

**ROTIFERA FROM AUSTRALIAN INLAND WATERS.
VI. PROALIDAE, LINDIIDAE (ROTIFERA: MONOGONONTA)**

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Summary

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Keys are given to the genera and species of the Rotifera: Monogononta of the families Proalidae (four genera) and Lindiidae (one genus). The proalid genus *Wulfertia* is not known from Australia, and a single record of *Bryceella* is doubtful. Two species of *Proalinopsis* and ten species of *Proales* are known from Australian inland waters. *Proales similis exoculis* (Herzins, 1953) is suppressed. Five species of the lindiid genus *Lindia* are confirmed, with a sixth, known from New Zealand, doubtful. All species of these genera recorded from Australian waters are described and figured with known distribution data and ecological information. Brief comments are included on current rotifer taxonomy and biogeography.

KEY WORDS: Rotifera, Proalidae, Lindiidae, Australia, taxonomic revision, biogeography.

Introduction

This paper is the sixth of a series reviewing the Rotifera recorded from Australia. The initial purpose of the series was to collate a century of records (much early survey work was done by visitors, and their publications were widely dispersed), bring nomenclature to accepted world standard, and provide usable keys to the known Australian rotifer fauna. As the series has progressed, so too has methodology; advances in light and electron microscopy, biochemical techniques and computing used in studies of the Rotifera worldwide have provided much better resolution of a number of problem areas, including systematics. Some of these advances are documented in the proceedings of triennial symposia on the Rotifera (e.g. Ricci *et al.* 1989), of which there have now been five.

Increasing attendances at these symposia suggest that more researchers are studying rotifers. Some impetus has been provided by the environmental crisis; microscopic aquatic organisms such as Protozoa and Rotifera have been seen as 'early warning systems' for deteriorating water quality, and their morphology, physiology, behaviour, or population characteristics, have been more closely examined. Whatever the reasons, interest in rotifers has expanded, and with it, requests for our revision papers from outside Australia. In view of this more widespread interest, and as a cautionary note to the use of our keys elsewhere, we felt it appropriate to briefly review present rotifer biogeography. At the

suggestion of an anonymous referee, to facilitate comparative studies, we also have included more formal taxonomic details than in the earlier parts.

Biogeography

Global rotifer biogeography and the evidence for vicariance were reviewed by Dumont (1983). He noted that each continent has a distinctive endemic faunule among more widely distributed taxa. Until relatively recently, cosmopolitanism has been promoted by the global use of authoritative taxonomic references (e.g. Ward & Whipple, revised by Edmondson 1963) or the use of figures from the work of respected taxonomists for taxa superficially similar (or not!) but geographically separated. In the Australian context, much of the earlier work was done elsewhere, by workers more familiar with the Rotifera of the northern hemisphere, at a time when rotifers, among others, were widely accepted as cosmopolitan. When competent local workers in Australia began to describe the indigenous species early this century, European reviewers 'cosmopolitanized' these species by synonymy with familiar northern hemisphere taxa.

It has become increasingly evident in our studies of Australian rotifer taxonomy, ecology and distribution that a high degree of endemism prevails (cf. Koste & Shiel 1987). Methods now exist by which superficially similar taxa can be resolved (cf. Koste & Shiel 1989). These include SEM, as used by Frey (in press) for chydorid cladocerans, and electrophoretic methods, as used by Benzie (1988) for *Daphnia*. Until such methods are applied to the Australasian Rotifera, caution should be used in identification below family, particularly where evaluation of environmental impacts or

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perturbations is involved. Similar caution should be exercised in use of our keys and figures to identify non-Australian rotifers.

Systematics

The families of Rotifera: Monogononta considered in this part of our revision are predominantly littoral (epiphytic or epibenthic) in affinity, collected in and around vegetation in shallow waters, e.g. billabongs, or at lake margins, where they graze on detritus, bacteria or algae. The Proalidae and Lindiidae are illoricate rotifers, i.e., they lack the firm, sometimes faceted cuticle (lorica) characteristic of most of the rotifer families we have reviewed (cf. Koste & Shiel 1990). On preservation, most illoricate taxa contract into indeterminate spherical 'blobs', and identification is difficult. Specific determination from preserved material therefore relies heavily on comparative morphology of the sclerotized mastax elements (trophi), which appear to be species-specific.

There are difficulties in detailed examination of trophi structure: the trophi of some rotifer genera are minute ($< 20 \mu\text{m}$), with correspondingly tiny components. Bleaching the body tissue away generally leaves the trophi, but delicate parts may be lost, and the three-dimensional orientation of the trophi is disrupted. In view of these difficulties, the details of trophi structure given in previously published works may be only partially accurate, or at worst, useless to interpret trophi morphology. Inadequate descriptions and figures may have passed through several generations of revisions. The recent application of scanning electron microscopy (SEM) to trophi structure (Markevich 1987; Markevich & Kutikova 1989) has improved resolution of components, but the problems of dissociation and disorientation remain.

In the systematic section below we have followed the format of earlier parts. Formal descriptions are modified (generally abbreviated in translation from the original author) with additions in some cases after the most recent reviser's comments (Koste 1978). Keys to families are included in Koste & Shiel (1987), and details of Rotifera outside Australia, including other species of the two families reviewed here, are found in Koste (1978). Information, where available, on type localities and known distribution, is included. Type material *per se* is very limited; some early taxonomists did not make type slides at all, and many extant collections were lost during the destruction in Europe during WWII. Our Australian type material has been or will be lodged in the South Australian Museum, Adelaide (SAM), and our collections, presently housed at the Murray-

Darling Freshwater Research Centre, or as subsamples in the Koste collection, Quakenbrück, ultimately will be deposited at the SAM.

Family Proalidae Bartos

Proalidae Bartos, 1959, 515. (= sub-family Proalinae Remane, 1933 partim).

Illoricate, body swollen, fusiform or vermiform; head and foot clearly defined; corona mostly supraoral; buccal field with rudiments of lateral cilia (*Bryceella* with two long cirri); mastax resembles malleate with different number of unci teeth (1-8), however is used like virgate mastax, with epipharynx present; hypopharynx muscle inserted on mastax wall, not fulcrum; eyespot on brain, sometimes lateral in *Proales*. Of four genera, *Proalinopsis* (2 spp.) and *Proales* (10 spp.) are known from Australia. *Bryceella* (1 sp.) is a doubtful record, and *Wulfertia* has not been recorded here.

Key to genera of the Family Proalidae

1. Corona with stout cirri with which the animal moves rapidly in a jerky motion; head with rostrum; body fusiform or pear-shaped with transverse pseudosegmentation; uncus 5-7 toothed, *Bryceella* Remane.
Corona without cirri, 2
- 2(1). Head long, with sulci; corona reduced, without lateral ciliary tufts; toes short, wide and acute; body fusiform, widening at beginning of posterior $\frac{1}{3}$; cuticle with longitudinal pleats; uncus 5-toothed; large epipharyngeal plate, *Wulfertia* Donner.
Corona with lateral ciliary tufts, 3
- 3(2). Spinulate papilla above cloaca; unci 8-9 toothed *Proalinopsis* Weber.
No papilla above cloaca; unci 1-6 toothed, *Proales* Gosse.

Genus *Bryceella* Remane

Bryceella Remane, 1929, p. 113

Type: *Stephanops stylatus* Milne, 1886 = *Bryceella stylata* (Milne).

Type locality: Moss, near Glasgow, Scotland.

Bryceella is isolated systematically by the possession of peculiar cirri assemblages on the corona. Body slender; anterior end oval, with neck clearly defined, head extended anteriorly (rostrum); abdomen oval, with narrow preanal section and short, squat tail; foot slender, with 2-3 pseudosegments; toes blunt, slender, curved ventrally; integument relatively stiff; abdomen with lateral longitudinal sulci; trophi small, of modified malleate type; manubria with lateral lamellae; unci with 5-7 teeth; rami with teeth on inner margin as well as basalapophysis; cirri of corona stand in several transverse rows and serve in locomotion

(reminiscent of the ciliate *Euplotes*); animal proceeds jerkily, with longest cirri to the front; laterally, a pair of extremely long sensory setae project from the head.

