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A redescription of *Eulimnadia rivolensis* (Brady, 1886) (Branchiopoda: Spinicaudata: Limnadiiidae), and its transfer to *Paralimnadia*

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Abstract

Timms, B.V. 2019. A redescription of *Eulimnadia rivolensis* (Brady, 1886) (Branchiopoda: Spinicaudata: Limnadiiidae), and its transfer to *Paralimnadia*. *Memoirs of Museum Victoria* 78: 57–64.

Eulimnadia rivolensis occurs across the southern Australian mainland and Tasmania but has not been collected in Victoria since 1910 and in south-east South Australia since 1975, where its former habitat has been destroyed. *E. rivolensis* is redescribed from syntype material and transferred to *Paralimnadia*. This species lacks a subcercopod spine and has other less characteristic features of *Paralimnadia*. *Eulimnadia palustera* Timms, 2015 is a junior synonym based on egg morphology and some characteristics of the telson.

Keywords

Subcercopod spine, cercopods, resting eggs, *Eulimnadia palustera*

Introduction

The taxon *Eulimnadia rivolensis* Brady, 1886, of southern Australia has had a chequered history. It was first applied to specimens from the Rivoli Bay environs in south-eastern South Australia, but the description is only of the carapace shape, which is now known to vary with age and habitat (Rogers et al., 2012; Straškraba, 1965), and the illustration could apply to many limnadiid species. Next, the name was used without any justification by Spencer and Hall (1896) for specimens supposedly from Central Australia. Sayce (1903) published some details of the morphology of *E. rivolensis* and provided more accurate drawings, basing his observations on specimens from Victoria and South Australia. Sayce's (1903) Onkaringa (Onkaparinga) Creek site was erroneously recorded as being in Central Australia, but it drains the eastern Adelaide Hills, and so this error introduces possible inaccuracies in distribution. Sayce (1903) suggested, without any evidence, that *E. rivolensis* may be synonymous with *Limnadia sordida*, which at that time was also poorly defined. Thus, New South Wales, the habitat of *L. sordida*, was added to the supposed distribution. This synonymy was perpetuated by Dakin (1914), who noted its occurrence in south-western Western Australia, and Henry (1924), except that *L. sordida* was moved to *Eulimnadia*. To add to the confusion, Daday (1925) retained the specific epithet *rivolensis* but transferred it to *Limnadia*. This was followed by Richter and Timms (2005), based on figures in Sayce (1903), and Gurney (1927) because neither recorded a subcercopod spine, a defining feature of *Eulimnadia* (Martin, 1989). Importantly, the species epithet was hidden in the synonymy, so its possible existence was not acknowledged in a recent review of Australian *Eulimnadia* (Timms, 2016a).

In 2015, I described *Eulimnadia palustera* from south-west Western Australia, which shares some features with Sayce's version of *E. rivolensis*, then thought to be *L. sordida*. Given that egg morphology in limnadiids is useful in distinguishing species (Belk, 1898; Rabet, 2010; Rogers et al., 2012; Timms, 2016a, 2016b), a comparison of the eggs from the few collections labelled *E. rivolensis* in the NMV and AM suggest a close similarity between the two species. In summary, there is uncertainty over the validity of *E. rivolensis* and *E. palustera*, to what species they are related and, indeed, to which genus they belong. Fortunately, there is enough material in the Australian Museum and National Museum Victoria to find solutions to these uncertainties. One subsidiary aim is to accurately plot the distribution of these species.

Material and methods

Drawings were made using a Wild M5 dissection microscope equipped with a camera lucida. Body measurements were made by placing a template marked in 0.5 mm spacings underneath the specimen at magnifications of 10–40 × and distance was estimated to the nearest half division. Accuracy is deemed to be ± 0.25 mm.

Eggs were prepared as detailed in Timms and Lindsay (2011) and studied on a Zeiss Evo LS15 Scanning Electron Microscope using a Robinson Backscatter Detector.

Terminology of the claspers of the Diplostraca follows Kaji et al. (2014): the hand (or palm) is composed of endites IV

and V; its thumb (or gripping knob) is derived from endite IV, the small palp from endite IV and the large palp from endite V; and the finger is derived from endite VI (or endopod).

Other abbreviations used in the text: AM = Australian Museum; BMNH = British Museum of Natural History; NMV = National Museum Victoria; SAM = South Australian Museum; WAM = Western Australian Museum.

