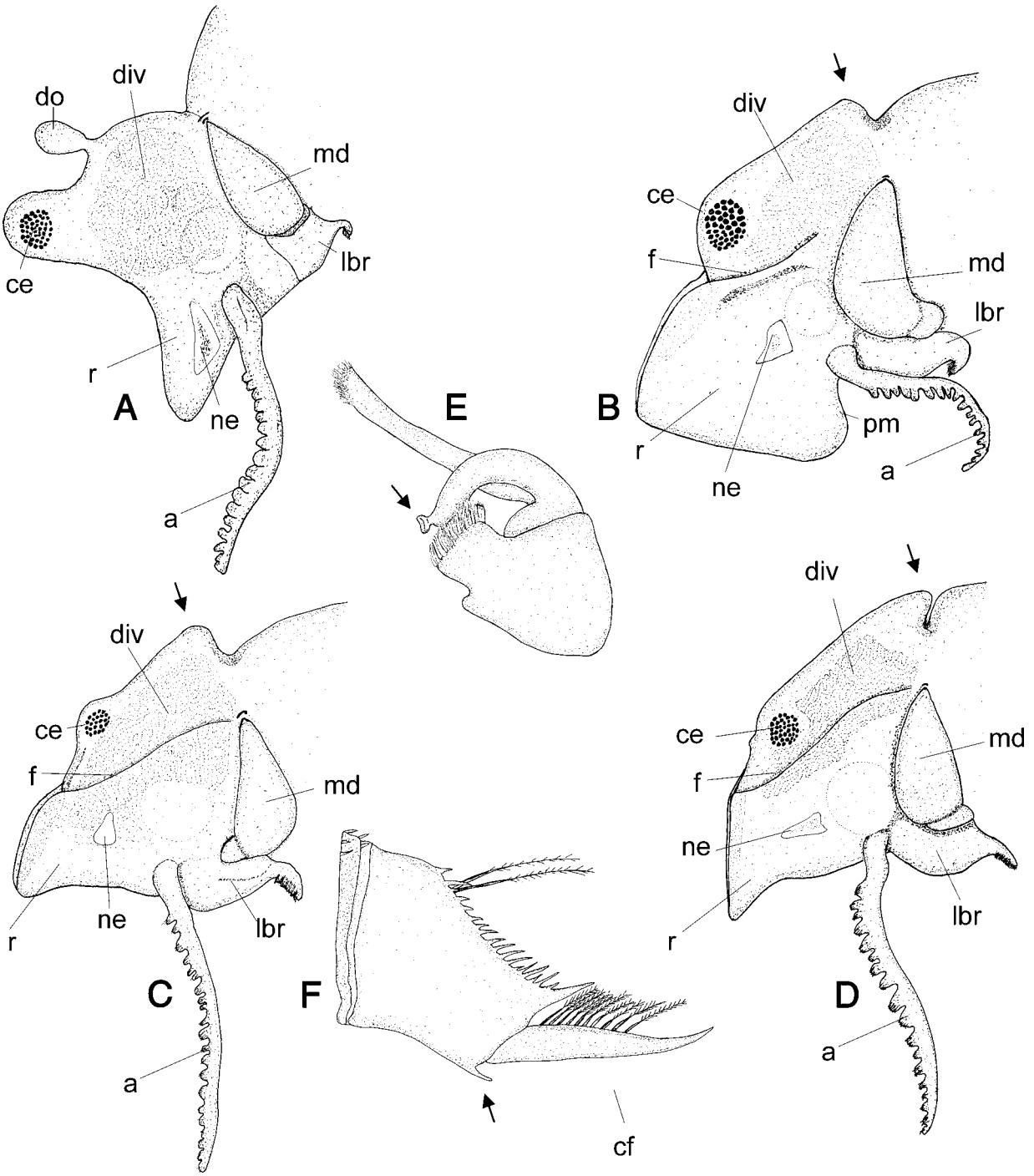

Fig. 4. Schematic drawings of Australian clam shrimps based on specimens in the private collections of BVT and SR—not to scale: (*A*)—head of a *Limnadopsis* sp. male (second antennae removed); note the pyriform dorsal organ (*do*). (*B*)—head of *Eocyzicus parooensis* male (second antennae removed); note the round and short condylus (arrow) of the dorsal posterior end of the head (occipital crest), and the posterior margin (*pm*) of the rostrum (*r*). (*C*)—Head of a *Caenestheria* sp. male (second antennae removed); note the round and short condylus (arrow) of the dorsal posterior end of head (occipital crest); no posterior margin of the rostrum is present. (*D*)—Head of a *Caenestheriella* sp. male (second antennae removed); note the pointed condylus (arrow) of the dorsal posterior end of head; no posterior margin of the rostrum is present. (*E*)—Clasper of a *Limnadia* sp. male; note the sucker-like projection (arrow) of the movable finger. (*F*)—Telson of a *Eulimnadia* sp. female; note the spine on the lower distal angle of the telson. Abbreviations: *a*, first antenna; *ce*, compound eye; *cf*, caudal furca; *div*, gut diverticula; *f*, fornix; *lbr*, labrum; *md*, mandible; *ne*, nauplius eye.

Key to the genera of Australian clam shrimps

Here, we provide a key to the genera of the Australian clam shrimps as accepted in this paper. We believe that all described Australian clam shrimps should be referable to one of the genera mentioned. However, characters might not be present or easily seen in juveniles, so this key is only valid for fully grown animals. Differences also exist between males and females, in particular, in the shape of the rostrum. In Fig. 4 only males (except for F) are shown.

1 Carapace without growth lines, telson without caudal furcae ..... *Lynceus*