Distribution: *B. stylata* (Milne, 1886) (Fig. 1:1) is known from the Palaearctic, and *B. tenela* (Bryce, 1897) (Fig. 1:2) is known more widely from acid waters of North and South America, Europe, Asia and New Zealand. *B. voighti* was described from Romania by Rodewald (1935), however the figures and description were unsatisfactory, and the status of this taxon was queried by Koste (1978). The single-toothed uncus, lack of inner-margin teeth of the rami, apparent absence of long lateral setae and differences in the morphology as figured, make placement of *B. voighti* doubtful.

Australian record: The only record is of *Bryceella voighti* by Berzins (1982) from two localities at Bombala, N.S.W. (28.xii.49 and 8.i.50), both from moss on *Eucalyptus* trunks. No figures or description were given, hence we regard it as an unverified record of an indeterminate taxon.

Genus *Proalinopsis* Weber

Proalinopsis Weber in Weber & Montet, 1918, p. 98.

Type: *Notommata caudata* Collins, 1872 = *Proalinopsis caudatus* (Collins)

Type locality: pools, Sandhurst, Berkshire, England.

Body elongated, illoricate, cuticle very transparent, adult sometimes with filamentous gelatinous envelope; head and foot clearly demarcated; body cross-section hemispherical; dorsal antennae on cuplike-cylindrical papillae; gibbous rump protrudes as a rim over foot; foot two-segmented, proximal segment longest, with dorsal knob bearing a long spine or setal tuft; corona an oblique disc with short marginal cilia and two lateral areas with long cilia; lateral antennae with long sensillae, on small protuberances, at level of upper intestine; long pointed toes, elongated foot glands; mastax intermediate between malleate and virgate; trophi; fulcrum slender, laterally dagger-like; rami symmetrical, large and triangular, without teeth or alulae; uncus with ca. eight long, thin teeth, clubbed at tips; epipharynx absent; eyespot, if present, cervical. Seven species are known (Koste 1978), two of which have been recorded from Australia.

Key to species of the genus *Proalinopsis* known from Australia

- Fine needle-like spinules on posterior dorsal papilla.....*P. caudatus* (Collins)
- Papilla with robust spine.....*P. staurus* Harring & Myers

Proalinopsis caudatus (Collins)

FIG. 1:3

Notommata caudata Collins, 1872, p. 11, Fig. 8

Proalinopsis caudatus: Weber & Montet 1918, p. 98.

Type locality: Pools, Sandhurst, Berkshire, England.
Holotype: Not designated.

Description: Body slender, bulging posteriorly, width $< \frac{1}{4}$ length; head narrow, separated from neck by transverse fold; bright red cervical eyespot; abdomen ends in short tail projecting over foot; foot two-segmented, fusiform; proximal segment with dorsal knob bearing long deflexed setae; toes long, acute, slightly curved; foot glands small and slender; mastax virgate, resembles malleate; eight teeth on left, seven on right uncus, ventral tooth in each case largest and clubbed, remaining teeth decreasing dorsally.

Length: 125–268 μm ; width to 77 μm ; toes 16–22 μm ; trophi 18 μm wide, 25 μm long; manubrium 18 μm ; fulcrum 7 μm ; unci 11 μm ; subitaneous egg 60 \times 30 μm .

Ecology: Widely distributed, probably cosmopolitan in slightly acid waters (pH 4.5–6.5), *Sphagnum* pools. Rare, N.S.W., W.A.

Literature: Koste (1978).

Proalinopsis staurus Harring & Myers

FIG. 1:4

Proalinopsis staurus Harring & Myers, 1924, p. 439–40,

Fig. 20: 5–9.

Type locality: No single locality specified; In 'floating and submerged *Sphagnum* in soft water lakes and ponds'. Mamie Lake, Eagle River and Lac Vieux Desert, Vilas County, Wisconsin, also New Jersey and Florida, U.S.A.

Holotype: ?Myers Coll., USNMNH, New York.

Description: Body fusiform; deep constriction separates head from abdomen; no red cervical eyespot; abdomen tapers gradually to tail; foot two-segmented, proximal segment with dorsal knob bearing single stout spine; toes stout at base, acute; foot glands large, pyriform; mastax virgate, resembles malleate; unci with eight or nine clubbed teeth, decreasing dorsally.

Length: 100 μm ; toes 18 μm ; trophi 15 μm .
Ecology: Only known previously from *Sphagnum* in North America. Two Australian records: L. Fidler (Gordon R.) and a stock dam at Golden Valley, Tas. 18.0–25.0°C, pH 5.8–7.8, 40.8–46.6 $\mu\text{S cm}^{-1}$, TDS 26.1 mg l⁻¹, 1.9 NTU.

Literature: Koste (1978); Koste *et al.* (1988).

Not recorded from Australia:

P. gracilis Myers, 1933, U.S.A.; *P. lobatus* Rodewald, 1935, Europe; *P. phagus* Myers, 1933 U.S.A.; *P.*

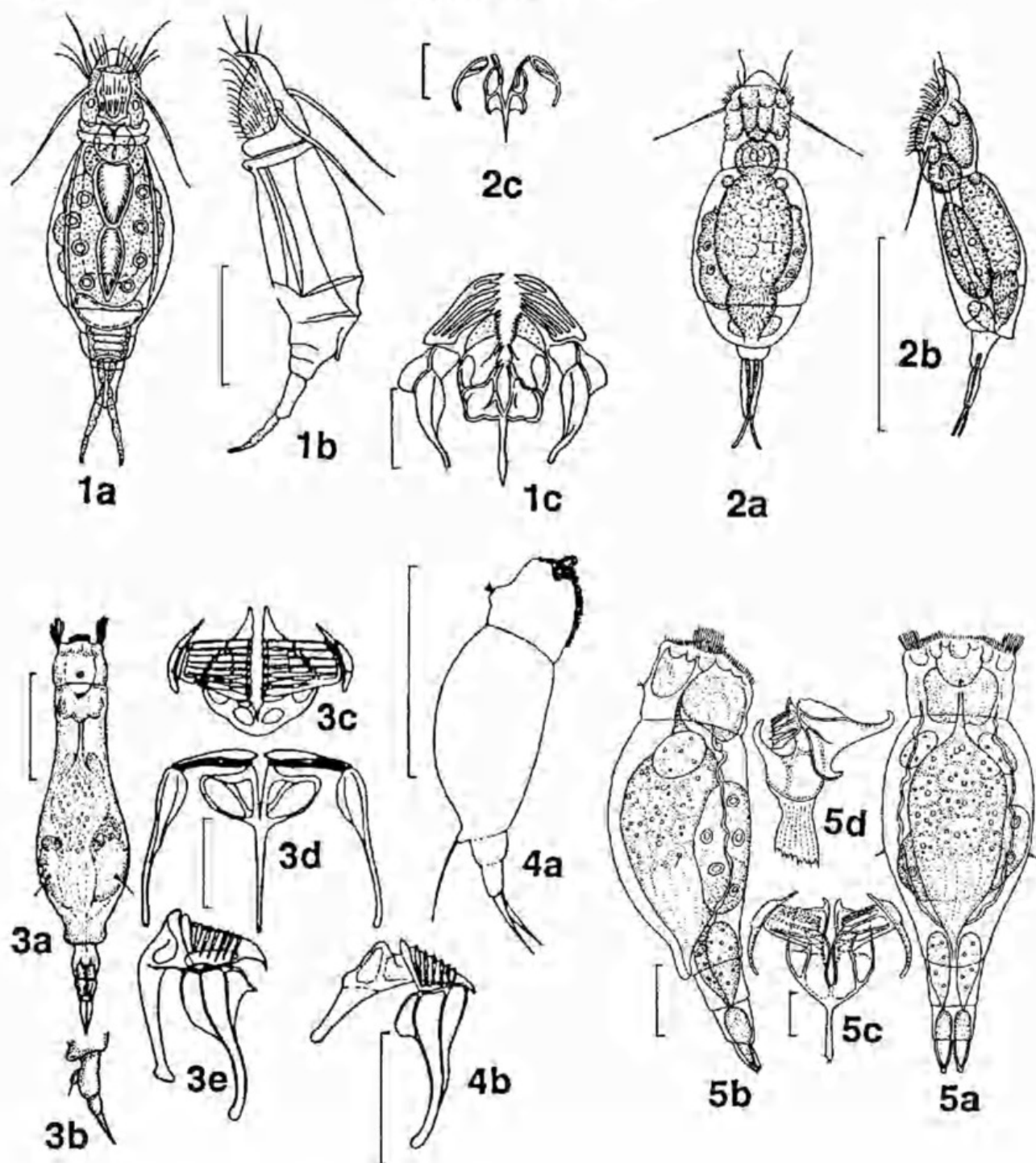


Fig. 1. 1, *Bryceella stylata* (Milne): (a) dorsal; (b) lateral; (c) trophi. 2, *B. tenela* (Bryce): (a) dorsal; (b) lateral; (c) trophi. 3, *Proalinopsis caudatus* (Collins): (a) dorsal; (b) foot and toes, lateral; (c) trophi, dorsal; (d) trophi, ventral; (e) trophi, lateral. 4, *P. staurus* Harring & Myers: (a) lateral; (b) trophi, lateral. 5, *Proales daphnicola* Thompson: (a) lateral; (b) dorsal; (c) trophi, ventral; (d) trophi, lateral. 1 after Wulfert (1940); 2 after Kutikova (1970); 3–5 after Harring & Myers (1924). Scale lines: adult 50 μ m, trophi 10 μ m.

selene Myers, 1933. U.S.A.; *P. squamipes* Hauer, 1935. Europe.

Genus *Proales* Gosse

Proales Gosse in Hudson & Gosse, 1886, 2, p. 36.

Type: *Notommata decipiens* Ehrenberg, 1832 = *Proales decipiens* (Ehrenberg).

Type locality: near Berlin, FRG.

A diverse series of taxa, from free-living to parasitic, freshwater to halophile. Fusiform illoricate body in free-living species, more swollen in parasitic taxa (also considerable distortion of the body in females bearing resting eggs); head separated from abdomen by slight constriction behind mastax; foot indistinct, very short to long and articulated; two toes; corona generally oblique, ciliary disc with short marginal cilia and two lateral tufts of long cilia (not contractile auricles as in *Lindia* or *Notommata* species); mastax modified malleate-virgate type; trophi very small.

Comment: *Proales* requires thorough revision; the diversity of taxa presently included in the genus undoubtedly will separate into more uniform groups with improvements in taxonomy, e.g. SEM study of trophi morphology as by Markevich (1987). Of 30 species recorded globally, 10 are known from Australia.

Key to species of the genus *Proales* known from Australia

1. Foot with single toe... *P. dollaris* (Rousselet)
- Foot with two-toes... 2
- 2(1). Eyespot below base of brain; body bulbous; toes coniform; commonly epizootic on *Daphnia*... *P. daphnicola* Thompson
- Eyespot, body and toes not as above; not epizootic on *Daphnia*... 3
- 3(2). Parasitic in colonies of *Volvox* or in *Vaucheria* cells... 4
- Free-swimming, not parasitic... 5
- 4(3). In *Volvox* colonies (not to be confused with *Ascomorphella volvocicola*; trophi small (to 15 µm))... *P. parasita* (Ehrenberg)
- In *Vaucheria* filaments... *P. wernecki* (Ehrenberg)
- 5(3). Toe:body ratio >18... 6
- Toe:body ratio <17... 7
- 6(5). Trophi <30 µm; small dorsal knob between toes... *P. fallaciosa* Wulfert
- Trophi >30 µm; pointed spine on dorsal margin of foot... *P. gigantea* (Gosse)
- 7(5). Foot long (2-3 × toe length)... *P. sordida* Gosse
- Foot short (<2 × toe length)... 8
- 8(7). Eyespot absent; body vermiform... *P. micropus* (Gosse)
- Eyespot present, median or laterally displaced; body fusiform... 9
- 9(8). Median eyespot, ventral to base of brain, no lens, 6 unci teeth... *P. similis* De Beauchamp
- Eyespot displaced to right, crystalline lens; 4/5 unci teeth... *P. decipiens* (Ehrenberg)

Proales daphnicola Thompson

FIG. 1:5

P. daphnicola Thompson, 1892, p. 220, Fig. 125.

Type locality: (England)

Holotype: Not designated.

Description: Body short, stout, widest medially with marked constriction behind head, fusiform thereafter; corona slightly oblique, with two lateral strongly-ciliated areas corresponding to auricles in notommatalids; integument soft, flexible; foot short, stout, two-segmented, with two short coniform toes, swollen at the base, with tubular spinules; reddish eyespot at underside of brain; trophi malleate with five clubbed unci teeth, rami with unusual doubled hornlike, conical, elongated spikes; oesophagus long, slender, gastric glands large; foot glands large, pyriform, with reservoirs in distal and proximal foot segments; subitaneous egg smooth; resting egg light-brown, covered in hooks. Male similar in form to female, slightly smaller.

Length 275-400 µm, toes 25-30 µm, trophi 36-40 µm, unci to 18 µm, subitaneous egg 96 × 30 µm, resting egg 105-109 × 76-80 µm.

Ecology: Widely distributed epizootic on *Daphnia* spp., where it feeds on flagellates and ciliates living on the carapace. Regarded in early literature as 'entozoically parasitic' (Hudson & Gosse 1886). Eggs generally are attached to the bases of the cladoceran's antennae (Koste 1978). Europe, Asia, N. America, Africa. Only known localities in Australia are from R. Murray billabongs near Albury-Wodonga on *D. carinata* and *D. cephalata*. 10.2-15.3°C, pH 6.9-7.9, DO 7.1-12.4 mg l⁻¹, 78-170 µS cm⁻¹, 4.0-39.0 NTU.

Literature: Harring & Myers 1924; Koste 1978.

Proales decipiens (Ehrenberg)

FIG. 2:1

Notommata decipiens Ehrenberg, 1832, p. 132.

Proales decipiens Hudson & Gosse 1886, 2, p. 36

Type locality: near Berlin, FRG.

Holotype: Not designated.

Description: Body elongate, slender, transparent; trunk widest in posterior third, tapers to two-segmented foot bearing two toes with acute points; integument with longitudinal folds; transverse folds demarcate head and neck from trunk; corona oblique with lateral ciliary fields; eyespot small, red, mostly displaced to right; distinct bubble-like retrocerebral sac; gastric glands oval or lobate; mastax with virgate trophi, but resembling malleate type; rami with large basal apophysis, on which are asymmetric teeth medially; no alulae; unci with 5/5 and 4/5 webbed teeth, the largest bifurcate, decreasing in size dorsally; epipharynx two hammer-