Results

Taxonomy

Diplostraca Gerstaecker, 1866
Spinicaudata Linder, 1945
Limnadiidae Baird, 1849
***Paralimnadia* Sars, 1896, emend Rogers et al., 2012.**
***Paralimnadia rivolensis* Brady, 1886**

Figures 1–4

Eulimnadia rivolensis Brady, 1886: 86–67, fig. D. — Simon, 1886: 456 (list); Spencer and 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. 1A.

Limnadia rivolensis — Daday, 1925: 150 (key), 173–175, fig. 121; Webb and Bell, 1979: 243 (text), table 1; Richter and Timms (text): 348.

Eulimnadia palustera Timms, 2015: 447–449, fig. 6. **New synonym**

Lectotype. *South Australia*, hinterland of Rivoli Bay, R. Tate, date unknown but before 1886, BMNH 1890.2.1.9. Male 9.0 mm long and 6.0 mm high.

Paralectotypes. *South Australia*, hinterland of Rivoli Bay, R. Tate, date unknown but before 1886, BMNH 1890.2.1.10. Male 8.9 mm long and 5.5 mm high; Rivoli Bay, freshwater swamps, 11 November 1882, collector unknown, 4 males, 1 female, NMV J14426.

Comment. Because the Brady collection in the National Museum Victoria is labelled from Rivoli Bay and has a date that aligns with the approximate date of collection of the lectotype, I believe the two are the contemporaneous. Hence, the collection NMV J14426 are herein designated as paralectotypes, which is convenient given there are no females or eggs among the original syntypes in the British Museum of Natural History.

Other material. *Northern Territory*: Central Australia, 3 males, 5 females, from Sayce collection but no further data, NMV J54016; *South Australia*; Lake Robe, nearby puddle, Margaret Brock, 23 September 1975, 3 males, 1 female, SAM C12297; Snake Lagoon, Kangaroo Island, South Australia, 24 August 1981, D.J. Williams, 4 males, 2 females, SAM C12296; *Tasmania*: no site recorded, R.W. Davis, 18 October 1969, 4 males, 2 females, NMV J46599; 4 km north of Campbelltown, 41.93° S, 147.5° E , 24 November 1963, J. Wilson, 1 male, 2 females, AM P55663; 4 km north of Campbelltown, 41.93° S, 147.5° E, 20 March 1964, J. Wilson, 7 males, 10 females, AM P55640; 1 female, AM P98988; 1 male, AM P99519; 1 female, AM P99520; Coles Bay, 31 December 1964, no collector recorded, 30 males, 42 females and 28 sex uncertain, NMV 54005; Campbelltown, 23 October 1965, no collector recorded, 1 female, NMV J46622; Bruny Island, between Big Lagoon and Little Lagoon, 21 September 1975, R.B. Manning, 3 males, 4 females, NMV J46600; *Victoria*: Elwood Swamp, 18 July 1899, collector unrecorded, 23 males, 24 females, NMV J53989; Elwood, from Sayce collection but no further data but co-types for *E. victoriensis* Sayce, 4 individuals sex uncertain, NMV J68583; Mordialloc, 25 October 1902, collector unrecorded, 1 male, NMV J46622; Cheltenham, 22 October 1910, collector unrecorded, 17 males, 25 females, NMV J53987; Cheltenham, from Sayce collection but no further data, 4 individuals sex uncertain, NMV J54049;

Diagnosis. Egg astroform, projections grooved. First antenna with about 11 lobes, second antenna of about 12 antennomeres. Trunk 18–20 segmented, long palps of claspers with 2–3 palpomeres and palpomere junctions generally inerm. Telson with about 20 dorsal spines, first 3 usually larger and more spaced than others. Cercopod basal section about 60% of total length and bearing about 8 setae of medium length.

Description. *Male: Head* (fig 1b) with ocular tubercle prominent, the compound eye occupying most (~80%) of it. Rostrum slightly more prominent than ocular tubercle, also slightly asymmetrical and with a rounded apex. Ocellus triangular dorsobasially in rostrum. Frons-rostrum angle about 90°. Dorsal organ posterior to eye by about its half its height, pedunculate about height of ocular tubercle.

First antenna (fig. 1b) distinctly longer than peduncle of second antennae, with 11 lobes, each with numerous short sensory setae. *Second antenna* (fig. 1d) with a spinose peduncle subequal to length to the rostrum, each flagellum with 11 antennomeres dorsally with 1–2 spines and ventrally with 1–7 longer setae. Basal and distal antennomeres with minimal spines, setae maximal on antennomeres 4–9 and only 1–3 setae on basal 3 antennomeres.

