VOLUME 52
PART 1

MEMOIRS

OF THE

QUEENSLAND MUSEUM

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National Library of Australia card number
ISSN 0079-8835

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A Queensland Government Project
Typeset at the Queensland Museum

A REVIEW OF *TEMNOHASWELLIA* AND *TEMNOSEWELLIA* (PLATYHELMINTHES: TEMNOCEPHALIDA: TEMNOCEPHALIDAE), ECTOSYMBIONTS FROM AUSTRALIAN CRAYFISH *EUASTACUS* (PARASTACIDAE)

KIM B. SEWELL, LESTER R.G. CANNON AND DAVID BLAIR

Sewell, K.B., Cannon, L.R.G. & Blair, D. 2006 11 10: A review of *Temnohaswellia* and *Temnosewellia* (Platyhelminthes: Temnocephalida: Temnocephalidae) ectosymbionts from Australian crayfish *Euastacus* (Parastacidae). *Memoirs of the Queensland Museum* **52**(1): 199–280. Brisbane. ISSN 0079-8835.

Temnohaswellia, containing six-tentacled and usually non-pigmented ectosymbiont worms from freshwater crayfish in Australia and New Zealand, is reviewed and 10 new species described from spiny mountain crayfish (*Euastacus* spp., Parastacidae) from eastern Australia. The sclerotic armature of the vagina was found most useful in discriminating species in this genus. Australian *Temnohaswellia* species are confined to *Euastacus* hosts, but are characterised by low level host specificity. *Temnosewellia*, with five tentacles and usually pigmented, is reviewed from *Euastacus* hosts in Australia and 31 new species are described. The sclerotic armature of the male cirrus was found most useful in discriminating species of this genus, with the vagina showing little variation. *Temnosewellia* species are not confined to *Euastacus* hosts, but on these hosts show much stricter host specificity. ❐ *Ectosymbionts, freshwater crayfish, temnocephalan, Platyhelminthes, Temnosewellia, Temnohaswellia, Euastacus, Parastacidae, Australia.*

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Temnocephalan worms are freshwater rhabdocoel turbellarian ectosymbionts associated in Australia with crustacean hosts, particularly parastacid crayfish. For more than 100 years, spiny mountain crayfish (*Euastacus* spp.) have been recognised as important hosts for temnocephalans. This genus is endemic to eastern Australia and is distributed along the Great Dividing Ra. from Cooktown in North Queensland to the South Australia–Victoria border (Morgan, 1986, 1988, 1989, 1991, 1997). To date, 43 species of *Euastacus* have been described (Coughran, 2002).

The first temnocephalan recorded from *Euastacus* crayfish was a large worm with five tentacles and brown pigment, *Temnocephala fasciata* Haswell, 1888, from the external carapace of *Astacopsis serratus* (Shaw, 1794) (A name now known to encompass several species in the genus *Euastacus*). Haswell (1888) mentioned smaller white worms with six tentacles, which he believed to be immature *T. fasciata*. Subsequently, Haswell (1893) recognised the distinctiveness of these 6-tentacled worms and named them *Temnocephala comes*. Much later in a footnote, Haswell (1924) provided brief details of another 6-tentacled worm with brown pigment which he planned to describe formally, but never did. This incompletely described worm, *Temnocephala simulator* Haswell, 1924, and the earlier *Temnocephala comes* Haswell, 1893 remain the only named species of 6-tentacled worms from *Euastacus* hosts. Periera & Cuocolo (1941) later proposed *Temnohaswellia* to accommodate the 6-tentacled worms formerly in *Temnocephala*.

Although *Temnohaswellia* also occurs in New Zealand where a single species, *T. novaezealandiae* (Haswell, 1888), is associated with freshwater crayfish *Paranephrops* (see Fyfe, 1942), in Australia this genus is known only from *Euastacus*.

In Australia, two further species of *Temnohaswellia* were described by Cannon (1993) from single specimens collected from freshwater shrimp, *Caridina* sp. (*nilotica* ?) at Aplin Weir, Townsville, north Queensland: *Temnohaswellia pugna* Cannon, 1993 and *T. tetrica* Cannon, 1993. We now believe that the record from *Caridina* sp. and the subsequent wrong identification of the worms is because of an error in specimen labeling. The worms probably came from a species of *Euastacus* from NSW (probably *Euastacus suttoni* from Glen Innes) and should be referred to Haswell's species *Temnohaswellia comes* and *T. simulator* respectively. Evidence to support

this belief is presented in the remarks section of *Temnohaswellia comes* description in this paper.

Haswell (1924) also drew attention to a possible new species of 5 tentacled worms which he described as a variety of *Temnocephala fasciata* and for which he figured the cirrus. In fact several species of temnocephalan worms with 5 tentacles occur in Australia on freshwater crayfish, crabs and shrimps (Hickman, 1967; Cannon, 1993; Cannon & Sewell, 2001). Australian members of *Temnocephala* with 5 tentacles were transferred to *Temnosewellia* by Damborenea & Cannon (2001).

Although Cannon & Sewell (1994) predicted that the recorded temnocephalan fauna of *Euastacus* would increase with closer examination of the hosts, to date only two other temnocephalans have been described from spiny mountain crayfish*, viz. Heptacraspedella peratus* Cannon & Sewell, 1995, and *Gelasinella powellorum* Sewell & Cannon, 1998. Both belong to the sub-family Craspedellinae, members of which live on crayfish gills.

The current study of *Temnohaswellia* and *Temnosewellia* from *Euastacus* hosts in Australia greatly increases the number of species recognised from these crayfish and complements a wider study to examine the possible co-evolution of temnocephalans and their *Euastacus* hosts using morphology and DNA sequences.

MATERIALS AND METHODS

Euastacus crayfish were collected from freshwater habitats either by hand after turning rocks or by using baited collapsible minnow traps. Many field localities visited and sampled in 1990–1992 by LRGC and KBS as part of fieldwork described in Cannon & Sewell (1994) were revisited in 2002 to collect live *Euastacus* hosts and their temnocephalan associates for histology and DNA analysis.

Most collected crayfish hosts are registered in the Queensland Museum (QM) Crustacean collection. The museum registration numbers of these are provided here, along with the registration numbers of any hosts from other Australian museums from which temnocephalans were borrowed. Where a crayfish is not registered with a museum it is termed 'unregistered host' the record is followed, where known, by the name and institutional details of the person who identified the host.

Specimen data are listed in condensed format in the order: QM registration number; specimen/slide preparation details (in parentheses, with the number of slides in square brackets [ ]); host specific name; museum host registration number, or for unregistered hosts, the host identification authority and details (in square brackets [ ]); locality details as provided with host; date collected; collector(s); histological fixation/staining procedures.

In the Materials section, full registration details are provided only for each holotype specimen and for each new locality. Discrete blocks of registration data are separated by semicolons. Data for all subsequent specimens listed (including paratypes) in the Materials section data are condensed to reduce repetition of data that are often common to a range of specimens e.g. location, date and collectors. The museum host registration number or identification details, museum temnocephalan registration number, and specimen slide preparation details are always provided, followed only by those data which are different from that of the preceding registration. Specimens recorded in the Materials section, other than type material and material from the type locality, are grouped by crayfish host, then Australian state, with wholemounts listed first followed by cirrus preparations and then serial sections. We consider these abbreviated data valuable as they readily allow other workers access to information without the ongoing need to query collection databases.

The single specimen of *Temnohaswellia comes* (Haswell, 1893) from the Australian Museum, Sydney was examined. This slide-mounted specimen was labelled 'type' and we assume it is the holotype. Specimens of *Temnohaswellia novaezealandiae* (Haswell, 1888) were obtained from *Paranephrops zealandicus* collected by colleagues in New Zealand, fixed and sent to Australia. Types of this species were not available in any museum collection in Australia or New Zealand. Specimens in 70% ethanol identified by William A. Haswell as *Temnocephala fasciata* Haswell, 1888 from the Australian Museum, Sydney were examined. Types, labeled as such, were not found in any museum in Australia or New Zealand. For other early-described species without types designated by their authors, we have selected a neotype only if we believe there is potential for confusion in identification. Only *Temnohaswellia simulator* comes into this category.

Live temnocephalans were removed from the surface of the crayfish using a sharp wooden

point or fine forceps. Processing of crayfish and worms and descriptive terminology essentially follows the conventions established by Cannon & Sewell (1995) and updated by Sewell & Cannon (1998a) and Cannon & Sewell (2001). Refinement of the protocols associated with temnocephalan taxonomy has continued in the present study. We therefore present here a detailed account of all methods currently employed.