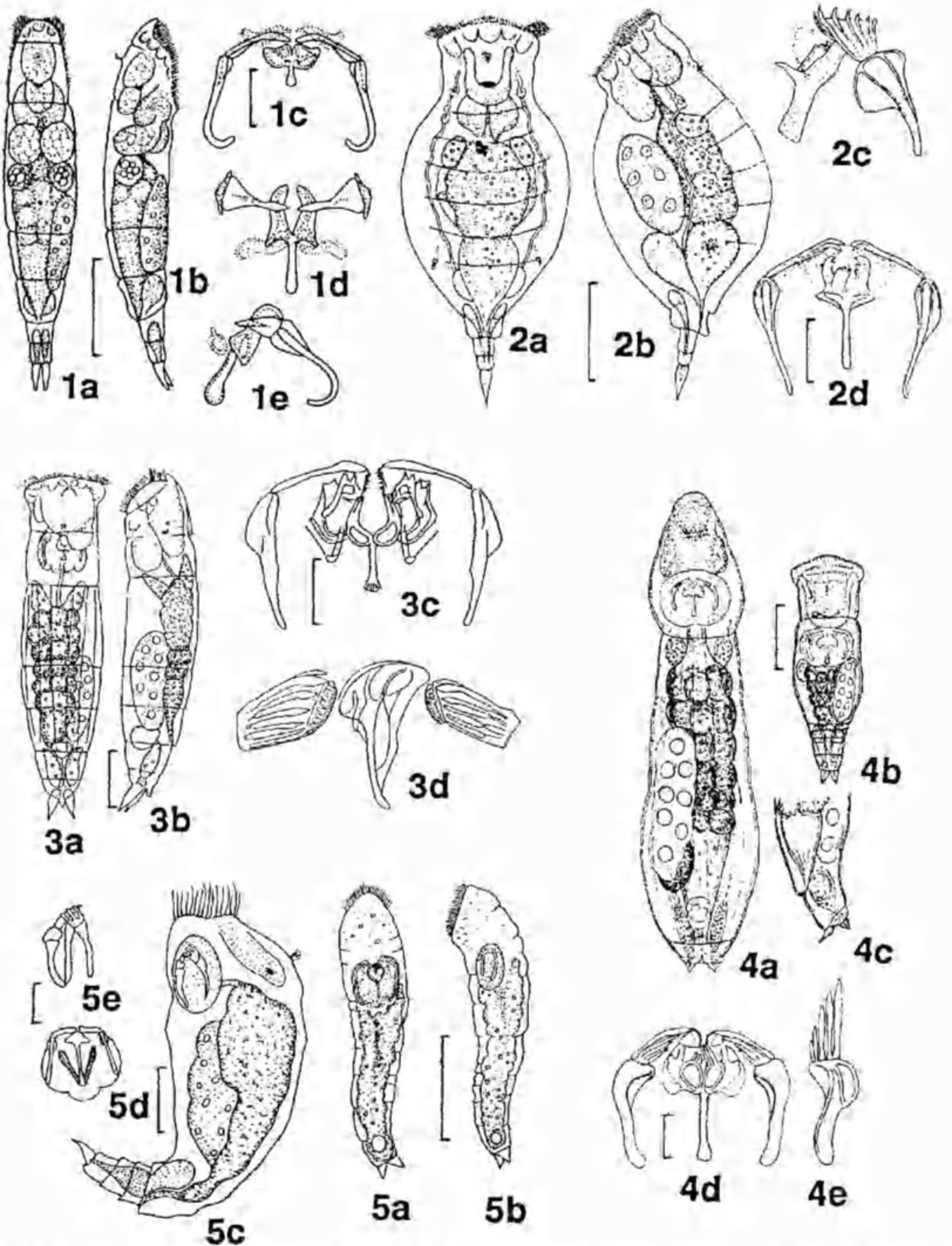


Fig. 2: 1, *Proales decipiens* (Ehrenberg): (a) dorsal; (b) lateral; (c-e) trophi, various aspects. 2, *P. doliaris* (Rousselet): (a) dorsal; (b) lateral; (c-d) trophi. 3, *P. fallaciosus* Wulfert: (a) dorsal; (b) lateral; (c-d) trophi. 4, *P. gigantea* (Glasscott): (a) dorsal; (b) juvenile; (c) posterior showing tail and toes; (d) trophi; (e) manubrium and uncus, lateral. 5, *P. micropus* (Gosse): (a) dorsal; (b) lateral; (c) 2nd individual, lateral; (d-e) trophi. 1, 2 after Harring & Myers (1924); 3 after Wulfert (1939); 4 after Koste (1978); 5 after Hudson & Gosse (1886), as figured by Kutikova (1970). Scale lines: adult 50 μ m, trophi 10 μ m.

like structures; manubrium long, broadly triangular ribbed plates. Male known.

Length: 120–270 μm , toes 10–16 μm trophi 15–21 μm .

Ecology: Cosmopolitan among vegetation, in small water bodies, billabongs, ponds. Rare; Tas., Vic. 10.2–21.0°C, pH 7.2–7.6, 11.8–57.3 $\mu\text{S cm}^{-1}$, DO 9.0 mg l⁻¹, 4.0–5.0 NTU.

Literature: Harring & Myers (1922); Koste (1978).

Proales dollaris (Rousselet)

FIG. 2:2

Microcodices dollaris Rousselet, 1895, p. 120, Fig. 7:4

P. dollaris: Harring & Myers 1924, p. 437, Fig. 19:3–7.

Type locality: U.K.

Holotype: Not designated.

Description: Cuticle soft and transparent; trunk oval to round in section; foot two- or three-segmented; two foot glands; indistinct reddish cerebral eyespot; corona oblique with supraoral buccal field; complete circumapical ciliation and lateral ciliary bundles; right uncus with seven, left uncus with six teeth; inner margin of rami with asymmetric hooklike denticles, externally with wide lamellae; retrocerebral organ absent.

Length: 170–300 μm ; toes 20–25 μm ; trophi 20–25 μm .

Ecology: Widespread (Europe, North America, New Zealand, Asia); Not seen in our material. Berzins (1982) recorded it from Sunbury, Vic.

Literature: Koste (1978).

Proales fallaciosa Wulfert

FIG. 2:3

Proales fallaciosa Wulfert, 1937, p. 65, Fig. 4; 1939, p. 597, Fig. 12.

Type locality: Bad Lauchstädt, FRG.

Holotype: Not designated.

Description: Variable morphology, body cylindrical with medial bulge, tapers to truncated two segmented foot with two conical toes; small rounded knob projecting dorsally between toes; cuticle generally with longitudinal folds; corona oblique, laterally with strong ciliary tufts rather than auricles; small rostrum present; hemispherical retrocerebral sac and red eyespot displaced to right; trophi primitive virgate type resembling malleate: left uncus with seven teeth, right with 5–6 teeth; fine denticles directed inwards along tooth-plate margin (Fig. 2:3c); rami with basal apophysis drawn into 2–3 points; no alulae; manubrium with shorter inner lamella and outer inwardly curving wider lamella; gastric glands round to elongated; foot glands with reservoirs.

Total length 200–320 μm ; toes 9–15 μm ; trophi 25–28 μm ; fulcrum 6–11 μm ; rami 9–12 μm ; unci 9–15 μm .

Ecology: Cosmopolitan in alkaline to slightly acid water, particularly decomposing macrophytes, where it feeds on detritus, bacteria and algae, also on decomposing microcrustaceans and macroinvertebrates. Often confused with *P. decipiens* or *P. sordida* (Koste 1978). Only known from Tasmania: stock dam near Huonville. 9.0–16.0°C, pH 5.7–7.6, 13.4–415 $\mu\text{S cm}^{-1}$, 0.6–0.7 NTU.

Literature: Koste (1978); Koste & Shiel (1986).

Proales gigantea (Glasscott)

FIG. 2:4

Notommata gigantea Glasscott, 1893, p. 80, Fig. 7.

Proales gigantea: Stevens 1912, p. 481, Fig. 24:1–5.

Type locality: (Ireland).

Holotype: Not designated.

Description: Body cylindrical, very flexible in living animal; clearly defined constriction behind mastax; trunk dilates distally to wide, short foot terminating in two short, conical toes; pointed spur on posterior dorsal margin of foot; mastax with asymmetric malleate-type trophi: incus straight; fulcrum long, with slight terminal curvature; manubrium with short lamella at head; rami broad, triangular, right ramus only with broad denticulate blade opposing first tooth of left uncus; right uncus 5–6 toothed, left 4–5 toothed; no alulae; gastric and foot glands elongated, fusiform.