—— Carapace with growth lines (sometimes inconspicuous), telson with caudal furcae 2

2 Head with pyriforme frontal organ posterior to the compound eyes (Fig. 4A) 3

—— Head without pyriforme frontal organ (Fig. 4B,C,D) 5

3 Movable finger of the two claspers in males with small sucker-like dorsodistal projection (Fig. 4E), growth lines restricted to marginal portion of carapace 4

—— Movable finger of the two claspers in males without sucker-like dorsodistal projection, the entire carapace with growth lines ..... *Limnadopsis*

4 Telson with spine on its lower distal angle (Fig. 4F) ..... *Eulimnadia*

—— Telson without spine on its lower distal angle ..... *Limnadia*

5 Dorsal margin of the telson with very large spines of almost similar size as the caudal furcae ..... *Cyclestheria*

—— Dorsal margin of the telson with small teeth of different size, but teeth never of almost similar size as the caudal furcae (Fig. 4F) 6

6 Rostrum in lateral view broad and hatchet-like, with posterior margin in addition to the anterior margin and the ventral margin. Posterior margin leads to the origin of the first antenna (Fig. 4B) 7

—— Rostrum in lateral view narrow, only with anterior and ventral margin, no obvious posterior margin. Ventral margin leads to the origin of the first antenna (Fig. 4C,D) 8

7 Dorsal posterior end of the head (occipital crest) with round and short condylus, distinct from the trunk (Fig. 4C) ..... *Eocyzicus*

—— Dorsal posterior end of the head with pointed condylus, head and trunk dorsally not distinct ..... *Cyzicus*

8 Dorsal posterior end of the head (occipital crest) with round and short condylus, distinct from the trunk (Fig. 4C) ..... *Caenestheria*

—— Dorsal posterior end of the head with pointed condylus, head and trunk dorsally not distinct (Fig. 4D) ..... *Caenestheriella*