Cold 100% ethanol was recognised as a valuable routine fixative for temnocephalans for the following reasons: worms fixed in this way are usually extended in a life-like manner and thus ideal for preparation of wholemounts (WM); worms can be cleared and mounted unstained without the need for further dehydration; worm tissue remains useful for DNA analysis; and worms can be rehydrated in water and mounted in Faure's medium to allow examination of the sclerotised components. In previous taxonomic publications (see Cannon & Sewell, 1995, 2001; Damborenea & Cannon, 2001; Sewell & Cannon, 1998a, b) we termed the chloral hydrate-based mounting medium we used (distilled water 50ml; chloral hydrate 50g; glycerol 20ml and gum arabic 30g) as 'de Faure's mounting medium'. The term is renamed in the present paper as Faure's mounting medium in the light of information provided by Upton (1993) who stated that this recipe (which originally included a small quantity of cocaine) was first devised by Dr Giovani Faure (not 'de Faure') in 1910.

Unstained wholemounts we regard as generally more useful for routine specimen preparation than stained specimens as they allow better definition of the male and female reproductive hard parts, and thus confirmation of the species' identity. To mount specimens unstained, after fixation in Bouin's fixative, they were soaked in a solution of 70% alcohol saturated with lithium carbonate to remove picric acid.

The pattern of the epidermal mosaic is well established as a valuable taxonomic character to discriminate taxa at the level of order and family (Joffe & Cannon, 1998; Cannon & Joffe, 2001; Damborenea & Cannon, 2001), but thus far has been regarded as less useful at lower taxonomic levels e.g. genus and species. Our investigations of the pattern of the epidermal mosaic are limited to a single species of each genus namely: *Temnohaswellia comes* and *Temnosewellia cypellum* sp. nov. Nonetheless, the pattern of the epidermal mosaic is included here as a potentially valuable character at the genus level. Terms used for the syncytia follow Joffe & Cannon (1998) and Cannon & Sewell (2001).

To show the epidermal mosaic, live worms were fixed by flooding with a solution of 2% silver nitrate heated to about 60°C, washed in distilled water then exposed to either bright sunlight, or incident light from a 'Volpi' cold light source for 15 to 30 minutes, dehydrated in ethanol and mounted in Euparol.

Since our initial use of Faure's mounting medium to clear worms (Cannon & Sewell, 1995), our species descriptions have relied increasingly on the sclerotised cirrus (male reproductive hard parts) as a character to discriminate species. In the case of *Temnohaswellia*, the arrangement of the sclerotised components of the vagina are equally valuable. Faure's medium provides much clearer images of these sclerotised organs than are available from stained or unstained wholemounts mounted in Canada Balsam. Nevertheless, we now recognise the following limitations of the use of Faure's medium. 1) Most importantly, slides mounted in Faure's medium are only semi-permanent and variable in their longevity (Upton, 1993). To counter the potential deterioration through drying of specimens mounted in Faure's, we have ringed the specimens using clear lacquer around the edge of the coverslip. It has been brought to our attention by one of the reviewers of this manuscript, that the use of Lanoline-Colophonium resin to ring specimens mounted in Faure's may better preserve the preparations. 2) The width of cirri increases slightly over time (years), presumably as the specimen flattens under the weight of the coverslip. 3) In the case of large, pigmented worms it is necessary to dissect the worms and remove the cirrus to obtain a good view of the organ. Dissection can be made easier by fixing live worms at capture in a few drops of Faure's medium. They can be stored in this way for extended periods until the need to mount the cirrus: this has the advantage that the specimen becomes softened in the medium and can thus more easily be dissected to remove the cirrus. For optimal results, specimens should be placed in Faure's medium before fixation. Fixed specimens should be soaked in water at least overnight to soften tissue prior to mounting in Faure's medium or prior to dissection to remove the reproductive structures.

Our descriptions of the cirrus and vagina are based on light microscope (LM) examination conducted with the aid of Nomarski interference

contrast. These organs occur in the posterior portion of the worms. Consequently we typically retained this part for morphological identification (i.e. after mounting in Faure's medium) and subsequent registration of the posterior end as a voucher specimen in a museum collection, while allowing the anterior end to be available for DNA sequence studies.

Images were captured digitally using Arcsoft Zipshot and edited and assembled into plates using Adobe Photoshop, diagrams were prepared using Adobe Illustrator.

TERMINOLOGY AND MEASUREMENTS

Body pigment, although rare in *Temnohaswellia* spp., is commonly present in *Temnosewellia* spp. Where present, it is comprised of fine brown particles forming a complex, ramifying dorsal network that penetrates the parenchyma and becomes less dense and regular ventrally. The general pattern of the pigment can be seen in wholemount specimens in Canada balsam, but is particularly clear in specimens mounted in Faure's medium. The pattern described for *Temnosewellia fasciata* by Haswell (1893) is typical of adults of most pigmented *Temnosewellia* species from *Euastacus* crayfish. Dorsally the pigment is continuous and, at least in larger worms, adopts a close woven appearance that usually resembles a network or cloth (Figs 19D, E; 23E, G; 33A). The body pigment is often concentrated around the eye region, including between the eyes, and extends to the tentacles, but is absent from the major reproductive, excretory and digestive organs (e.g. testes, excretory ampullae, gut), and the nervous system (e.g. nerve cords). This absence results in open spaces in the pigment that outline these organs and the nerve plexus (Fig. 27A). The pigment is generally little developed on the ventral body surface and on the dorsal surface of the sucker. The density of body pigment was, however, observed to vary within and between species.

Some species completely lack body pigment, even as large adult specimens. These worms appear white except for discrete brown to dark brown eyes and a dark gut. In some species, though juvenile worms may have almost no body pigment, as the worms increase in size (= age) the density of pigment increases such that large worms have the typical dense woven pattern. In other species, juvenile worms may have well developed pigment, although it is always less dense than in large adults.

Our descriptions of body pigment focus on the dorsal most body pigment of adult worms and we use three terms to describe the pigment pattern: 'lacking', 'typical' and 'punctate'. Worms that have no pigment granules in the dorsal body or have pigment granules restricted to a small concentration around or between the eyes are classified as 'lacking' body pigment. We term as 'typical' the pattern of dense, woven dorsal body pigment such as that described for *Temnosewellia fasciata* by Haswell (1893). We term as 'punctate' dorsal body pigment that has clumped regions of denser pigment set within the woven network (Figs 23F; 45A).

Cannon & Sewell (1995) provided measurements of selected internal structures of only the taxonomic type series, indicating that such measurements are valuable only as guide to the overall size and shape of the worms and their organs. Here, we extend this assertion and exclude measurements of some internal structures (i.e. testes, excretory ampullae, ovary) provided in previous publications (Cannon, 1993; Cannon & Sewell, 1995, 2001; Sewell & Cannon, 1998a).

Our taxonomic descriptions again focus largely on the sclerotised reproductive structures as providing characters for discriminating species. In the current study we were able to obtain sufficient material for most species to allow high resolution LM examination of the sclerotised components of the male and female reproductive organs cleared in Faure's medium. Nevertheless, resolution of detail is sometimes difficult and we choose to remain cautious in our counts, indicated by '?', of jumbled overlapping structures. Given our continued and increasing reliance on these structures as characters to discriminate species, it is timely to reiterate and update some of the terminology used (see Fig. 1A, B).

After Cannon & Sewell (1995), we define the cirrus as the entire sclerotised male copulatory organ comprised of an 'introvert' (flexible distal eversible region armed with spines) and 'shaft' (rigid, tubular region tapering distally). Shaft length was measured from the proximal rim to the introvert base along the outside of the shaft wall but inside the introvert swelling. Although the cirrus generally appears to be more or less curved, the degree of curvature of the shaft is in our opinion not a reliable taxonomic character,