Length: 140–510 μm toes 8–12 μm , trophi length 30–35 μm , unci to 19 μm , manubrium 18 μm , subitaneous egg 150 \times 50 μm .

Ecology: Europe, N. America, N.Z. Parasitic in pond snail eggs (e.g. *Lymnaea*, *Radix*). Young female pierces egg shell, lays eggs, juvenile *P. gigantea* eat the snail embryo. A 140 μm juvenile leaving an eggshell can reach 510 μm in 5–6 days (Koste 1978). We have not encountered this animal in our Australian material, however Laird (1956, verified by Russell 1957) recorded it free-swimming from a ponded stream near Rollingstone, Queensland (19°03'S/146°24'E).

Literature: Harring & Myers (1924).

Proales micropus (Gosse)

FIG. 2:5

Furcularia micropus Gosse in Hudson & Gosse, 1886, 2, p. 46, Fig. 19:12.

Proales micropus: Jennings 1901, p. 743, Fig. 5:82.

Type locality: A ditch near Birmingham, England.

Holotype: Not designated.

Description: Small cylindrical vermiform body, colourless, illoricate, very pliable and variable in living animal; trunk tapers to minute conical toes almost as wide as long; toes with inner convexity, commonly deflected ventrally; corona oblique; eyespot occasionally present; small rostrum may be extended; uncus with three teeth; epipharynx with two small plates.

Length: 100–150 μm , toes 6–9 μm , trophi 14–16 μm .

Ecology: Rare in periphyton, on *Chara* in ponds and lakes, Europe, N. America. Not seen in our material. Single unconfirmed record from Queensland by Colledge (1911).

Literature: Koste (1978).

Proales parasita (Ehrenberg)

FIG. 3:1

Notommata parasita Ehrenberg, 1838, p. 426, Fig. 50:1.

Proales parasita: Rousselet 1911, p. 8.

Type locality: Near Berlin, FRG.

Holotype: Not designated.

Description: Body short and stout, integument flexible; head and neck marked by transverse folds; trunk dilated posteriorly, tapering to foot; tail a rounded median lobe; foot broad, indistinctly two-segmented; toes wide at base, conform to acute points; corona with two lateral ciliary tufts; brain quadratic with hemispherical retrocerebral sac; red eyespot at end of brain; Wulfert (1960) reported red crystalline bodies in a light sensitive organ, displaced to right; mastax small, epipharynx two slender curved rods; trophi modified virgate type; basal apophysis a semicircular plate; unci 3-toothed, teeth joined by thin lamellary web; rami asymmetric, more developed on right than left, without alulae; manubria with broad plates anteriorly, continue as slender, curved rods; gastric glands small; stomach commonly filled with green or dark red-yellow food mass; separate intestine; foot glands large, sausage-shaped with reservoirs; resting egg covered with short, strong spines.

Length 140–180 μm , toes 10 μm , trophi 15 μm , subitaneous egg 64 μm , male 40 μm .

Ecology: Europe, N. America, Asia. Lives in colonies of *Volvox*, *Ophridium*, *Uroglena*, occasionally confused with *Ascomorphella volvocicola*, which its behaviour resembles. Eggs laid in algal colony, young animals and parent graze individual algal cells, eventually swim from the ruptured colony to seek fresh colonies. Not seen in our material. Recorded by Whitelegge (1889) from N.S.W., and by Colledge (1914) from Queensland. These records may represent *A. volvocicola*.

Literature: Harring & Myers (1922); Koste (1978).

Proales similis De Beauchamp

FIG. 3:2

Proales similis De Beauchamp, 1907, p. 153, Fig. 2.

Type locality: (France).

Holotype: Not designated.

Description: Body elongate transparent cylinder, slightly dilated medially, tapering to comparatively long wrinkled foot and toes; ruby-red eyespot behind brain, medial, displaced ventrally; retrocerebral sac small, ductless; stomach and intestine not clearly separated; mastax light brown; epipharynx two long curved rods in anterior mastax wall; trophi intermediate between virgate and malleate; rami triangular, without denticulation on inner edge; short, pointed alulae present; fulcrum short; unci with six teeth, last two on dorsal margin partly fused (NB: 4–5 teeth were reported by De Beauchamp 1908 and 6–7/8–9 by Wulfert 1942); foot glands small, pyriform, with small mucus reservoir at base of toes.

Length 125–180 μm , toes 7–20 μm , trophi 18–24 μm .

Ecology: Halophile, in athalassic saline, estuarine and brackish waters, Europe, N. America. Single record from Diana's Basin near St Helens, Tasmania 19.0°C, pH 8.9, 34.8 mS cm^{-1} .

Comment: A variant described by Berzins (1953) as *P. similis* var. *exoculis*, from saline (ephemeral) waters near Tammin, W.A., is here synonymised. Its measurements fall within the range of *P. similis*. The lack of an eyespot as noted by Berzins is probably a preservation artefact.

Literature: Koste (1978).

Proales sordida Gosse

FIG. 3:3

Proales sordida Gosse in Hudson & Gosse, 1886, 2, p. 37, Fig. 18:7.

non *P. sordida*: Harring & Myers 1922, p. 605, Fig. 51:9–12.

Type locality: Not specified. 'Many localities in England and Scotland: common in pools.'

Holotype: Not designated.

Description: Squat, head slightly flared anteriorly; head and neck marked by transverse folds; trunk almost cylindrical, tapering to 3-segmented foot with rounded distal segment projecting over swollen bases of stout toes; foot with median longitudinal depression; corona oblique; numerous vesicles in anterior of head; large hemispherical retrocerebral sac; brain with lateral ruby-red eyespot; stomach and intestine not separated; foot glands large with reservoirs; unci with five teeth; rami with large alulae; epipharynx unciform with characteristic basal plate.