Carapace (fig. 1a) elongated oval, pellucid and with weakly expressed growth lines, numbering about 9. Older growth lines well spaced compared with closer-spaced newer growth lines near carapace margin. Both anterior and posterior angles hardly noticeable.

Twenty pairs of thoracopods, the first two modified as claspers. Claspers (fig. 1f) with palm (endites IV and V) trapezoidal with a slight rounded protrusion distomedially. Apical club (endite IV) rounded with thick denticles distomedially and many spines apicolaterally, moveable finger (endite VI) of normal curved structure and palps of typical structure. Moveable finger terminating in a suctorial disc and distoventrally with many small pits. Long palp (endite V) subequal in length to the palm in the first clasper and about 1.5× longer in second clasper. Short and long palps, both with three palpomeres with junctions between them inerm. Last palpomere the longest, particularly in the second-longest palp. Other thoracopods of typical structure for *Eulimnadia*, decreasing in size and complexity after 10th thoracopod. Dorsal surface of trunk (fig.1e) with a short spine posteriormedially on each of the 12 posterior trunk segments.

Telson (fig. 1c) with about 20 pairs of dorsal spines, with the first three larger than the next 17, although these generally increase in length posteriorly. Most spines inerm. Caudal

filaments originating from a mound a little higher than the dorsal telsonic floor and between the 4th and 5th spine. This dorsal floor posterior to the mound with a moderate declivity then an even slope to cercopod posterior. Cercopod almost as long as the telson dorsum, the basal 60% hardly thinning to a small naked spine, then rapidly thinning to an acute apex. The basal 60% with about 8 short setae dorsolaterally; length of most about basal cercopod diameter, with setae 5thto 7th longest and the last one the shortest). Many tiny denticles dorsolaterally on apical 40% of cercopod. All setae geniculate. Triangular projection beneath the cercopods at the ventroposterior corner of the telson.

Comments

Three previous authors have commented on aspects of the morphology of this species. Brady's (1886) original description is ambiguous and could apply to many limnadiids. Sayce (1903) notes the 20 trunk segments, which are unusual among *Eulimnadia* and *Paralimnadia* (Timms, 2016a, b), and comments on 20 telsonic spines and proximal half of cercopod bearing about 10 shortish seta Brady's (1886) illustration (Plate XXXII) confirms a rounded protruding rostrum in the male, many growth lines similar to that described presently from the syntypes (Brady, 1886) and a similar clasper also as described presently but with 1–2 spines at the palpomere junctions. Sayce (1903)