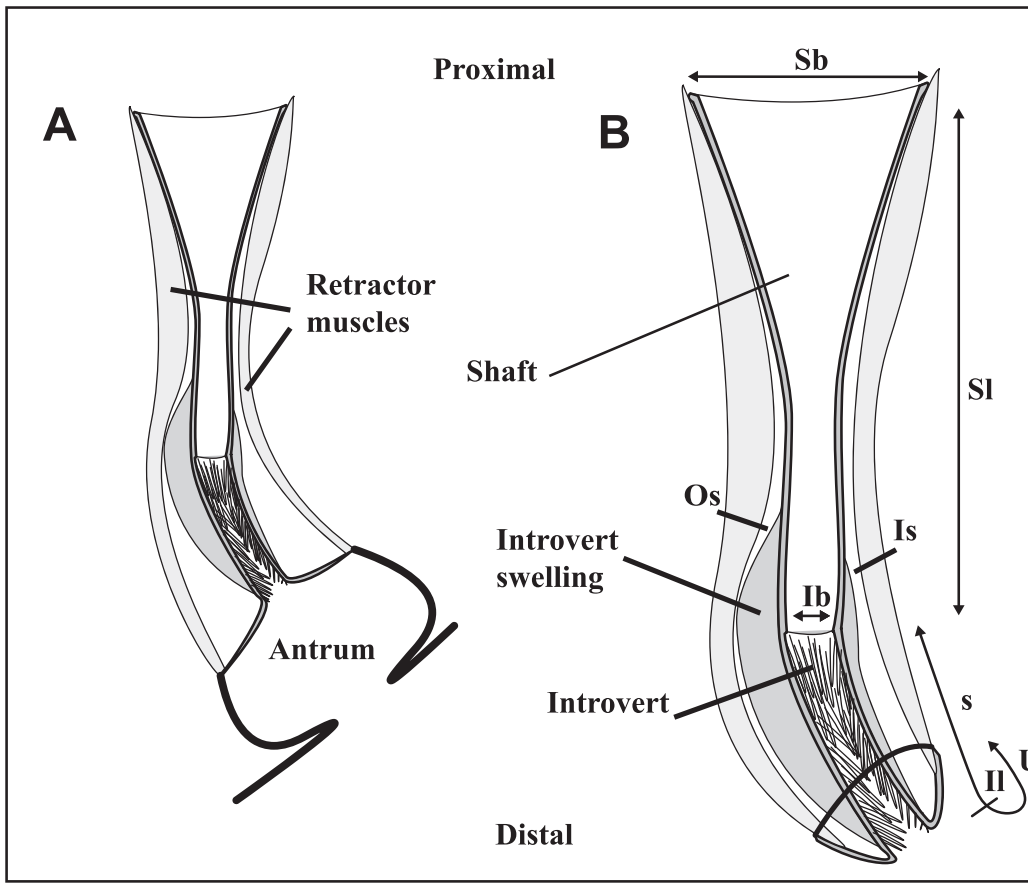


FIG. 1. Diagram of the temnocephalan cirrus typical for *Temnohaswellia* in sagittal view. A, orientation and relationships of the shaft, retractor muscles, eversible spined introvert (with unspined region), and the opening of the antrum; B, measured regions of the cirrus used for species descriptions. Sl, shaft length; Sb, shaft base width at the proximal end; Il, introvert length (of spined region(s) on the introvert longer [= outer] side); Ib, introvert base width at the proximal end; Is, Introvert swelling extending proximally past the introvert base on the the inner side; Os, introvert swelling extending proximally past the introvert base on the outer side of the cirrus; U, unspined distal region.

often being affected by fixation and by mounting in Canada balsam.

The introvert extends from the distal insertion of the introvert eversion muscle to the proximal junction with the shaft, i.e. the introvert base (Fig. 1A, B). The introvert is the portion of the cirrus first formed in juveniles, and its dimensions, unlike those of the cirrus shaft, remain nearly constant as worms age (unpublished observations). In most temnocephalans the introvert bears spines throughout its length, but in many Australian species of *Temnohaswellia* there is a distinct unspined zone distally that is well sclerotised (labeled 'U' in Fig. 1B) and frequently appears as a collar folded back over the spiny region. It is unclear from light microscopy whether this zone comprises a terminal part of the cirrus or is part of the antrum. In other genera this zone is less well developed and may be difficult to resolve. We have termed the zone the 'unspined distal region' (Fig. 1A-B). The unspined distal region is often very difficult to observe in specimens not cleared in Faure's medium. Sometimes it has prominent longitudinal folds similar in appearance to those figured by Haswell (1888: plate XXII, fig. 8) for *Temnomonticellia quadricornis* (Haswell, 1888) and often it has thickened walls distally. The presence and/or dimensions of this character

can be difficult to determine if specimens are not well cleared in Faure's medium, or when the cirrus is very small. Consequently, we have listed the measurements of the spined region of the introvert and the unspined distal region separately in species descriptions.

The introvert swelling is the optically distinct layer surrounding the inner introvert wall from which the spines project inward and distally when the cirrus is not everted (Cannon & Sewell, 1995). The introvert swelling is a clearly recognisable hyaline structure but we are not able to describe it in detail histologically or to confirm its exact function. The introvert swelling varies in thickness along the length and around the circumference of the introvert, and extends proximally past the introvert base to the distal region of the shaft (Fig. 1A–B). The swelling can be classifed as 'even', 'uneven' or 'very uneven' in the relative thickness of the longer and shorter sides of the introvert (Fig. 2). Where the swelling is not even, it is invariably thicker on the longer side of the introvert (Fig. 1A–B). The relative shape and size of the introvert swelling are useful taxonomic characters with the following limitations. The dimensions of the introvert swelling, unlike the other dimensions of the introvert, appear to increase somewhat as worms increase in size (= age). Moreover, in some specimens, the swelling is difficult to resolve, usually either because it has completely cleared as a result of an extended period in Faure's medium or because it is very narrow.

Descriptions of the cirrus and the introvert refer to the inverted/relaxed state of the structure (Figs 1A–B, 2). Two main cirrus eversion muscle bundles attach to the distal region of the introvert dorsally and ventrally. In specimens mounted in Faure's medium, the presence of these muscle bundles ensures that the cirrus rolls, under the coverslip pressure, to present a longer and shorter introvert side when the distal opening is oblique.

The shape of the shaft may be described as a 'funnel', 'goblet' or 'cone' (Fig. 2). Funnel or goblet-shaped shafts have a wide proximal region, which tapers rapidly to form a narrow tubular distal region (Fig. 2).

We recognise the general shape of the spined region when inverted as (i) like a 'cylinder', i.e. a continuation of the introvert margins, without inflation, of the line of the shaft, (ii) a 'cone', i.e. with the distal opening wider than the base, (iii) a 'scoop', i.e. with the lateral margins inflated, but with a distal opening not greatly larger than the base, and (iv) a 'goblet', i.e. with inflated lateral margins and an opening greatly wider than the base (Fig. 2). We also recognise the distal opening of the introvert spined region may be at right angles to the long axis of the shaft, i.e. 'transverse', or it may be 'oblique' or even 'very oblique' (Fig. 2).

Descriptions of the introvert generally exclude fine details of the spines. In general the spines are longest on the longer side of the introvert and are shorter distally. Detailed analysis of the spination at the light microscope level requires examination of fully everted cirri, a situation which, in our experience, occurs relatively rarely in fixed specimens. The introvert spines are attached to ridges that run parallel to the long axis of the introvert. However, in some species the ridges spiral, so that spines on adjoining parallel ridges line up optically in rows that appear diagonal to the long axis of the inverted introvert. Measurements of the cirrus are recorded from selected cirrus preparations from the type host and locality cleared in Faure's medium that were the best representatives of those available i.e. undamaged specimens lying flat.

Although the cirrus is a principal focus for the recognition of temnocephalan species we have found that in *Temnohaswellia* the sclerotised nature of the vagina is a most useful character (see Fig. 3A–B). After Cannon (1986), we term a vagina the entire region of the female tract that extends inwards from the common genital opening and ends distal to the entrance of the oviducts. The vagina (Fig. 3A–B) consists of: 1) the 'distal vagina', a broad distal cavity with muscular walls (delineated distally by a variably developed sphincter); and 2) the 'proximal vagina', a narrower proximal cavity with thinner muscular walls, a thin inner surface with a less regular shape and clearly able to expand. The inner surface of the entire vagina, particularly in species of *Temnohaswellia*, is folded into obvious longitudinal and circumferential ridges, with a pattern similar to the ribbed cuff of a knitted sock. This surface may be sclerotised to variable degrees. The ridges are delineated into 'columns' by the pattern of large longitudinal muscle bundles, and 'rows' demarked by smaller circumferential muscles. Here, we further divide the distal vagina into: 1) an 'outer region' adjacent to the opening to the atrium that is often thickly sclerotised and formed into teeth (Fig. 3B); and 2) an 'inner region' which