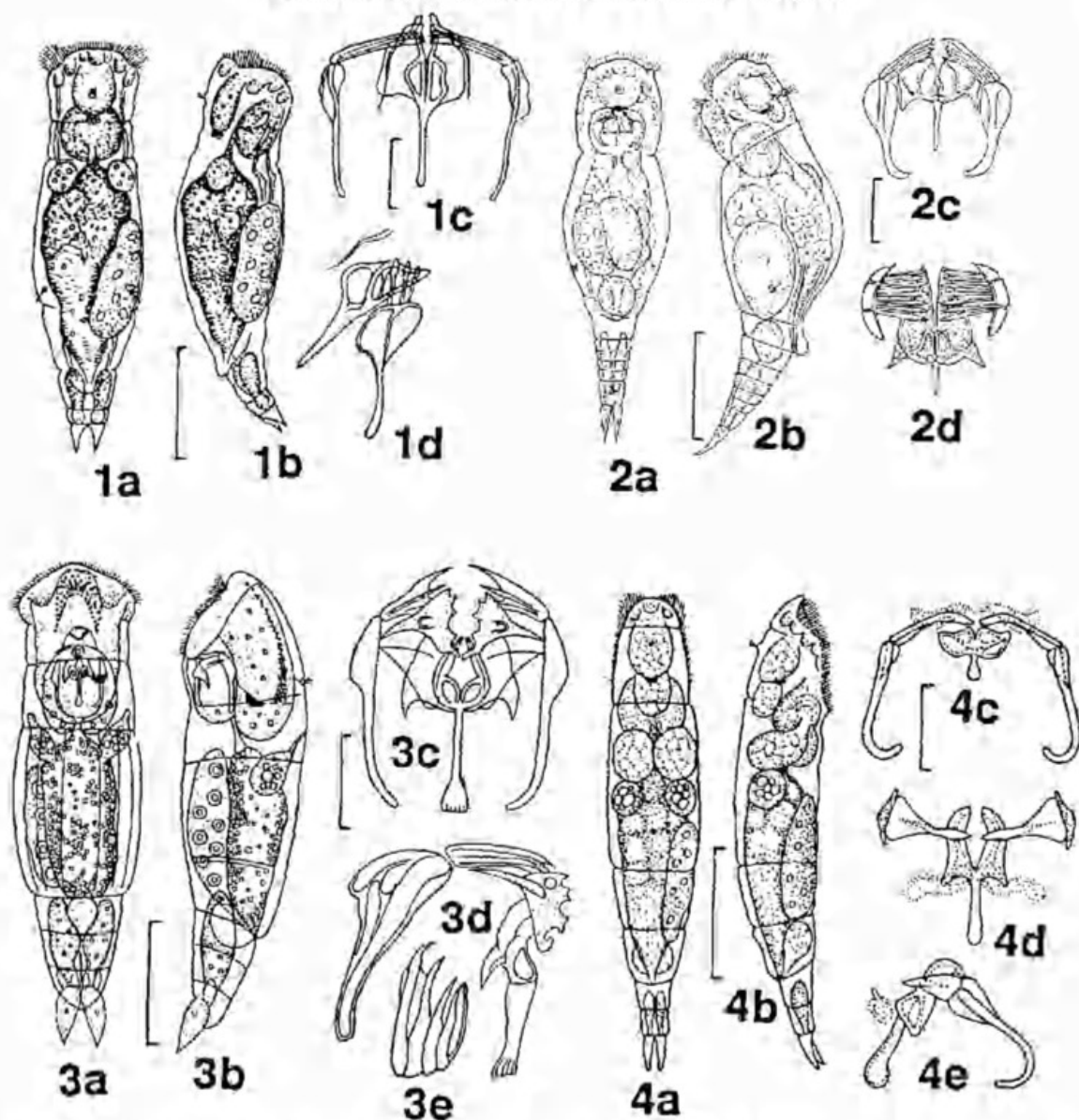


Fig. 3: 1, *Proales parasita* (Ehrenberg): (a) dorsal; (b) lateral; (c-d) trophi. 2, *P. similis* De Beauchamp: (a) dorsal; (b) lateral; (c-d) trophi. 3, *P. sordidus* (Gosse): (a) dorsal; (b) lateral; (c-d) trophi. 4, *P. wernecki* (Ehrenberg): (a) dorsal; (b) lateral; (c-e) trophi, various aspects. 1 after Harring & Myers (1924); 2 Koste, orig.; 3 after Wulfert (1939). Scale lines: adult 50 μ m, trophi 10 μ m.

Length: 150–230 μ m, toes 10–12 μ m, trophi 25 μ m, fulcrum 12 μ m, unci to 12 μ m, manubrium to 20 μ m.

Ecology: Cosmopolitan, in periphyton and diatom films. Not seen in our material; recorded by Colledge (1911) from Queensland and Evans (1951) from Victoria.

Literature: Koste (1978).

Proales wernecki (Ehrenberg)

FIG. 3:4

Notommata werneckii Ehrenberg, 1834, p. 216.
Proales werneckii: Hudson & Gosse 1889, p. 23, Fig. 32:18.

Type locality: Near Dassau, FRG.

Holotype: Not designated.

Description: Body elongate, transparent, very slender; integument flexible; head longer than wide, rounded anteriorly, slight constriction demarcating neck; body cylindrical, tapering to 2-segmented foot with slightly decurved conical toes; corona oblique with lateral ciliary tufts; retrocerebral sac present; mastax with salivary glands; epipharynx two sigmoid plates embedded in mastax wall near base of rami; trophi resemble malleate type; rami triangular, decurved at posterior ends; unci single-toothed; manubria with small anterior lamellae, elongate with hooked ends curving diagonally

inwards; gastric glands large, filled with refractive globules; stomach not separated from intestine; retrocerebral sac present; eyespot posterior to brain. Resting egg with smooth shell.

Length: 140–200 μm , male 128–150 μm , toes 11–16 μm , trophi 12–18 μm , subitaneous egg 65–87 μm , resting egg 62–72 μm .

Ecology: Parasitic in filaments of *Vaucheria* spp., the cells of which form galls around the rotifer, which subsists on chloroplasts, cytoplasm and oils produced by the alga. Up to 80 subitaneous eggs produced by the female in the gall, where she subsequently dies. Young animals leave the gall; copulation is outside the host, with resting eggs produced overwintering in the sediments. Europe, North America. Two Australian records: Sydney (Whitelegge 1889) and Macquarie Marshes, N.S.W. (F. Crome unpubl.)

Literature: Koste (1978). For species not recorded from Australia, see Koste (1978: 267–284).

Family Birgeidae Remane, 1937

Not recorded from Australia (see Koste 1978: 284–5)

Family Lindiidae Remane, 1933

Vermiform or fusiform rotifers in general appearance and coronal form resembling *Notommata* (Notommatidae); mastax cardate; manubria with characteristic hooked structure. Remane (1933) separated *Lindia* Dujardin, 1841 into two subgenera, *Lindia* (s. s.) and *Lindia* (*Halolindia*), which, although having comparable trophi structure, have marked differences in body- and coronal-form, also in ecology. *Lindia* (s. str.) occurs in freshwater, and is oviparous. *L. (Halolindia)* occurs in marine or athalassic saline waters, and is viviparous. Five species of *Lindia* (s. s.) are known from Australia, none of *L. (Halolindia)*. *Lindia parrotti* Russell, described from New Zealand, also may occur here.

Genus *Lindia* (s. s.) Dujardin

Lindia Dujardin, 1841, p. 653.

Type locality: (France).

Body cylindrical or fusiform; head with lateral, medium to very long, ciliary auricles (not everted under pressure of coverslip in mounted preparations); head and neck delineated by transverse sutures, which also occur along trunk, but most obviously on tail; foot short, stout, two-segmented, cylindrical with short acute conical toes; trophi with small 2–4 toothed unci; manubria with

dorsal projecting plate; hook, strut- or sickle-shaped structures; preuncial teeth in several species; conspicuous epipharynx generally present; hypopharynx muscle, when present, rudimentary; salivary glands present in *L. truncata*; stomach and intestine indistinctly separate; gastric glands mostly large; protonephridia and retrocerebral sac without structure; subcerebral glands absent; cerebral eyespot always present.

Key to species of *Lindia* known from Australia

1. Body <100 μm ; trophi <10 μm *L. parrotti* Russell
- Body >100 μm ; trophi >10 μm 2
- 2(1). Toes >30 μm *L. eccla* Myers
- Toes <30 μm 3
- 3(2). Distinct bilateral spherical protrusions of integument in contracted individuals (Fig. 4:2b); trophi >50 μm long *L. deridderi* Koste
- No obvious protrusions; trophi <50 μm long 4
- 4(3). Trophi <20 μm *L. annecta* Harring & Myers
- Trophi >20 μm 5
- 5(4). Head with rostrum; toes cylindrical with offset short points; elongate ciliated auricles (Fig. 4:4a); trophi 26–32 μm *L. torulosa* Dujardin
- Head without rostrum; toes conical, tapered; ciliary auricles short (Fig. 4:5a); trophi 30–43 μm *L. truncata* Jennings

Lindia annecta Harring & Myers

FIG. 4:1

Lindia annecta Harring & Myers, 1922, p. 622–624, Fig. 54: 6–9

Type locality: No single locality specified. '... *Sphagnum* bogs and ditches near Atlantic City, New Jersey.'

Holotype: ?Myers Coll., USNMNH, New York.

Description: Body slender, transparent, transverse folds give annular appearance; head and neck sections of similar length and width; trunk widest posteriorly, tapering to indistinctly 3-lobed rump, two-jointed foot, short, conical, acute toes; corona extends ventrally ca. 1/5th of body length; lateral auricles small, widely tongue-shaped as in many *Notommata* species; rudimentary salivary glands, large gastric and food glands; brain large, saccate, with posterior retrocerebral organ encasing distinct red eye-spot, scattered pigment granules; mastax specialized virgate type: fulcrum short, quadrate; manubria with wide lamellae, before hooked appendage; unci with three teeth, median twice as long and more strongly developed than two laterals, all three joined by elongate plate.