Discussion

The Australian clam shrimp fauna is not well known. One recent study (Timms & Richter, 2002) showed a diverse fauna in a small area of the arid-zone, with many of the species new to science. Unfortunately, clam shrimps are a problematic group. Species demarcation and identification is difficult and the validity of the genera is far from being universally accepted. A recent study of clam shrimps based on molecular markers shows that the conchostracans are very probably paraphyletic with the Cyclestheriidae as sister group to the Cladocera and the Spinicaudata as sister group to both taxa (Braband *et al*., 2002). Another result of this study is important for the taxonomy of the spinicaudatan clam shrimps: the monophyly of the three families Leptestheriidae (two species belonging to *Leptestheria* included), Cyzicidae (four species belonging to Daday's four genera included) and Limnadiidae (four species belonging to *Limnadia, Eulimnadia, Limnadopsis*, and *Imnadia* included) is supported.

Therefore, at least the spinicaudatan families seem to be well defined. Taxonomic problems appear on the genus and species level. The major problem concerns the family Cyzicidae (see Daday, 1914). Based on Henry's (1924) revision only one genus seemed to occur in Australia—*Cyzicus* (with *Estheria* as a synonym), a position followed by more recent authors (e.g., Bishop, 1967c; Williams, 1980; Geddes, 1983). However, Daday (1914: fig. 1 on page 44, key on page 51–52) split the genus *Estheria* into several genera. Within the Cyzicidae (described by Daday as Caenestheriidae) he distinguished four genera: *Caenestheria, Caenestheriella, Cyzicus*, and *Eocyzicus* (Daday,

1914). Within the Leptestheriidae he recognized three genera: *Leptestheria, Eoleptestheria*, and *Leptestheriella* (Daday, 1923). This approach has been accepted or at least been used by many workers (e.g., Pennak, 1989; Bănărescu, 1990; Dodson & Frey, 1991; Martin, 1992; Dobrynina, 1995; Maeda-Martínez *et al*., 1997; Hamer & Martens, 1998) for other areas in the world. However, Straškraba (1965) doubted the validity of Daday's genera and Sassaman (1995) followed Straškraba insofar as not accepting *Caenestheriella* but accepting *Caenestheria* as a valid genus. Brtek (1997) synonymized *Caenestheria* with *Eocyzicus* (with *Eocyzicus* as the valid genus name) and *Caenestheriella* with *Cyzicus* (with *Cyzicus* as the valid genus name) on the basis of "continuous transitional features" (previously suggested by Brtek *et al*., 1984). Naganawa (2001) synonymized all cyzicid genera with *Cyzicus*. Other significant changes by him such as the erection of several new families have no impact to the Australian fauna.

Although we agree that the differences between the genera might not be obvious and some doubt is justified about the validity of the four genera, it is possible to refer all the Cyzicidae in the extensive collections in the Australian Museum to three of Daday's four genera (the fourth, *Cyzicus* seems not to be present in Australia) by using the key given above. Nevertheless, a worldwide revision of the Cyzicidae might show that one or other of the four genera is not monophyletic, and this should be the only criterion for acceptance or rejection of the validity of a genus. For now, however, we accept Daday's genera for the Australian fauna. One should keep in mind that the assumption that only representatives of the genus *Cyzicus* are represented in the Australian fauna (e.g., Williams, 1980) is based only on the usage of Henry's (1924) monograph and not on any taxonomic decisions (i.e., for example suggesting the synonymy of all of Daday's four genera). This has caused misleading biogeographical conclusions concerning the worldwide distribution of clam shrimp genera (e.g., Bănărescu, 1990).

Other taxonomic problems concern the Limnadiidae. Besides the South American *Metalimnadia*, the European *Imnadia*, and the Australian *Limnadopsis*, two widespread genera are described, *Limnadia* and *Eulimnadia*; both occur in Australia and both have often been confused. Based on published descriptions by several authors, Webb & Bell (1979) suggested that *Eulimnadia* Packard, 1874, should be synonymized with *Limnadia* Brongniart, 1820. This was recently accepted by Brtek (1997) and Naganawa (2001). The reason for this proposal was that a complete gradation exists in the single character separating the two genera that were proposed by Daday (1925), i.e., the presence in *Eulimnadia* and the absence in *Limnadia* of a spine on the lower distal angle of the telson. In contrast, based on a re-study of different species, Belk (1989) pointed out that the presence or absence of such a telson spine is a distinct character. According to Belk (1989), a further difference in the two genera is the fusion of the dorsal left and right ridges of the telson just posterior to the moundlike base of the telson filaments in *Limnadia* or anterior to the moundlike base of the telson filaments in *Eulimnadia*. Martin (1989) has also confirmed that a well-developed blunt spine below the insertion of the caudal furcae is a characteristic of the genus *Eulimnadia*.