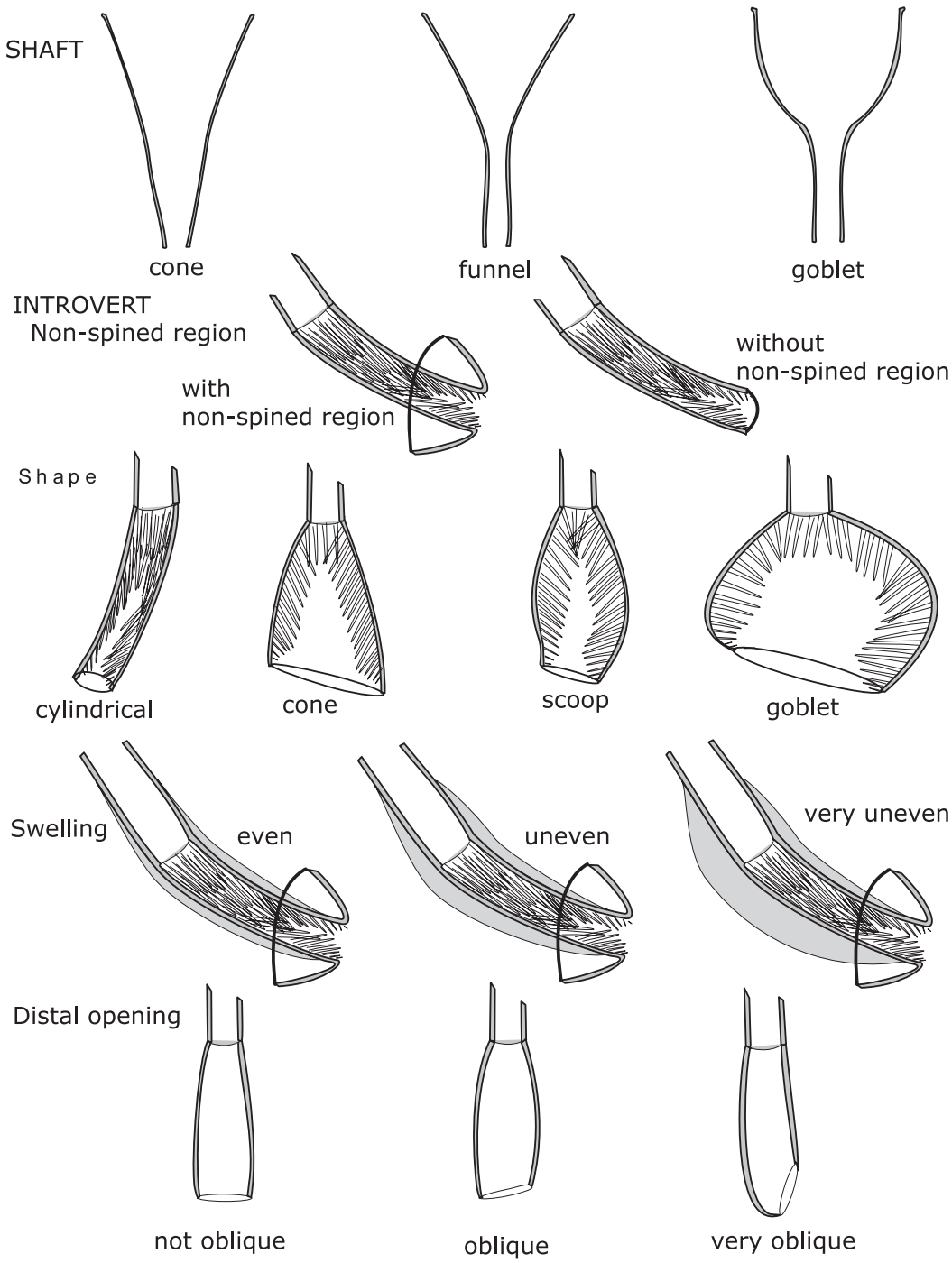


FIG. 2. Diagrams showing the terminology applied to the shaft (top row) and introvert (remaining rows) of the temnocephalan cirrus. See text for a full description.

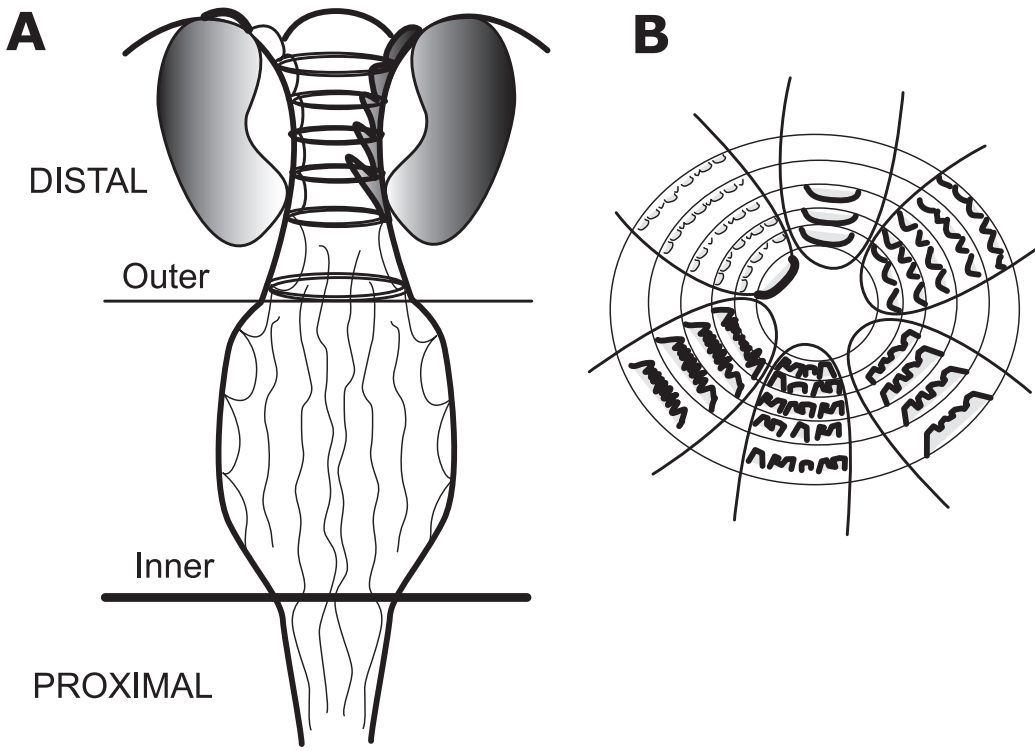


FIG. 3. Diagrams of the temnocephalan vagina. The arrangement figured is more typical of *Temnohaswellia*. A, vagina (sagittal) showing distal muscular sphincter, middle chamber with expandable walls and inner (proximal) canal. B, diagram (as if looking out towards genital pore) of the variety of sclerotised 'teeth' which can be found adorning the vaginal walls.

is frequently less sclerotised and more sac-like (expansive). Our descriptions of the vagina of *Temnohaswellia* focus largely on the sclerotised surface features of the outer region of the distal vagina. Descriptions of the vagina are derived mostly from Faure's preparations of the cirrus and surrounding areas, but in some cases also from histological sections.

All measurements were made in microns (μm) with the aid of a drawing tube. The sequence adopted for presentation of general body measurements is: 'B', total length of worm to tip of tentacles × width at greatest dimension; 'LE', length from posterior of worm to eyes; 'PH', pharynx length × width; 'SD', sucker diameter; 'PD', sucker peduncle diameter.

The sequence for the the cirrus measurements (see Fig. 1A–B) is: 'S', shaft length [Sl] X shaft base diameter [Sb]; 'I', Introvert length of spined region [Il] X introvert base width [Ib]; 'U', length of unspined introvert region (if present); 'IS', length of introvert swelling proximal to the introvert base on introvert outer side [Os] × length of introvert swelling extending proximal to introvert base on introvert inner side [Is].

The following abbreviations are also used: ACT, Australian Capital Territory; AD, adhesive disk syncytium, Alc, ethanol; AM, Australian Museum, Sydney; Bouin, Bouin's fixative; BS, body syncytium; ca, circa; CALC, locality co-ordinates calculated from locality description provided; Ck, Creek; CP, cirrus preparation; Fau, Faure's mounting medium; E, east; Form, 10% formalin buffered to pH 7.0 with phosphate; Form-Acetic, Acetic-Formalin-Alcohol (AFA); Carn, Carnoy's fixative; FP; Forest Park; FR Forest Reserve; g, gonopore; H, Holotype; H&E, haematoxylin and eosin stain, HF, hot 10% formalin; HW, hot water, Hx, Mayer's or Harris's haematoxylin stain; LS, longitudinal sections; m, mouth; MB, melanin bleached; MP, epidermal mosaic preparation stained

with silver nitrate and mounted in Euparol; N, neotype; na, not available; NMV, Museum of Victoria, Melbourne; NP, National Park; np, nephridiopore; NR, Nature Reserve; nr, near; NSW, New South Wales; NZ, New Zealand; P, paratype; PP, pigment preparation; Qld, Queensland; PS, peduncular syncytium; PTS, post-tentacular syncytium; QM, Queensland Museum; R., River; Ra., Range; S, South, SA, South Australia; SF, State Forest; trib., tributary; TS, tentacular syncytium; Un, unstained; VIC, Victoria; WNW, west north west; WM, wholemount [Canada balsam].

TAXONOMY

Order TEMNOCEPHALIDA

Family TEMNOCEPHALIDAE Monticelli, 1899

Subfamily TEMNOCEPHALINAE

Temnohaswellia Pereira & Cuocolo, 1941

Temnohaswellia Pereira & Cuocolo, 1941: 103.

TYPE SPECIES. *Temnocephala novaezealandiae* Haswell, 1888, by original designation of Pereira & Cuocolo, 1941. Gender feminine. Host: *Paranephrops zealandicus* (White, 1847) [senior synonym of *Paranephrops setosus* Hutton, 1873 and *P. neozelanicus* Chilton, 1889].