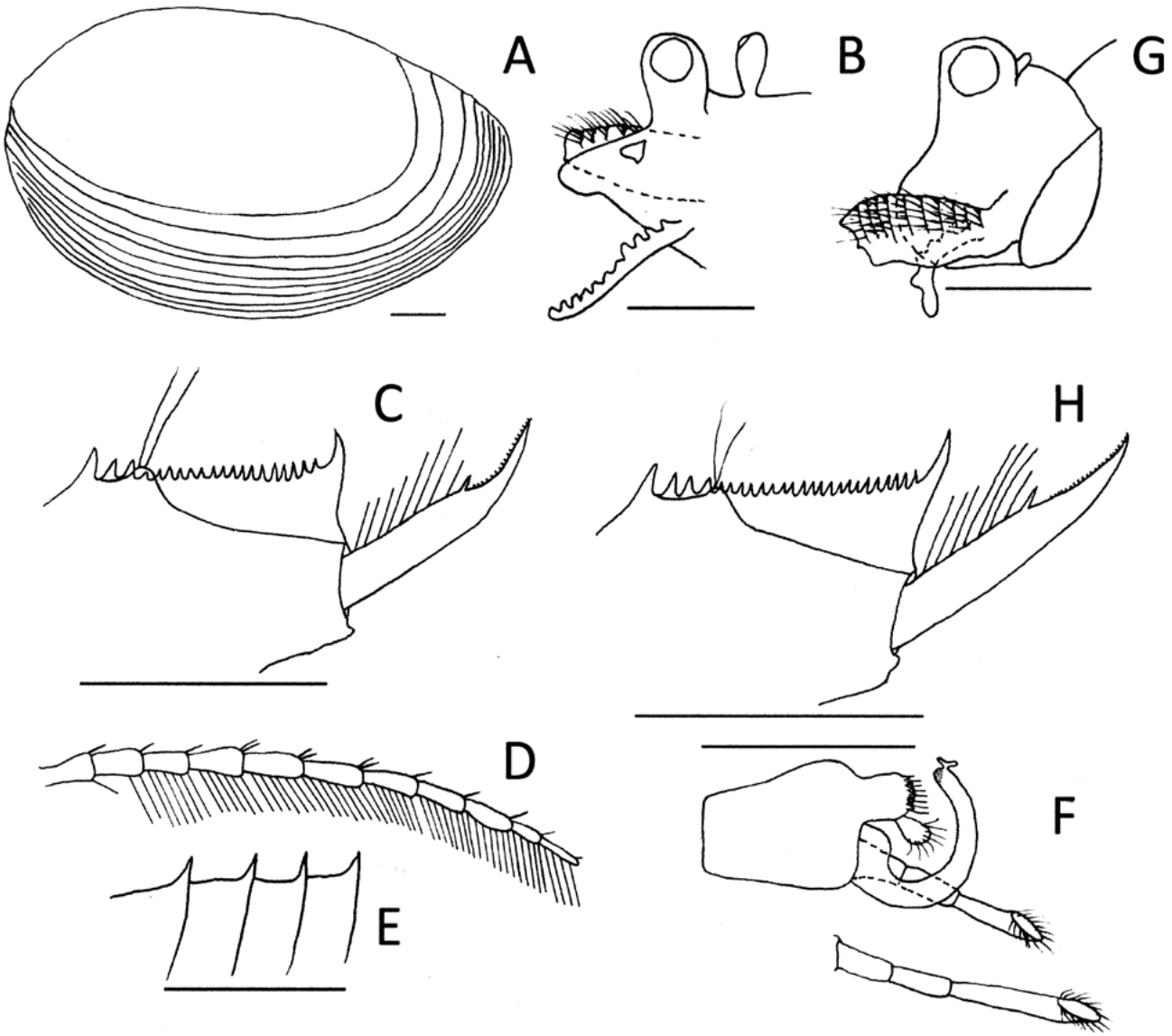

Figure 1. Drawings of types of *P. rivolensis*, male lectotype BMNH 1890.2.1.9. A, carapace; B head, C, telson and cercopod; D, an antennal flagellum; E trunk segments XIV to XVVII dorsa; F, clasper I with insert of long palp of clasper II; female from paralectotype NMV J14426; G, head; H, telson and cercopod. Scale bars 1 mm.