The new record of *Eocyzicus* species in Australia is remarkable. It shows that the genus *Eocyzicus* is not restricted to North America, Asia, and Africa. Therefore, it seems that within the Cyzicidae, only representatives of Daday's *Cyzicus* are absent in Australia. Also no representatives of the Leptestheriidae Daday, 1923 have been recorded from Australia.

Finally, it is remarkable that *E. parooensis* n.sp. is the first clam shrimp species preferring hyposaline habitats (see also Timms & Richter, 2002).

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References

Anderson, D.T., 1967. Larval development and segment formation in the branchiopod crustaceans, *Limnadia stanleyana* King (Conchostraca) and *Artemia salina* (L.) (Anostraca). *Australian Journal of Zoology* 15: 47–91.

Baird, W., 1859. Description of some new recent Entomostraca from Nagpoor, collected by the Rev. S. Hislop. *Proceedings of the Zoological Society of London* 1859: 231–234, pl. 63.

Baird, W., 1860. Description of a new Entomostracous Crustacean, belonging to the order Phyllopoda, from South Australia. *Proceedings of the Zoological Society of London* 1860: 392–393, pl. 72.

Bănărescu, P., 1990. *Zoogeography of fresh waters. Vol. 1. General distribution and dispersal of freshwater animals*. Wiesbaden: Aula.

Belk, D., 1989. Identification of species in the conchostracan genus *Eulimnadia* by egg shell morphology. *Journal of Crustacean Biology* 9: 115–125.

Bishop, J.A., 1967a. Seasonal occurrence of a branchiopod crustacean, *Limnadia stanleyana* King (Conchostraca) in eastern Australia. *Journal of Animal Ecology* 36: 77–95.

Bishop, J.A., 1967b. Some adaptations of *Limnadia stanleyana* King (Crustacea: Branchiopoda: Conchostraca) to a temporary freshwater environment. *Journal of Animal Ecology* 36: 599–609.

Bishop, J.A., 1967c. Branchiopoda (excluding Cladocera). In *An illustrated key to the genera of the Crustacea of Australian Inland Waters*, ed. I.A.E. Bayly, J.A. Bishop & I.D. Hiscock. *Australian Society for Limnology. A special issue of the newsletter of the Society*: 8–10.

Bishop, J.A., 1968a. Aspects of the post-larval life history of *Limnadia stanleyana* King (Crustacea: Conchostraca). *Australian Journal of Zoology* 16: 885–895.

Bishop, J.A., 1968b. Resistance of *Limnadia stanleyana* King (Branchiopoda, Conchostraca) to desiccation. *Crustaceana* 14: 35–38.

Bishop, J.A., 1969. Feeding behavior of larval and post-larval *Limnadia stanleyana* King, 1855 (Branchiopoda: Conchostraca). *Crustaceana* 17: 108–109.

Braband, A., S. Richter, R. Hiesel & G. Scholtz, 2002. Phylogenetic relationships within the Phyllopoda (Crustacea, Branchiopoda) based on mitochondrial and nuclear markers. *Molecular Phylogenetics and Evolution* 25: 229–244.

Brady, G.S., 1886a. Notes on freshwater Entomostraca from South Australia. *Proceedings of the Zoological Society of London* 1886: 82–93, pl. 8–10.