Length: 300–350 μm ; toes 15–18 μm ; trophi 18 μm long, 30 μm wide.

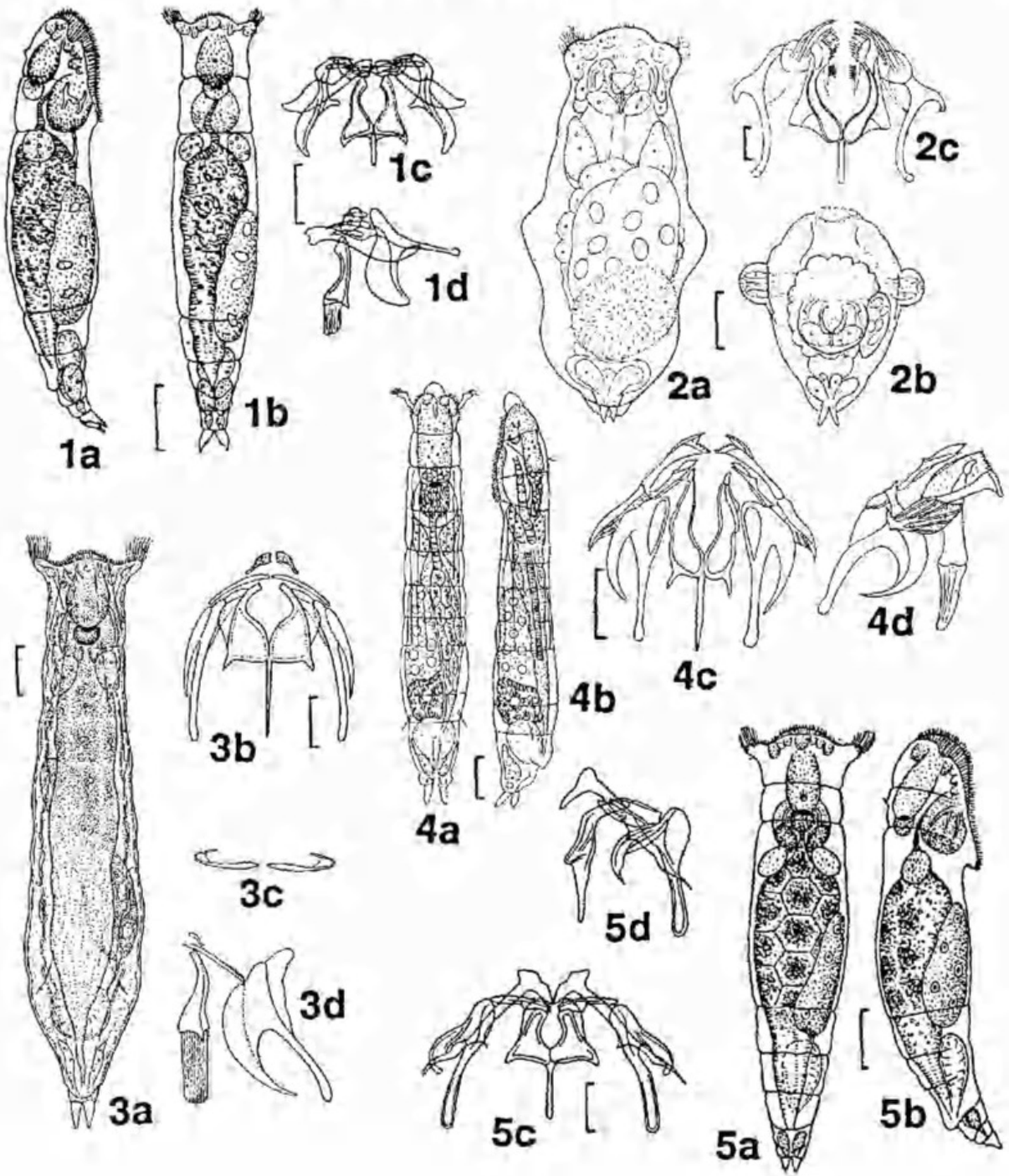


Fig. 4: 1, *Lindia annecta* Haring & Myers: (a) lateral; (b) dorsal; (c-d) trophi. 2, *L. deridderi* Koste: (a) dorsal, slightly contracted; (b) fully contracted; (c) trophi, ventral. 3, *L. eccla* Myers: (a) dorsal; (b) trophi, ventral; (c) unci, frontal; (d) trophi, lateral. 4, *L. torulosa* Dujardin: (a) dorsal; (b) lateral; (c-d) trophi. 5, *L. truncata* (Jennings): (a) dorsal; (b) lateral; (c-d) trophi. 1, 4 after Haring & Myers (1922); 2 after Koste (1981); 3 after Myers (1933); 5 after Wulfert (1939). Scale lines: adult 50 μ m, trophi 10 μ m.

Ecology: Most abundant in *Sphagnum* and periphyton. Single unconfirmed Australian record from 2000 m, Mt Buffalo, Vic. (Berzins 1982).
Literature: Koste (1978).

Lindia deridderi Koste

FIG. 4:2

Lindia deridderi Koste, 1980, p. 504–511, Figs 1–4.

Type locality: Ryan's 1 billabong, Wodonga, Vic. (36°07'S, 146°53'E).

Holotype: Holotype trophi only and three paratype trophi preparations lodged with the Type Collection, Zoological Museum, University of Kiel, F.R.G., Nos. Rot 15–18.

Description: Fusiform body with distinctive paired lateral protrusions of integument (more obvious in contracted individuals), trunk broadly rounded to rump projecting over single segmented foot and conical toes; head and neck distinctly pseudosegmented by dorsal annular creases, which also occur (less distinctly) on trunk; corona of *Notommata* type; oval salivary glands, very large elliptical gastric glands; large retrocerebral sac and eye spot present; mastax with specialized cardate trophi, with distinct paired hypopharyngeal muscles unique to genus binding fulcrum and rami; rami sickle-shaped, acutely pointed, bearing two small pointed teeth; unique to *L. deridderi* also are the widened tips of the rami, forming spoonlike extensions bearing 11 small, sharp teeth (Fig. 4:2c) below the inwardly directed main teeth; unci plates with four longer rod-like teeth, beneath which are 6–7 denticles on a rod-like structure, possibly functioning in opposition to the rami-processes (?preuncinal teeth). Subitaneous egg spiny.

Length: 300–400 μm ; toes 14–20 μm ; trophi 53 μm long, 60 μm wide; fulcrum 12 μm ; rami 29–32 μm ; longest unci tooth 16–20 μm ; manubrium 40 μm ; subitaneous egg 136 \times 100 μm with 12–16 μm spines.

Ecology: Endemic. Recorded only in billabongs on the R. Murray floodplain between Wodonga and Yarrawonga, Vic. Often with cyanobacterial remains in gut. 10.2–17.5°C, pH 6.8–7.2, DO 7.3–9.0 mg l⁻¹, 108–145 $\mu\text{S cm}^{-1}$, 4.0 NTU.

Lindia eccla Myers

FIG. 4:3

Lindia eccla Myers, 1933, p. 8–9, Fig. 3.

Type locality: Mt Desert Island, Maine, U.S.A., among *Nitella* and *Batrachospermum* in permanent bodies of acid water.

Holotype: Myers Coll., USNMNH, New York.

Description: Body elongate, cylindrical, slender, integument very flexible; head small, neck fold indistinct; abdomen swollen posteriorly, tapers abruptly to very short foot with equally short, acute toes; corona extends ca. 30% along ventral surface; retrocerebral sac (posterior to brain) round, ductless, encloses eyespot and red pigment granules; trophi cardate; rami lyrate with thin lunate extensions on margins; fulcrum a subsquare plate; unci with single long ventral tooth and smaller accessory, joined by weblike plate; manubria with large, crescentic anterior branch; epipharynx of two irregular plates, finely denticulate on inner margins.