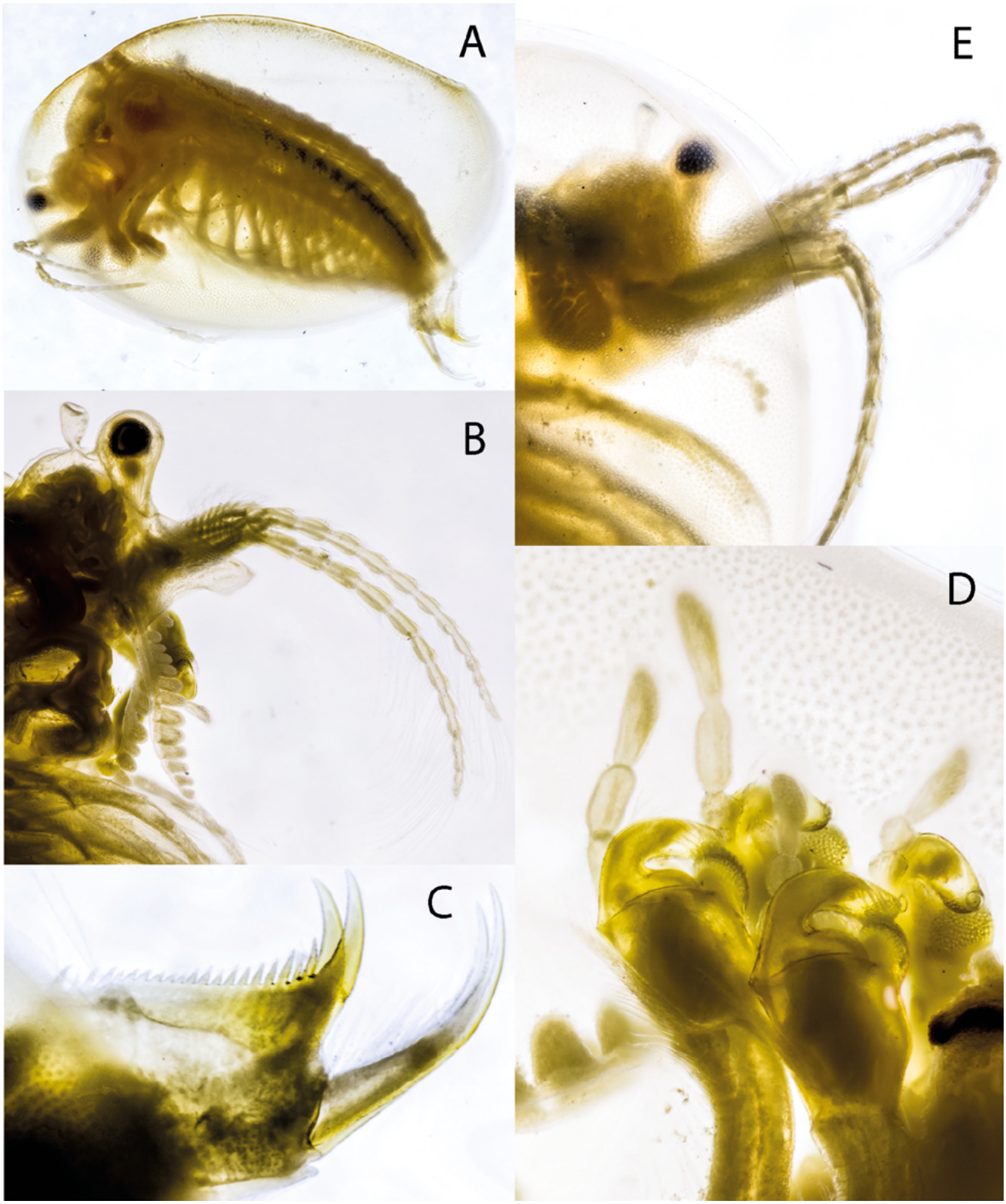

Figure 2. Digital images of male *P. rivolensis* from NMV J55640. A, male carapace; B, male head, C, male telson; D, male claspers, E, female head.

illustrates a third trunk segment with a long palp of endite V, as is typical of *Eulimnadia* and *Paralimnadia* (Timms, 2016a, 2016b). Gurney (1927) illustrates a male telson, which besides showing some variation in size and spacing of 21 telsonic spines, clearly shows a basal cylindrical 45% of the cercopod with 7 setae of moderate length and the telsonic base under the cercopod insertion with a mild triangular protrusion. Gurney (1927) could not find any growth lines. Nowhere in any of these three early descriptions is a subcercopod spine mentioned or illustrated.

This subcercopod spine is also absent in all of the material seen in the Australia Museum and National Museum Victoria, in all cases being replaced by a triangular protrusion of various sizes. Also, given that all specimens examined have 11–12 antennomeres and cercopods with basal 45–60% bearing setae (Timms 2016b), the conclusion is inescapable that this species belongs to *Paralimnadia*, not *Eulimnadia*. Further indication that it is a *Paralimnadia* and not a *Eulimnadia*, although not absolute (Timms, 2016a), is that the sex ratios are