DIAGNOSIS. Temnocephalinae generally less than 3mm long, six anterior tentacles and posterior pedunculate adhesive disc present; conspicuous papillate ridges or imbricating scales absent from tentacles or dorsal body; single dorsal pair of brown to dark brown pigmented eyes at base of tentacles; brown to dark-brown body pigment (melanin?) usually absent or restricted to region around or between eyes. Gut appears dark. Sclerotised distal vaginal cavity folded to form prominent papillae or 'teeth' distally, and longitudinal ridges and folds proximally. Testes two pairs postero-lateral to gut; vasa deferentia enter seminal vesicle separately; ejaculatory sac usually semi-discrete (with slightly-narrowed neck). (All species other than *T. novaezealandiae* restricted to Australia and only on *Euastacus* spp.).

Epidermal Mosaic (based on *Temnohaswellia comes* (Haswell, 1893)). Epidermis composed of 5 syncytia: 1, tentacular; 2, single, characteristically saddle-shaped, post-tentacular plate; 3, body; 4, peduncular; and 5, adhesive disc (Fig. 9). Post-tentacular syncytium contains the nephridiopores dorsally. Shallow groove marks border between dorsal and ventral surfaces along lateral margins of body and peduncular syncytia.

INCLUDED SPECIES

Temnohaswellia alpina sp. nov.
Temnohaswellia breviumbella sp. nov.
Temnohaswellia capricornia sp. nov.
Temnohaswellia comes (Haswell, 1893)
= *T. pugna* Cannon, 1993
Temnohaswellia cornu sp. nov.
Temnohaswellia crotalum sp. nov.
Temnohaswellia munifica sp. nov.
Temnohaswellia novaezealandiae (Haswell, 1888)
Temnohaswellia pearsoni sp. nov.
Temnohaswellia simulator (Haswell, 1924)
= *T. tetrica* Cannon, 1993
Temnohaswellia subulata sp. nov.
Temnohaswellia umbella sp. nov.
Temnohaswellia verruca sp. nov.
Temnohaswellia sp.

KEY TO SPECIES OF *TEMNOHASWELLIA*

1. Body pigment present in large specimens, or a concentration of pigment around the eye region 2
   Pigment lacking except for a thin tracery between the eyes 3
2. Body pigment concentrated in the eye region; outer vagina with a few teeth . . *T. simulator* (Haswell, 1924)
   Body pigment not concentrated in the eye region; outer vagina with very numerous large teeth . . . . . *T. novaezealandiae* (Haswell, 1888)
3. Teeth in the outer vagina. 6
   No teeth in outer vagina 4
4. About 10 large spines on the base of the introvert . . . . . *T. comes* (Haswell, 1893)
   No large spines on the base of the introvert 5
5. Cirrus shaft gracile and gently tapered, with long, narrow cylidrical introvert about 130µm long . . . . . *T. subulata* sp. nov.
   Cirrus shaft not gracile and gently tapered, with short, cylindrical introvert about 55µm long. . . . *T. cornu* sp. nov.
6. Eyes present 7
   Eyes absent; outer vagina with about 6 rows and columns of rounded teeth . . . . . *T. pearsoni* sp. nov.
7. Outer vagina with block-like teeth arranged in very obvious columns and rows, larger proximally . . *T. crotalum* sp nov.
   Outer vagina with teeth that are not block-shaped . . . 8
8. Rows and columns of teeth in the outer vagina that resemble combs 9
   Rows and columns of teeth in the outer vagina do not resemble combs 10
9. Blunt, comb-like teeth in the outer vagina, larger

proximally; cirrus with long unspined distal region with prominent longitudinal folds about twice as long as the spined region . . . . . *T. umbella* sp. nov.

Sharp, comb-like teeth in the outer vagina, smaller proximally; cirrus with long unspined distal region with prominent longitudinal folds about same length as the spined region . . . . . *T. breviumbella* sp. nov.

10. A single row of cusp-like teeth that ring the distal opening of the outer vagina, otherwise lacking teeth 11

Lacking a single row of cusp-like teeth that ring the distal opening of the outer vagina; with rows and columns of teeth 12

11. About 6 cusp-like teeth present . . . . . *T. verruca* sp. nov.

About 8 cusp-like teeth present . . . . . *T. alpina* sp. nov.

12. Outer vagina with about 4 rows of large, teeth; cirrus introvert large . . . . . *T. munifica* sp. nov.

Outer vagina with about 2 rows of teeth . . . . . *T. capricornia* sp. nov.

Temnohaswellia novaezealandiae
(Haswell, 1888) (Fig. 4A–D)

Temnocephala novaezealandiae Haswell, 1888: 284, pl. 22, figs 10, 19.

Temnohaswellia novaezealandiae: Pereira & Cuocolo, 1941: 103.

ETYMOLOGY. Clearly for New Zealand, where both worm and host are found.

MATERIAL. QMG211229–211233 (WM) from *Paranephrops zealandicus* [unreg. host], Orokunui Stream, Blueskin Bay, Dunedin (45°45'S 170°35'E), Jul. 1992, T. Dodgshun, HW/70% alc/Hx; [QMW26676], QMG221175–221179 (WM), McRaes Ck, Otago, New Zealand (45°48.0'S 170°25.1'E), 5.10.1996, K. Garrett, 100% alc/Un; QMG221167–221168, 221171–221174 (CP) 100% alc/Fau; QMG221169–221170 (CP) 100% alc/Fau/Alcian Blue; QMG221180–221184 (CP), 100% alc/Fau. QMG221191–221194 (CP) from *Paranephrops zealandicus* [unreg. host], Taieri R. trib., Otago, S Island, New Zealand, ca Nov. 2002, J. Hollows, 100% alc/Fau.

DESCRIPTION. *Temnohaswellia novaezealandiae* was described by Haswell (1888) and revised by Haswell (1893, 1924), Merton (1914) and Fyfe (1942). The description is updated here from fixed specimens with reference to these previous works, particularly that of Fyfe (1942).

General Anatomy. Characteristics of genus, but lacking pigment in young worms (except for brown intestine), with light brown pigment distributed in dorsal body and not concentrated around the eye region. Selected body measurements of specimens from *Paranephrops zealandicus* are: QMG221175: B(3019 × 1938), LE(1999), PH(545 × 683), SD(797), PD(480); QMG221176: B(3550 × 2081), LE(2387), PH(691 × 715), SD(854), PD(537); QMG221177: B(2203 × 1673), LE(1754), PH(520 × 528), SD(423), PD(650); QMG221178: B(1897 × 1714), LE(1469), PH(419 × 593), SD(602), PD(366); QMG221179: B(3774 × 1489), LE(2509), PH(748 × 650), SD(268), PD(268).

Reproductive System. Female. Vagina: Outer region with teeth, arranged in very numerous columns and rows of large, wide based, triangular teeth [as figured by Haswell (1893: plate XIV, fig 3); Fyfe (1942: plate 22)] with often rounded tip, smallest distally and proximally. Distal vagina very thickly muscled.

Male. Cirrus: General form as figured by Haswell (1893: plate XIII, fig. 17). Shaft cone-shaped. Introvert essentially as figured by Haswell (1893: plate XIII, fig. 18), cone to scoop-shaped; distal opening slightly oblique to oblique [as figured by Haswell (1893: plate XIII, fig. 18)]. Unspined distal region absent, but with distinct thickened rim at point of insertion of introvert eversion muscle. Swelling even [as figured by Haswell (1893 : plate XIII, fig. 18)], extends proximally well past introvert base on both sides, slightly farther on longer side. Distal spines project conspicuously past distal tip of fully inverted introvert [as figured by Haswell (1893: plate XIII, fig. 18); Fyfe, (1942: plate 22)]. Selected cirrus measurements of specimens from *Paranephrops zealandicus* are: QMG221169: S(602 × 181), I(116 × 59), IS(244 × 197); QMG221170: S(411 × 167), I(114 × 59), IS(na × 71); QMG221171: S(392 × 122), I(130 × 55), IS(203 × na).QMG221180: S(367 × 93), I(100 × 51), IS(181 × 122); QMG221181: S(533 × 183), I(102 × 47), IS(167 × 163); QMG221182: S(413 × 157), I(102 × 51), IS(152 × 132); QMG221183: S(551 × 128), I(108 × 51), IS(254 × 234).

HOSTS. *Paranephrops* spp.

DISTRIBUTION. New Zealand: from streams of the North and South Islands.

REMARKS. Haswell (1888) listed *Temnohaswellia novaezealandiae* as a new species but provided an incomplete description based only on fixed specimens. Haswell (1893, 1924) and Merton (1914) subsequently updated the original description and Fyfe (1942) provided a comprehensive account of the anatomy and systematics of the species. More recently, considerable work has been done on the ultrastucture of the species (see for example, Williams (1975, 1982, 1985 and references therein).