Brady, G.S., 1886b. Notes on Entomostraca collected by Mr. A. Haly in Ceylon. *Journal of the Linnean Society* 19: 294–417, pl. 37, figs. 1–3.

Brongniart, A., 1820. Mémoire sur le *Limnadia*, nouveau genre des Crustacés. *Mémoires musée national d'Histoire naturelles* 6: 83–93.

Brtek, J., 1997. Checklist of the valid and invalid names of the "Large Branchiopods" (Anostraca, Notostraca, Spinicaudata and Laevicaudata), with a survey of the taxonomy of all Branchiopoda. *Zborník Slovenského Národného Múzea* 43: 3–66.

Brtek, J., L. Forró & J.E. Ponyi, 1984. Contributions to the knowledge of the Branchiopoda (Crustacea) fauna of Mongolia. *Annales historico-naturales Musei nationalis hungarici* 76: 91–99.

Bunn, S.E., & P.M. Davies, 1999. Aquatic food webs in turbid, arid zone rivers: Preliminary data from Cooper Creek, western Queensland. In *A free-flowing river: the ecology of the Paroo River*, ed. R.T. Kingsford. Sydney: National Parks and Wildlife Service, pp. 67–76.

Chilton, C., 1917. Crustacea. In *Results of the South Australian Museum Expedition to Strzelecki and Cooper Creeks, September and October 1916. Transactions of the Royal Society of South Australia* 41: 475–482.

Claus, C., 1872. Über den Körperbau einer australischen *Limnadia* und über das Männchen derselben. *Zeitschrift für wissenschaftliche Zoologie* 22: 355–364.

Daday, E., 1914. Monographie systématique des Phyllopodes Conchostracés. Première partie. *Annales des Sciences Naturelles*, Zoologie, 9e série 20: 39–330.

Daday, E., 1923. Monographie systématique des Phyllopodes Conchostracés. Deuxième partie. *Annales des Sciences Naturelles, Zoologie*, 10e série 6: 255–390 (331–462).

Daday, E., 1925. Monographie systématique des Phyllopodes Conchostracés. Troisième partie. *Annales des Sciences Naturelles*, Zoologie, 10e série 8: 143–184 (463–504).

Daday, E., 1926. Monographie systématique des Phyllopodes Conchostracés. Troisième partie (suite). *Annales des Sciences Naturelles*, Zoologie, 10e série 9: 1–81 (505–585).

Daday, E., 1927. Monographie systématique des Phyllopodes Conchostracés. Troisième partie (fin). *Annales des Sciences Naturelles*, Zoologie, 10e série 10: 1–112 (587–698).

Dakin, W.J., 1914. Fauna of Western Australia. II. The Phyllopoda of Western Australia. *Proceedings of the Zoological Society of London* 1914: 293–305.

Dobrynina, T.I., 1995. Conchostraca [in Russian]. In *Key to freshwater invertebrates of Russia*, ed. S.J. Tsalolikhin. St. Petersburg: Zoological Institute of the Academy of Science.

Dodson, S.I., & D.G. Frey, 1991. Cladocera and other Branchiopoda. In *Ecology and classification of North American freshwater invertebrates*, ed. J.H. Thorp & A.P. Covich. San Diego: Academic Press.

Dumont H.J., & S.V. Negrea, 2002. *Introduction to the Class Branchiopoda Guides to the Identification of the Micro-invertebrates of the Continental Waters of the World*. No. 19. Leiden: Backhuys Publishers, 398 pp.

Forró, L., & J. Brtek, 1984. Anostraca and Conchostraca taxa described by E. Daday together with a catalogue of pertinent material in the Hungarian Natural History Museum. *Miscellanea Zoologica Hungarica* 2: 75–104.

Geddes, M.C., 1973. A new species of *Pararteмia* (Anostraca) from Australia. *Crustaceana* 25: 5–12.

Geddes, M.C., 1981. Revision of Australian Species of *Branchinella* (Crustacea: Anostraca). *Australian Journal of Marine and Freshwater Research* 32: 253–295.