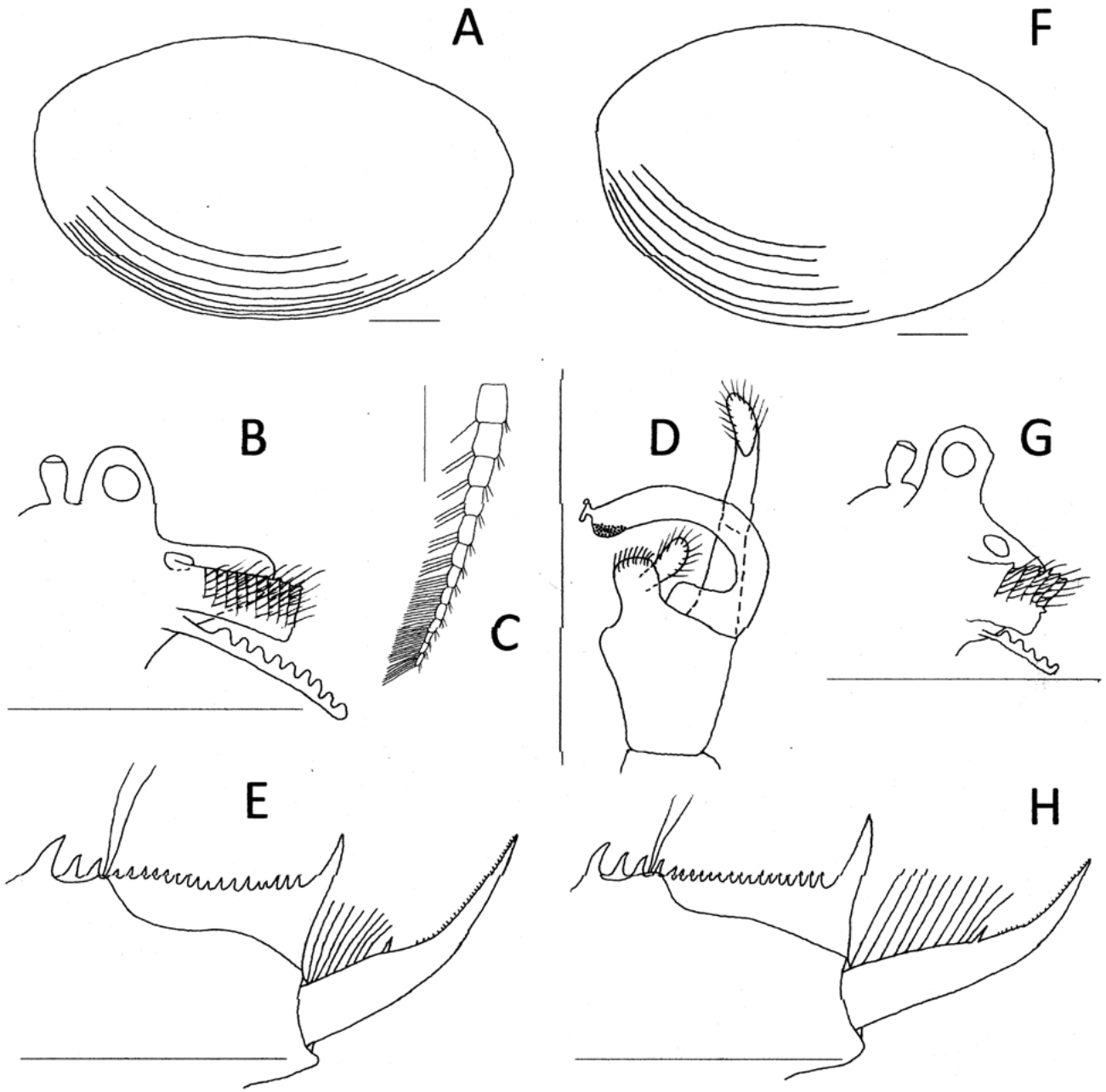

Figure 3. Drawings of male and female of *P. rivolensis* from NMV J55640. A, male carapace; B, male head; C, male antennal flagellum; D, male clasper I, E, male telson; F, female carapace; G, female head; H, female telson. Scale bars 1 mm.

broadly 1:1 and not female or hermaphrodite dominated. This indicates gonochoristic reproduction and not the androdioceous reproduction that is characteristic of *Eulimnadia* (Timms, 2016a, Weeks et al., 2008).

While the lectotype has 20 trunk segments, all other material seen has 18 trunk segments, including the paralectotypes in NMV J14426.

There are no females in among the original syntypes (now lectotype and a paralectotype), so the single female in NMV J14426 was studied (fig. 3).

Head (fig. 3g) with ocular tubercle prominent with a compound eye occupying much of it (50–70% in preserved material). Rostrum a smooth bulge about as prominent as the ocular tubercle and at an angle of about 120° to the frons. Ocellus not visible and dorsal organ apparently missing.

First antenna (fig. 3g) a little shorter than peduncle of the second antenna, and with five small lobes with short sensory setae. *Second antenna* as in male.

Carapace (fig. 3f) as in male, although dorsum more vaulted.

Nineteen *thoracopods* of typical *Eulimnadia* structure. Trunk dorsum with 3–9 setae terminally, these setae few, short and stout on posterior few segments, numerous and longer on segments 8–15, and hardly any setae on anterior trunk segments 1–7.