Type specimens of *Temnohaswellia novaezealandiae* were not found by officers at any of the following institutions deemed to be likely

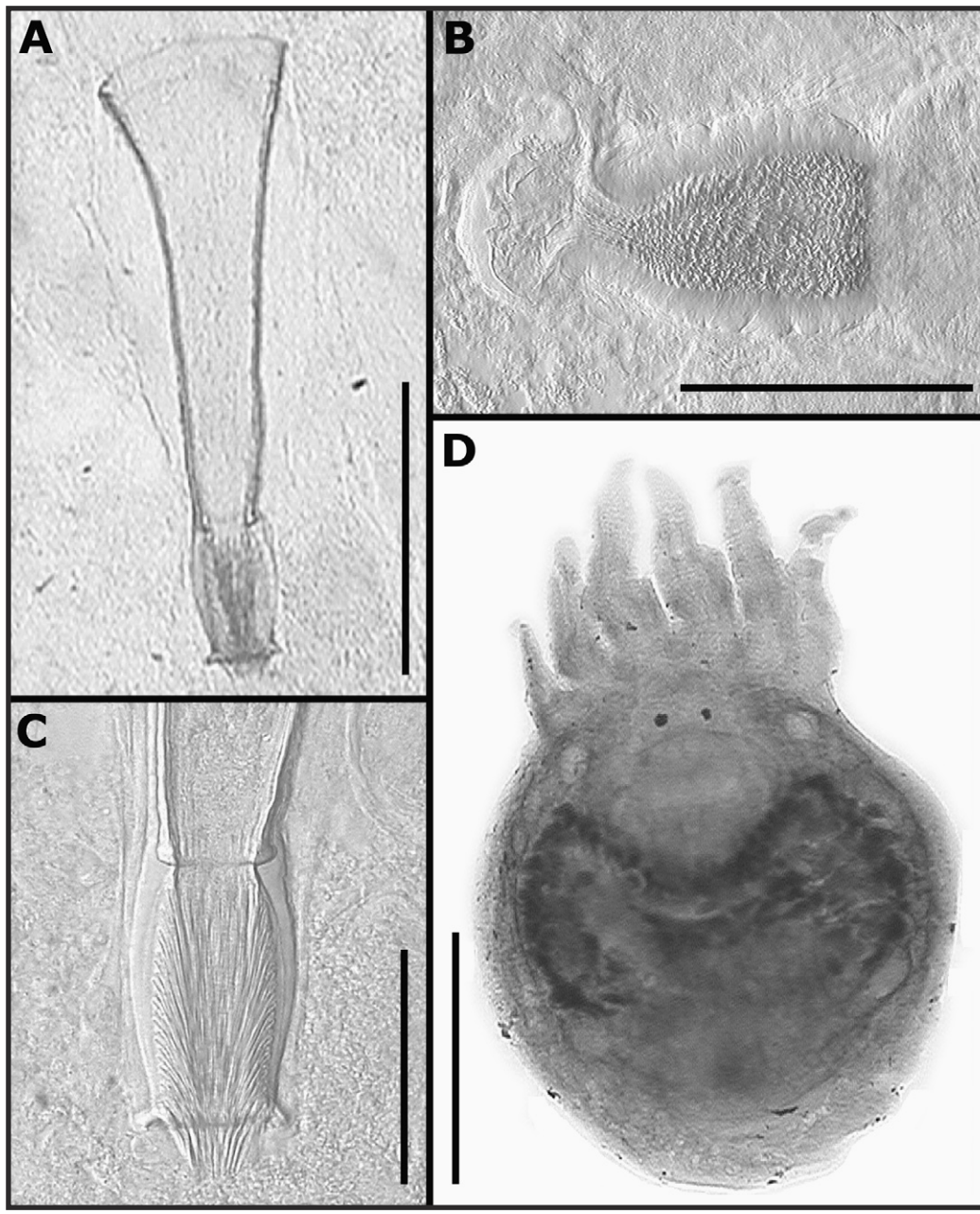


FIG. 4. *Temnohaswellia novaezealandiae* A–C, Nomarski interference contrast photomicrographs of Faure's preparations. A, QMG221182, whole cirrus. Scale = 250µm; B, QMG221182, vagina, scale = 250µm. C, QMG221182, introvert, scale = 100µm. D, QMG221175, wholemounted specimen showing light brown body pigment, scale = 1mm.

repositories for material examined by Haswell: The Otago Museum, Dunedin, NZ; The Cantebury Museum, Christchurch, NZ; The Auckland Museum, Auckland, NZ; The Museum of Wellington City & Sea, Wellington, NZ; and The Australian Museum, Sydney. There is, however, little doubt that the worms redescribed here are specimens of *Temnohaswellia novaezealandiae* which remains the only species of the genus known from New Zealand. We obtained specimens from the host *Paranephrops zealandicus*, which was the host species from which Fyfe (1942) obtained living and preserved specimens.

The worms are larger than all the Australian species examined in the present study.

Body pigment was observed to occur only in large specimens: it is comprised of fine, light brown granules with an uneven, slightly clumped distribution. Fyfe (1942), who observed live worms, described the body pigment as greenish-grey or brown. The eyes of *Temnohaswellia novaezealandiae* are discrete and comprised of granules of a dark brown pigment. The eyes lack a concentration of body pigment around them. In other species of *Temnohaswellia* with body pigment, the pigment is most concentrated around the eye region and sometimes closely associated with the eyes, often in thick tracts.

Haswell (1893: plate XIII, figs 17–18) drew the cirrus of *Temnohaswellia novaezealandiae* as long slender and curved while Fyfe (1942) described the organ as L-shaped and figured it so (Fyfe, 1942: plate 22). We do not consider the curvature of the cirrus as a very reliable taxonomic character, particularly in species that have a long cirrus shaft. In such species, the curvature varies between individuals from the same locality, ranging from nearly straight to considerably curved. The curvature appears to be influenced by the size of the organ and by fixation, and is frequently more pronounced in wholemounted specimens where muscle contraction may influence the final shape.

The rows and columns of large teeth in the outer vagina of this species are much more numerous and extensive than those observed for any Australian species. Consequently, for *Temnohaswellia novaezealandiae*, the exact number could not be determined even from specimens mounted in Faure's medium. The shape of the teeth is somewhat variable within and between individuals and is apparently influenced by the extent to which the rows are compressed in the specimen being examined. In some wholemounted specimens and specimens mounted in Faure's medium they appear almost as papillate crenulations (e.g. Fig. 4B) whereas in others they can appear more triangular as figured by Haswell (1924: plate LV, fig. 11), or even as rectangular with a triangular tip such as figured by Haswell (1888: plate XXII, fig. 19) and Fyfe (1942: plate 22). In this species the teeth are largest centrally and smaller both proximally and distally, suggesting they may be added with growth (= age).

Temnohaswellia alpina sp. nov.
(Fig. 5A–D)

ETYMOLOGY. Latin *alpinus* = of the high mountains; referring to the Australian Southern Alps where the species occurs.

MATERIAL. HOLOTYPE: QMG220149 (WM), from *Euastacus rieki* [QMW26644], Wragges Ck on Kosciusko Rd 5km NE Perisher Valley, Kosciusko (36°22.9'S 148°27.4'E), 18.03.2002, K.B. Sewell, 70% alc/Un. PARATYPES: QMG220150 (WM), 70% alc/Un; [QMW26645], QMG220151 (WM), 14.10.1991, L.R.G. Cannon & K.B. Sewell, HW/Form/Hx. OTHER MATERIAL FROM TYPE LOCALITY: [QMW26644] QMG220152 (WM), 18.03.2002, K.B. Sewell, 70% alc/Un; [QMW26645], QMG220153 (WM), 14.10.1991, L.R.G. Cannon & K.B. Sewell, HW/Form/Hx; [QMW26644], QMG220154–220156 (CP), 18.03.2002, K.B. Sewell, 100% alc/Fau. OTHER MATERIAL. From *Euastacus* sp. NSW: [unreg. host] AMW28691–28692 (WM), Blue Pools, N of Tantangara Dam, Snowy Mts (35°45'S 148°39'E), 23.02.1969, J. Beeman, unknown fixation/Hx; AMW28693– 28694 (LS[2,2]), unknown fixation/MB/H&E.

DESCRIPTION. Characteristics of genus but lacking body pigment except for thinly scattered pigment between the eyes. Selected body measurements of type specimens from *Euastacus rieki* are: QMG220149: (H): B(1929 × 934), LE(1408), PH(497 × 386), SD(386), PD(223); QMG220150: (P): B(1236 × 707), LE(894), PH(236 × 293), SD(317), PD(179); QMG220151: (P): B(1057 × 455), LE(683), PH(187 × 293), SD(203), PD(89).

Reproductive System. *Female*. Vagina: Outer region with single row of about 8 cusp-like teeth.