Geddes, M.C., 1983. Biogeography and Ecology of Australian Anostraca (Crustacea: Branchiopoda). In *Papers from the Conference on the Biology and Evolution of Crustacea. Held at the Australian Museum Sydney 1980*, ed. J.K. Lowry. *Australian Museum Memoir* 18: 155–163.

Glauert, L., 1924. Contributions to the fauna of Western Australia. 5. Crustacea. *Journal of the Royal Society of Western Australia* 10: 59–64.

Grube, E., 1865. Ueber die Gattungen *Estheria* und *Limnadia* und einen neuen *Apus*. *Archiv für Naturgeschichte* 31: 203–282.

Gurney, R., 1927. Some Australian freshwater Entomostraca reared from dried mud. *Proceedings of the Zoological Society of London* 1927: 59–79.

Hamer, M.L., & K. Martens, 1998. The large Branchiopoda (Crustacea) from temporary habitats of the Drakensberg region, South Africa. *Hydrobiologia* 384: 151–165.

Henry, M., 1924. A monograph of the freshwater Entomostraca of New South Wales. Part IV. Phyllopoda. *Proceedings of the Linnean Society of New South Wales* 1924: 120–137.

Herbert, B., & B.V. Timms, 2000. A new species of *Streptocephalus (Parastreptocephalus)* (Crustacea: Anostraca: Streptocephalidae) from North Queensland, Australia. *Memoirs of the Queensland Museum* 45: 385–390

King, R.L., 1855. On Australian Entomostracans. *Papers and Proceedings of the Royal Society of Tasmania (Van Diemen's Land)* 3: 56–75.

King, R.L., 1863–1866 (read 5th September 1864). On the anatomy of certain forms of Australian Entomostraca. *Transactions of the Entomological Society of New South Wales* 1, 162–166, pl. 11.

Longhurst, A., 1955. A review of the Notostraca. *Bulletin of the British Museum of Natural History* 3: 1–57.

Maeda-Martínez, A.M., D. Belk, H. Obregón-Barboza & H. Dumont, 1997. Large branchiopod assemblages common to Mexico and the United States. *Hydrobiologia* 359: 45–62.

Martin, J.W., 1989. *Eulimnadia belki*, a new clam shrimp from Cozumel, Mexico (Conchostraca: Limnadiidae), with a review of Central and South American species of the genus *Eulimnadia*. *Journal of Crustacean Biology* 9: 104–114.

Martin, J.W., & D. Belk, 1988. Review of the clam shrimp family Lynceidae Stebbing, 1902 (Branchiopoda: Conchostraca), in the Americas. *Journal of Crustacean Biology* 8: 451–482.

Martin, J.W., & G.E. Davis, 2001. An updated classification of the recent Crustacea. *Natural History Museum of Los Angeles County Contributions to Science* 39: 1–124.

Martin, J.W., S.L. Boyce & M.J. Grygier, 2003. New records of *Cyclestheria hislopi* (Baird, 1859) (Crustacea: Branchiopoda: Diplostraca: Cyclestherida) in Southeast Asia. *The Raffles Bulletin of Zoology* 52: 215–218.

McMaster, K., A. Savage, T. Finston, M.S. Johnson & B. Knott, in press. Has *Artemia parthenogenetica* been introduced into Western Australia through human agency? *Hydrobiologia*.

Naganawa, H., 2001. Current prospect of the recent large branchiopodan fauna of East Asia: 1. Order Spinicaudata. *Aquabiology* 22: 272–278.

Novojilov, N., 1958. Recueil d'articles sur les Phyllopodes Conchostracés. *Ann. Serv. Inf. Géol*. BRGGM 26: 5–134.

Olesen, J., J.W. Martin & E.W. Roessler, 1996. External morphology of the male of *Cyclestheria hislopi* (Baird, 1859) (Crustacea, Branchiopoda, Spinicaudata), with a comparison of male claspers among the Conchostraca and Cladocera and its bearing on phylogeny of the "bivalved" Branchiopoda. *Zoologica Scripta* 25: 291–316.