Telson (fig. 3h) dorsally on each side with 4 larger and more robust spines anteriorly followed by 21 small spines slightly increasing in length posteriorly and terminating in a large spine. Most spines inerm. Telsonic filaments inserted on a mound between the 4th and 5th spines. Cercopod subequal in length to the telson with a cylindrical basal section about 60% of its length followed by a rapidly thinning apical section with many denticles dorsally, the two sections separated by a spine. About 7 setae on the basal section, all a little longer than the diameter of the cercopod, but with the 4th to 6th a little longer again. A blunt triangular projection posteriorly ventral to the cercopod base.

Egg (fig. 4) astroform with 14–20, mean 16.8 ± 2.6 (n = 10) projections, each subtended by 3–8 sharp-edged grooves in different planes arranged radically around its base. One to three of these grooves reach the projection apices on any one aspect of the projection. Projections often bent, length–base ratio varying from 1–2.5 (n = 10). Egg diameter 325 ± 31 μm (n = 10).

Variability. Only the lectotype and paralectotypes have 19–20 trunk segments; all other specimens examined had the usual 18 segments of *Paralimnadia* and *Eulimnadia* (Timms, 2016a,

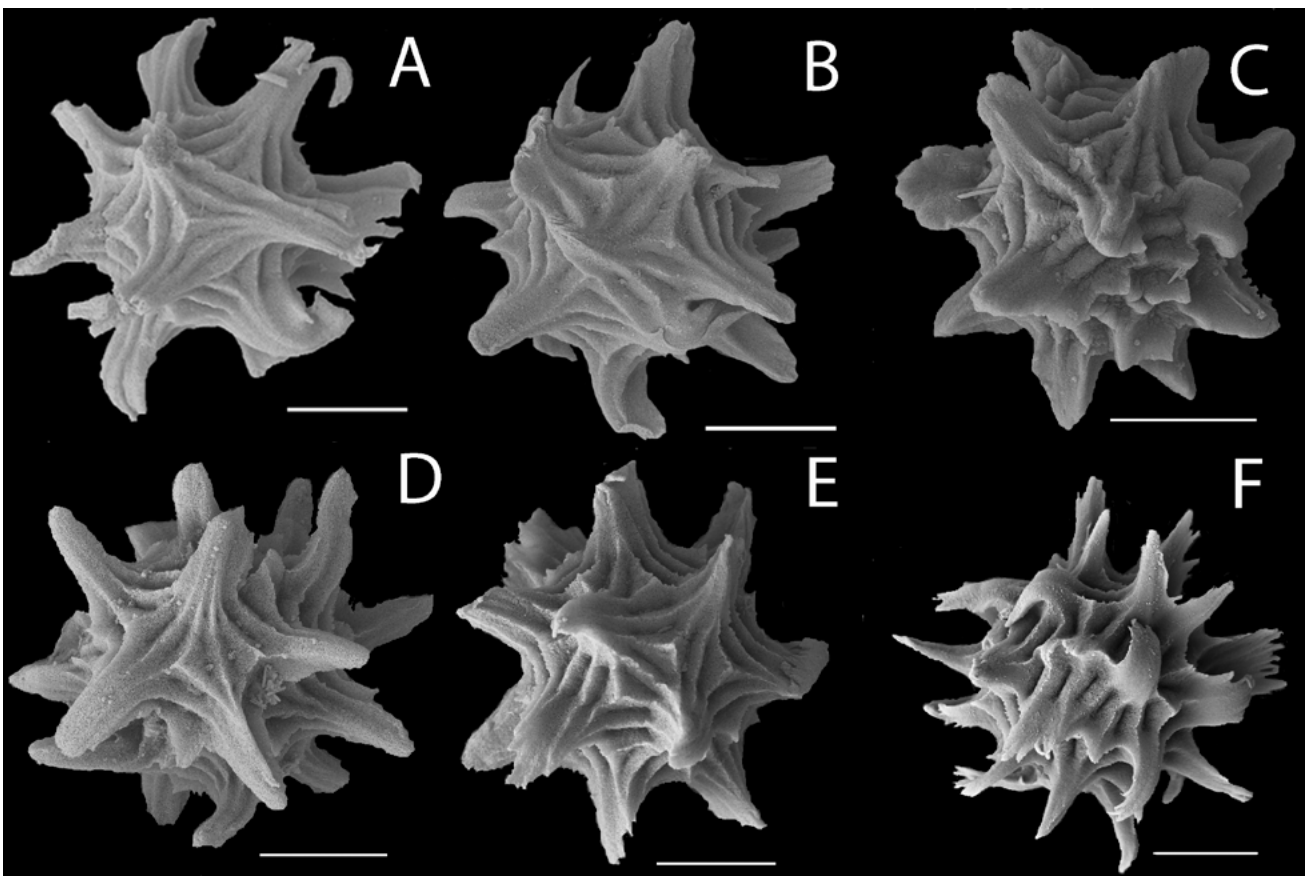

Figure 4. SEM images of eggs of *P. rivolensis*. A, from type locality Rivoli Bay, SA, freshwater swamps, NMV J14426; B, from Campbelltown Tas, AM P55640; C, from Bruny Island, Tas, NMV J46600; D, from Central Australia, NMV J54016; E, from Flinders Island, Tas, AM P97387; F, swamps from near Lake Muir, WA, WAM C57251

2016b). Male antennomeres ranged from 11–13, and lobes on the first antennae perhaps varied by one unit. The number of telsonic spines was more variable (20–26, but typically 21), while the palpomeres and cercopod setae were also variable. Palpomere numbers ranged from 2–3, again the lectotype and paralectotype the only collections with 3 + 3. The cercopod setae ranged from 7–10 and their lengths varied a little from being uniform and of moderate length (i.e. ca. 1.5× cercopod diameter) to being of variable length, some being subequal to cercopod diameter. The lack of a dorsal organ on the female paralectotype is most unusual.

Synonymy of *E. palustera*

This species was originally assigned to *Eulimnadia* on the sole criterion of an apparent spine beneath the cercopod base (Timms, 2015). However, this spine is not a typical subcercopod spine of most *Eulimnadia* but a rather sharp triangular ventroposterior corner of the telson. Hence, an assignment to *Paralimnadia* is necessary. Furthermore, three other features suggest placement in *Paralimnadia*: a cercopod with a spine approximately midlength and not at about 80% of its length, 13 antennomeres rather than about 8, and a sex ratio approximating 1:1, all generally (but not absolutely) indicating *Paralimnadia* (Timms, 2016a, 2016b).