Male. Cirrus: Shaft cone-shaped. Introvert cylinder-shaped; distal opening oblique. Unspined distal region about one fifth length of introvert longer side. Swelling uneven, asymmetrical, wider on longer side, extending proximally slightly past introvert base on longer side and just past introvert base on shorter side. Selected cirrus measurements of

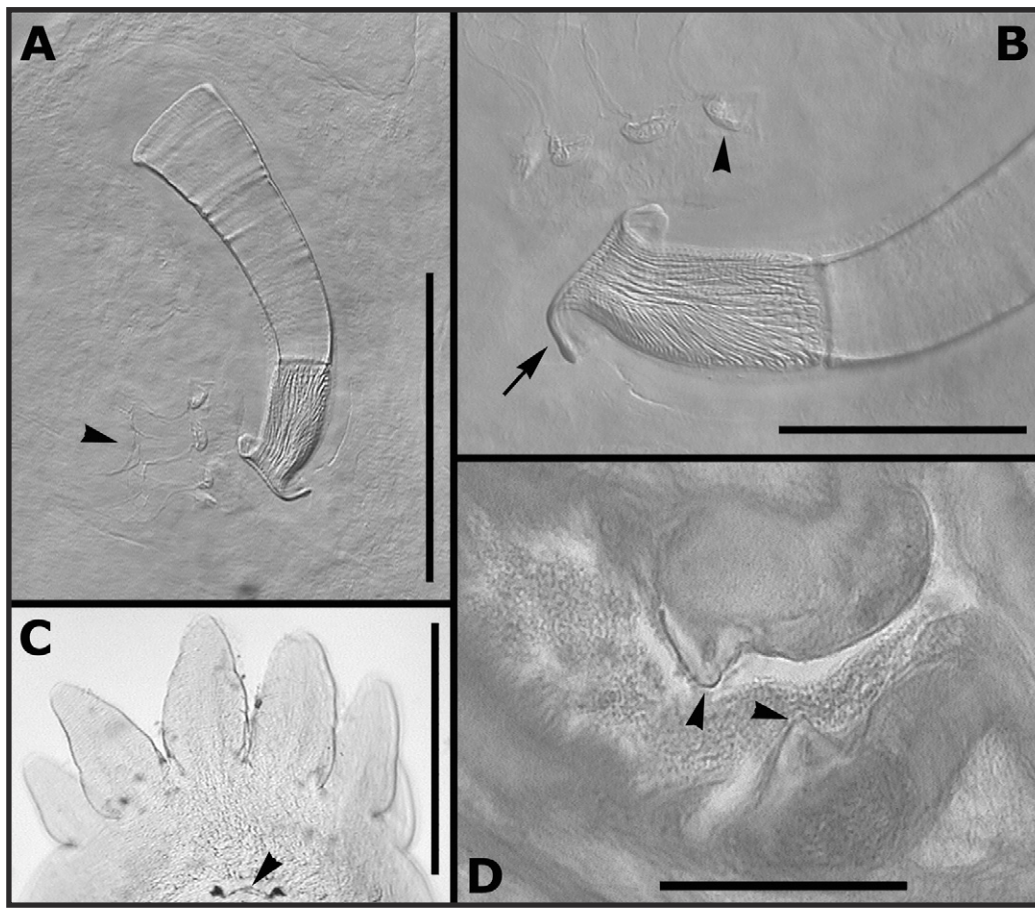


FIG. 5. *Temnohaswellia alpina* sp. nov. A-B, Nomarski interference contrast photomicrographs of Faure's preparations. A, QMG220156, whole cirrus and vagina (arrowhead), scale = 250µm; B, QMG220156, introvert with short unspined distal region (arrow) and vagina with cusp-like teeth (arrowhead) in the outer region of the distal vagina, scale = 100µm; C, QMG220149, anterior end of worm showing thin scatter of pigment between eyes (arrowhead), scale = 500µm; D, AMW28693, longitudinal section through vagina showing cusp-like teeth in the outer region of the distal vagina (arrowheads), scale = 50µm.

specimens from *Euastacus rieki* from the type locality are: QMG220149 [WM]: S(89 × 47), I(104 × 37), U(22), IS(na × na); QMG220154 [juvenile]: S(14 × 41), I(108 × 41), U(22), IS (na × na); QMG220155 [juvenile]: S(0 × na), I(102 × 37), U(20), IS(na × na); QMG220156: S(264 × 91), I(114 × 42),U(22), IS(60? × 4).

HOSTS. *Euastacus rieki*, *Euastacus* sp.

DISTRIBUTION. South-eastern NSW — from the Australian Alps region: Mt Kosciusko NP at Wragges Ck; and N of Tantangara Dam at Blue Pools.

REMARKS. The worms are morphologically close to *Temnohaswellia simulator*, but in *T. alpina* sp. nov. the outer vagina lacks numerous rows and columns of teeth, the cirrus introvert is longer, and the worms have no body pigment other than that between the eyes.

Temnohaswellia breviumbella sp. nov.
(Fig. 6A–B)

ETYMOLOGY. From Latin *brevis* = short and *umbella* = parasol; a reference to the unspined distal region of the introvert that resembles a short folded parasol or umbrella.

MATERIAL. HOLOTYPE: QMG220054 (CP), from *Euastacus bidawalus* [QMW26588], Dingo Ck, crossing on Euchre Valley Drive, Lind NP, VIC (37°34.7'S

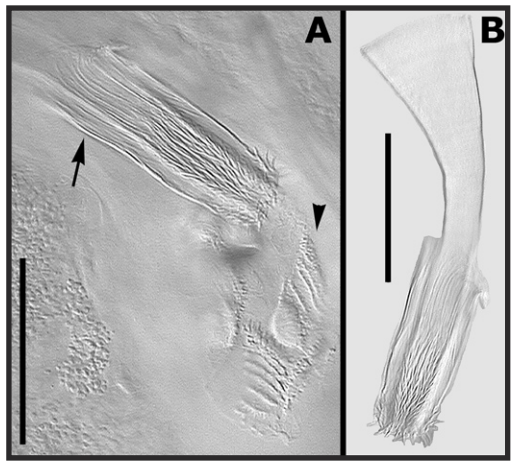


FIG. 6. *Temnohaswellia breviumbella* sp. nov. A, B. Nomarski interference contrast photomicrographs of Faure's preparations. A, QMG220054. Introvert with long unspined distal region (arrow) and vagina showing rows of comb-like teeth in the distal region (arrowhead). Scale = 100µm. B, QMG220054. Whole cirrus (stitched image). Scale = 100µm.

148°58.2'E), 20.03.2002, K.B. Sewell, S.H. Lawler & G.N. Edney, 100% alc/Fau. PARATYPE: QMG220055 (CP) 100% alc/Fau. OTHER MATERIAL FROM TYPE LOCALITY: [QMW27482], QMG221195, (CP), 5.01.2004, D. Blair, R.D. Sewell, S.H. Lawler & G.N. Edney, 100% alc/Fau.

DESCRIPTION. Characteristics of genus but lacking body pigment except for eyes and occasionally thinly scattered pigment between them. Selected body measurements of type specimens from *Euastacus bidawalus* are: QMG220054 (H): B(1612 × 836), LE(1102), PH(306 × 367), SD(286), PD(163); QMG220055 (P): B(1326 × 836), LE(796), PH(245 × 306), SD(306), PD(163).

Reproductive system. Female. Vagina: Outer region with single row of cusp-like teeth distally (6?), proximally with teeth arranged in 6(?) columns and 8(?) rows of comb-like teeth increasingly smaller proximally.

Male. Cirrus: Shaft cone-shaped. Introvert cylinder-shaped; distal opening not obviously oblique. Unspined distal region long, thin, about length of introvert longer side, with prominent folds oriented parallel to long axis of the introvert. Swelling even, extending proximally just past introvert base on both sides(?). Selected cirrus measurements of type specimens from *Euastacus bidawalus* are: QMG220054: S(215 × 81), I(114 × 26), U(118), IS, (na × na); QMG220055: S(234 × 67), I(112 × 26), U(122), IS, (na × na).

HOST. *Euastacus bidawalus*.

DISTRIBUTION. South-eastern VIC — from the east Gippsland region: Lind, NP at Dingo Ck.

REMARKS. Only two Faure's mounted specimens are available but the species is clearly distinct. It most closely resembles *Temnohaswellia umbella* sp. nov. in the form of the vagina and cirrus. The introvert, however, is clearly shorter, particularly the unspined distal region of the introvert which is only half the length of that of *Temnohaswellia umbella* sp. nov. The cusps that ring the vaginal opening are particularly prominent. The exact dimensions of the introvert swelling could not be observed in these specimens due to the long unspined distal region, although it is clearly narrow and does not extend proximally far beyond the introvert base.

Temnohaswellia capricornia sp. nov.
(Fig. 7A–E)

ETYMOLOGY. Referring to the Queensland Capricorn region where the worms were collected.