Olesen, J., & B.V. Timms, 2005. Caenestheriella mariae n.sp. (Crustacea:Branchiopoda: Spinicaudata: Cyzicidae): a new clam shrimp from Western Australia. Zootaxa 824: 1–8.
www.mapress.com/zootaxa/2005/zt00824.pdf

Packard, A.S., 1874. Synopsis of the fresh-water phyllopod Crustacea of North America. [Seventh] Annual report of the United States Geological and Geographical Survey of the Territories, embracing Colorado, year 1873, F.V. Hayden, United States Geologist. Part III, article 13: 613–622.

Pennak, R.W., 1989. *Fresh-water Invertebrates of the United States—Protozoa to Mollusca*. 3rd edition. New York: John Wiley & Sons.

Remigio, E.A., P.D.N. Hebert & A. Savage, 2001. Phylogenetic relationships and remarkable radiation in *Parartemia* (Crustacea: Anostraca), the endemic brine shrimp of Australia: evidence from mitochondrial DNA sequences. *Biological Journal of the Linnean Society* 74: 59–71.

Sars, G.O., 1887. On *Cyclestheria hislopi* (Baird), a new generic type of bivalve Phyllopoda; raised from dried Australian mud. *Christiana Videnskabs-Selskabs Forhandlinger* 1: 1–65.

Sars, G.O., 1895. Descriptions of some Australian Phyllopoda. *Archiv for Mathematik og Naturvidenskab* 17(2): 1–51, pl. 1–8.

Sars, G.O., 1896a. Development of *Estheria packardi* Brady, as shown by artificial hatching from dried mud. *Archiv for Mathematik og Naturvidenskab* 18(2): 1–27, pl. 1–4

Sars, G.O., 1896b. Descriptions of two new Phyllopoda from North Australia. *Archiv for Mathematik og Naturvidenskab* 18(8): 1–34, pl. 1–6

Sars, G.O., 1897. On some West-Australian Entomostraca raised from dried sand. *Archiv for Mathematik og Naturvidenskab* 19(1): 1–35, pl. 1–4.

Sassaman, C., 1995. Sex determination and evolution of unisexuality in the Conchostraca. *Hydrobiologia* 298: 45–65.

Savage, A., 2003. *Biology of the brine shrimp genus* Parartemia *in Western Australia*. Ph.D. Thesis, University of Western Australia.

Sayce, O.A., 1903. The Phyllopoda of Australia, including descriptions of some new genera and species. *Proceedings of the Royal Society of Victoria* 15: 224–261, pl. 27–36.

Schneider, E.L., & S.L. Sissom, 1982. An account of *Limnadiopsis brunneus* Spencer and Hall 1896 (Crustacea: Conchostraca) in Western Australia. *The Western Australian Naturalist* 15: 72–73.

Shen, C.J., & A.Y. Dai, 1987. A new and rare species of Conchostraca from Yunnan Province China (Crustacea: Conchostraca). *Acta Zootaxonomica Sinica* 12: 353–356.

Simon, E., 1886. Étude sur les crustacés du sous-ordre des Phyllopodes. II. Catalogue général des Phylopodes et descriptions d'espèces nouvelles. *Annales de la Société entomologique de France* 6: 441–460.

Spencer, W.B., & T.S. Hall, 1896. Crustacea. *Report on the Work of the Horn Scientific Expedition to Central Australia. II. Zoology. London, and Melbourne* 8: 227–248.

Straškraba, M., 1965. Taxonomical studies on Czechoslovak Conchostraca. II. Families Lynceidae and Cyzicidae. *Vestník Ceskoslovenské spolecnosti zoologické* 29: 205–214.