Given the placement of *P. palustera* within *Paralimnadia*, its eggs are identical with those of *P. rivolensis* being astroform with 14–20 projections subtended by 3–8 sharp-edged grooves (fig. 4). Egg morphology has proved to be the most reliable character separating species within *Eulimnadia* (Belk, 1998; Rabet, 2010; Rogers et al., 2012; Timms, 2016a) and *Paralimnadia* (Timms, 2016b). The next most reliable species indicator in both genera is the nature of the cercopod setae. Both *P. palustera* and *P. rivolensis* have about 8 medium length (i.e. 1–2× cercopod diameter) setae (cf. fig. 6 in Timms, 2015 and figs 1–3). Again, both species have about 21 telsonic spines, although spacing is different in the two species. In *P. rivolensis*, all are evenly sized and spaced, except for the first three, which are larger and more spaced. In *P. palustera*, the telsonic spines are mixed in size (cf. fig 6 in Timms 2015 and figs 1–3). Two characters generally of poor differentiating ability are the first antennae and rostrum, although in these two species, there are only minor differences (cf. fig 6 in Timms and figs 1–3).

The claspers are somewhat different between the two species. *P. palustera* has a distinct hamulus medially on the hand (endite IV), while *P. rivolensis* has just a slight swelling there. The palps are variable, with 3 palpomeres in the paralectotype of *P. rivolensis*, but only 2 indistinct ones in most other specimens examined. *P. palustera* generally has 3 palpomeres but may have the second division indistinct or incomplete. Sometimes there are spines at palpomere junction 1–2 in *P. rivolensis*. Similar variability has sometimes been observed in a few other *Paralimnadia* species (Timms 2016b).

Distribution. South-western Western Australia, south-eastern South Australia, southern Victoria and Tasmania. There is a single record from central Australia, which is difficult to accept considering the prominent maritime distribution across southern Australia. It has not been collected in Victoria since 1910, its habitat in the swamps of eastern Port Philip Bay being drained and urbanised in the early 1900s. Widespread drainage in the south-east of South Australia seems to have denied it habitat there. The most recent collection from near the type locality is dated 1975, and my expeditions there in the spring of 2010 and winter of 2016 were unsuccessful. Sites in central Tasmania seem (as of March 2018) also to be drained, so that perhaps it now only occurs in refuges of Flinders Island, Kangaroo Island and south-western Western Australia.

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