Length: 570 μm ; toes 32 μm .

Ecology: In permanent acid waters, apparently feeding on cyanobacteria (blue-green algae) (Myers 1933). Single record from humic waters in Tasmania, near L. Garcia on the west coast, 17.0°C, pH 3.1, 80.6 $\mu\text{S cm}^{-1}$, 0.6 NTU.

Literature: Koste et al. (1988).

Lindia torulosa Dujardin

FIG. 4:4

Lindia torulosa Dujardin, 1841, p. 653, Fig. 22.2.

Type locality: (France).

Holotype: Not designated.

Description: Body elongate, fusiform to vermiform, transparent; cuticle thin, very flexible; adult animal tinged yellow to orange-red; transverse folds distinct anteriorly, many partly telescopic annular rings posteriorly in creeping animal; abdomen tapers to rounded lobe of tail; foot indistinctly two-segmented; foot-glands small bulbs in terminal segment; toes small, cylindrical, terminate in minute tubules; mastax specialized virgate, with lyrate rami; alulae well-developed; fulcrum a triangular plate; unci with three teeth, first or ventral most developed; lamellary web unites teeth; manubria with crescentic ventral and straight median branch; epipharynx two bent rods behind mouth, with two rhomboidal lamellae from external angles of which 12–15 thin ribs radiate; small brain with red eyespot; retrocerebral sac brown to black; oesophagus, long, ringed; stomach and intestine not separate, often filled with *Oscillatoria* fragments.

Length: 250–600 μm , toes to 11 μm , trophi 26–32 μm , male to 175 μm .

Ecology: Cosmopolitan in still and flowing waters; mass developments in *Oscillatoria* blooms; single record from Sheepwash Billabong, Yea, Victoria, 11.0°C, pH 7.2, DO 6.1 mg l⁻¹, 170 $\mu\text{S cm}^{-1}$, 17 NTU.

Literature: Koste (1978).

Lindia truncata (Jennings)

FIG. 4:5

Notommata truncata Jennings, 1894, p. 16, Figs 10, 11.
Lindia truncata after Harring & Myers, 1922, p. 626,
Fig. 54:1, 2.

Type locality: Lake St Clair, Michigan, in bottom vegetation.

Holotype: Not designated.

Description: Elongate fusiform body, with annulate transverse folds, tapers to rounded tail; two-segmented foot with short, conical toes; body orange-brown to red coloured; retrocerebral sac dark red to red-brown; cerebral eye carmine red; mastax with two large salivary glands pushing posterior ends of manubria outward; rami lyrate with large alulae and long right-angled dorsal extension supporting rami; fulcrum slender, tapering; unci with three teeth united by lamellary web; ventral branch of manubrium crescentic, dorsal branch short, forms anterior margin of broad lamella projecting dorsally; epipharynx two hammer-like pieces behind mouth; brain large and elongate, posteriorly with hemispherical heavily red-pigmented retrocerebral sac enclosing eye-spot.

Length: 200–512 μm , toe 8–15 μm , trophi 30–43 μm long, to 50 μm wide (fulcrum 9 μm , manubria 25 μm , rami 16 μm); epipharynx width 19 μm ; subitaneous egg 90 \times 60 μm .

Ecology: Europe, N. America, E. Asia in *Rivularia* and *Gleotrichia* colonies, occasionally in periphyton on submerged macrophytes. Two records: Yarnup Swamp, W.A. and Scotts Peak, near L. Pedder, Tas. 14.0°C, pH 6.2, 75–1600 $\mu\text{S cm}^{-1}$.

Literature: Koste *et al.* (1983), Koste & Shiel (1987).

Incertae sedis

A rotifer identified as *Russelletia* (sic) *parrotti* Russell ? was listed from Myall Lake, ca. 80 km north of Newcastle, by Sudzuki & Timms (1977). No description or figures were provided. If this is the rotifer described by Russell (1947), it was ascribed to the genus *Lindia*, now placed in the family Lindiidae, not *Rousseletia* (Notommatidae).

Lindia parrotti Russell

Lindia parrotti Russell, 1947, p. 403.

Type locality: Victoria Lake, Christchurch, N.Z.

Holotype: Canterbury Museum, Christchurch.

Description: Elongate, slender body tapering gently to foot; no distinct separation between head and abdomen; annulation obvious in contracted animal; foot rudimentary, no tail; toes short; single dorsal antennae on papilla; lateral antennae not described; corona weak, oblique, extends ventrally to retractile

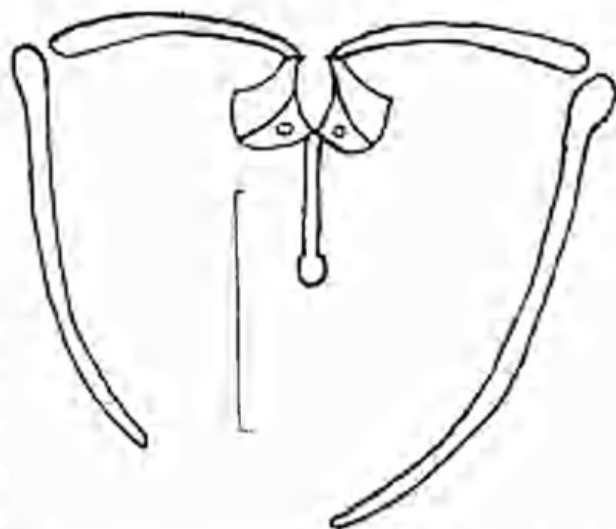


Fig. 5 Trophi of *Lindia parrotti* Russell, 1947 as figured by Russell. Scale line 5 μm .

chin; mastax cardate, small; fulcrum long, narrow, terminates in circular plate; rami lyrate, not denticulate; unci with four teeth (three rudimentary, lamellate); manubria long, slender, curved, expanded proximally at junction with unci; ?no epipharynx; ?no retrocerebral organ; foot glands indistinct.

Length 80–100 μm ; width 27–35 μm ; manubrium 7–9 μm ; unci 5 μm ; fulcrum 3 μm ; subitaneous egg 45 \times 25 μm .

Ecology: Described from Victoria Lake, Christchurch, N.Z. 18–24°C, pH 8.5–10. Record from Myall Lake needs verification. Occurrence with *Brachionus plicatilis* and other halophile rotifers and microcrustaceans suggests that the Myall Lake species is a halophile.

Literature: Sudzuki & Timms (1977).

Comment: Russell provided no figure of this species, and the trophi as figured (Fig. 5) are inadequate, however the description appears valid. No authority is given by Sudzuki & Timms for the relocation of *L. parrotti* to the notommatid genus *Rousseletia* Harring. Russell described the trophi as cardate (vs. virgate trophi in *Rousseletia*); other differences in trophi morphology separate the genera. We regard the Myall Lake record as *incertae sedis*.

Acknowledgments

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MORPHOLOGY AND BIOLOGY OF THE AUSTRALIAN TREE FROG *LITORIA PEARSONIANA* (COPLAND) (ANURA: HYLIDAE)

BY KEITH R. McDONALD† & MARGARET DAVIES†*

Summary

Litoria pearsoniana (Copland) is a small, polymorphic tree frog found in northeastern NSW and southeastern Qld at elevated altitudes. Morphometric data, colour variation and osteological data are provided together with observations on large winter aggregations of the species, temperature regulation and behaviour. The call and tadpole are described and a possible decline in populations is reported.

KEY WORDS: *Litoria pearsoniana*, tree frog, morphology, biology, advertisement call, osteology, larval development, winter hibernaculum, distribution.



Koste, Walter and Shiel, R J. 1990. "ROTIFERA FROM AUSTRALIAN INLAND WATERS VI. PROALIDAE LINDIIDAE ROTIFERA MONOGONONTA." *Transactions of the Royal Society of South Australia, Incorporated* 114, 129–144.

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