Tasch, P., 1969. Branchiopoda. In *Treatise on invertebrate paleontology, part R: Arthropoda 4*, ed. R.C. Moore. *Geological Society of America, Boulder, and University of Kansas Press, Lawrence, Kansas* 1: 128–191.

Timms, B.V., 1979. The benthos of some lakes in northeastern Queensland. *Proceedings of the Royal Society of Queensland* 90: 57–64.

Timms, B.V., 1986. *Cyclestheria hislopi* (Conchostraca) in Australia. *Crustaceana* 51: 302–305.

Timms, B.V., 1993. Saline lakes of the Paroo, inland New South Wales, Australia. *Hydrobiologia* 267: 269–289.

Timms, B.V., 1999. Local runoff, Paroo floods and water extraction impacts on wetlands of Currawinya National Park. In *A free-flowing river: the ecology of the Paroo River*, ed. R.T. Kingsford. Sydney: National Parks and Wildlife Service, pp. 51–66.

Timms, B.V., 2001. Two new species of Branchinella Sayce, 1903 (Crustacea: Anostraca: Thamnocephalidae) from the Paroo, inland Australia. Records of the Australian Museum 53(2): 247–254. www.amonline.net.au/pdf/publications/1331_complete.pdf

Timms, B.V., 2003. The Fairy Shrimp Genus *Branchinella* Sayce (Crustacea: Anostraca: Thamnocephalidae) in Western Australia, including a description of four new species. *Hydrobiologia* 486: 71–89.

Timms, B.V., 2004. *An Identification Guide to the Fairy Shrimps (Crustacea: Anostraca) of Australia*. Thurgoona (New South Wales, Australia): CRCFC Identification and Ecology Guide no. 47, 76 pp.

Timms, B.V., 2005. Two new species of *Branchinella* (Anostraca: Thamnocephalidae) and a reappraisal of the *Branchinella nichollsi* group. *Memoirs of the Queensland Museum* 50(2): 441–452.

Timms, B.V., in press. Large branchiopods of gnammas (rock holes) in Australia. *Hydrobiologia*

Timms, B.V., & M.C. Geddes, 2003. The Fairy Shrimp Genus *Branchinella* Sayce (Crustacea: Anostraca: Thamnocephalidae) in South Australia and the Northern Territory, including a description of three new species. *Transactions of the Royal Society of South Australia* 127: 53–68.

Timms, B.V., & S. Richter, 2002. A preliminary analysis of the conchostracans (Crustacea: Spinicaudata and Laevicaudata) of the middle Paroo catchment of the Australian arid-zone. *Hydrobiologia* 486: 239–247.

Timms, B.V., & P. Sanders, 2003. Biogeography and ecology of Anostraca (Crustacea) in middle Paroo catchment of the Australian arid-zone. *Hydrobiologia* 486: 225–233.

Webb, J.A., & G.D. Bell, 1979. A new species of *Limnadia* (Crustacea: Conchostraca) from the granite belt in southern Queensland and north New South Wales. *Proceedings of the Linnean Society of New South Wales* 103: 237–245.

Whitelegge, T., 1889. List of the Marine and Freshwater Invertebrate Fauna of Port Jackson and the Neighbourhood. *Journal and Proceedings of the Royal Society of New South Wales* 23: 163–323.

Williams, W.D., 1980. *Australian Freshwater Life—The Invertebrates of Australian Inland Waters*. Melbourne: Macmillan Company of Australia Pty Ltd.

Williams, W.D., & M.C. Geddes, 1991. Anostracans of Australian salt lakes, with particular reference to a comparison of *Parartemia* and *Artemia*. In *Artemia Biology*, ed. R.A. Browne, P. Sorgeloos and C.A.N. Trotman. Florida: CRC Press, pp. 367–372.

Wolf, E., 1911. Phyllopoda. In *Die Fauna Südwest-Australiens. Ergebnisse der Hamburger südwest-australischen Forschungsreise 1905*, ed. W. Michaelsen and R. Hartmeyer. Jena: G. Fischer, 3: 253–276.

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