MATERIAL. HOLOTYPE: QMG220098 (WM) from *Euastacus monteithorum* [QMW26634], Kroombit Tops, in rainforest at headwaters of Kroombit Ck in 'Beauty Spot 98', Kroombit Tops SF Qld 24°22'S 150°59'E, Nov–Dec. 1990, L.R.G. Cannon & J.B. Jennings, HW/ Form-Acetic/Un. PARATYPES: QMG220099 (WM) HW/ Form-Acetic/Un; QMG220100–220101 (WM), HW/ Form-Acetic/Hx; QMG220102 (WM), Form/Hx. OTHER MATERIAL FROM TYPE LOCALITY: [QMW26634], QMG220103–220104 (WM), Form/ Hx; QMG220105 (WM), HW/Form-Acetic/Un.; QMG220106–220111 (CP), Form/Fau; QMG220112–220117 (LS[1,1,1,1,1,2]), Form/H&E. OTHER MATERIAL. [unreg. host], QMG220118–220123 (CP), Kroombit Tops, in rainforest at headwaters of Kroombit Ck, Kroombit Tops SF (24°22.2'S 151°00.4'E), 30.01.1997, M. Mathieson & M. Schultz, Fau; [unreg. host], QMG220124–220129 (WM), Kroombit Ck tributary headwaters, Kroombit Tops SF (24°20'S 150°26'E), G.B. Monteith & S.R. Monteith., 70% alc(?)/Un; QMG220130–220132 (WM), 70% alc(?)/Hx; QMG220133–220138 (CP), 70% alc(?)/Fau.; QMG220139–220140 (LS[1,1]), 70% alc(?)/H&E; [QMW27493], QMG221196–221198 (CP), Kroombit Ck headwaters, Kroombit FR Kroombit Ck headwaters, Kroombit FR Qld 24°21.8'S 151°00.4'E, 18.02.2004, H.B. Hines & B. Manning, alc/Fau.

DESCRIPTION. Characteristics of genus but lacking body pigment. Eyes tiny. Selected body measurements of type specimens from *Euastacus*

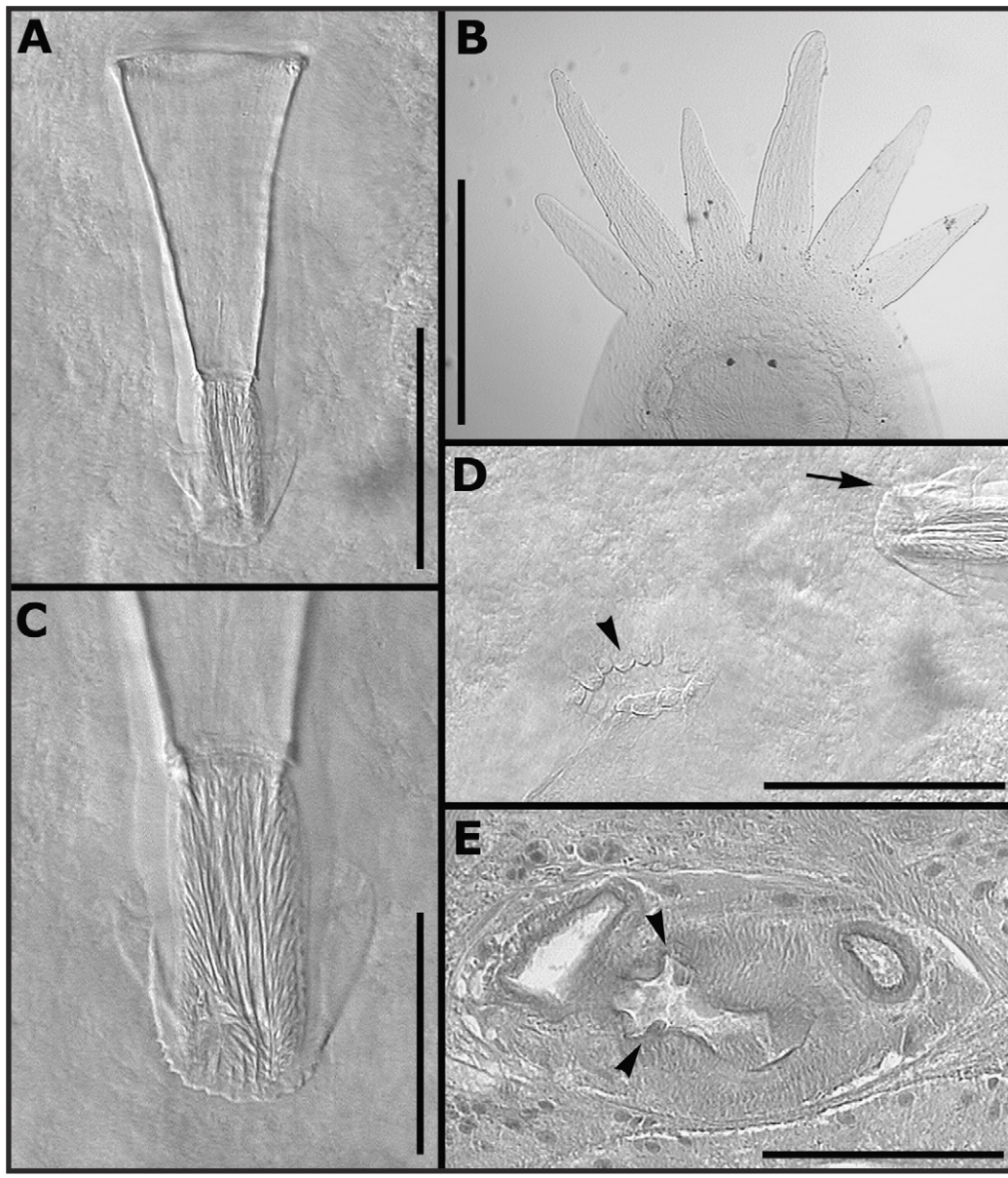


FIG. 7. *Temnohaswellia capricornia* sp. nov. A, C, D, Nomarski interference contrast photomicrographs of Faure's preparations. A, QMG220119, whole cirrus, scale = 100µm; B, QMG220098, anterior end of worm showing the lack of a concentration of body pigment around the eyes, scale = 500µm; C, QMG220119, introvert, scale = 50µm; D, introvert (arrow) and vagina showing teeth (arrowhead), scale = 100µm; E, QMG220116, longitudinal section through vagina showing teeth in the outer region of the distal vagina (arrowheads), scale = 100µm.

monteithorum are: QMG220098 (H): B(1545 × 756), LE(902), PH(244 × 366); SD(325), PD(167); QMG220099 (P): B(1530 × 816), LE(836), PH(214 × 255); SD(326), PD(163); QMG220101 (P): B(1693 × 959), LE(959), PH(306 × 428); SD(399), PD(163); QMG220102 (P): B(1122 × 857), LE(918), PH(194 × 367); SD(366), PD(211).

Reproductive system. Female. Vagina: Outer region with teeth (when folds sufficiently compressed [as in a concertina]), arranged in numerous (>10) columns and few (2?) rows.

Male. Cirrus: Shaft cone-shaped. Introvert cylinder-shaped; distal opening slightly oblique. Unspined distal region about length of introvert longer side. Swelling even, extending proximally well past introvert base about equally on both sides. Selected cirrus measurements of specimens from *Euastacus monteithorum* from type locality are: QMG220106: S(146 × 59), I(63 × 20), U(53), IS(49 × 49); QMG220107: S(138 × 69), I(49 × 19), U(49), IS(48 × 51); QMG220109: S(130 × 49), I(73 × 18), U(51), IS(51 × 41); QMG220110: S(140 × 51), I(59 × 20), U(61), IS(53 × 49); QMG220111: S(130 × 53), I(53 × 18), U(49), IS(41 × 41).

HOST. *Euastacus monteithorum*.

DISTRIBUTION. Mid-eastern Qld — from the Capricorn region, at Kroombit Tops SF.

REMARKS. This species appears morphologically close to *Temnohaswellia simulator* but can be discriminated on the basis of the cirrus and vagina. *Temnohaswellia capricornia* sp. nov. has fewer rows of teeth in the outer vagina, a cirrus with a longer unspined region, smaller eyes, and lacks a concentration of pigment around the eye region.

Temnohaswellia comes (Haswell, 1893) (Figs 8A–G, 9)

Temnocephala comes Haswell, 1893: 134, pl. 13, figs 15,16.

Temnohaswellia comes: Pereira & Cuocolo, 1941: 103; Joffe & Cannon, 1998: 3, figs 2, 3.

Temnohaswellia pugna Cannon, 1993: 30–31, figs 7, 11g.

ETYMOLOGY. Haswell (1893) provided no derivation of the name. Without doubt it is from the Latin *comes* = companion or associate, evidenced by the observation of Haswell (1924) that *Temnocephala comes* is 'an invariable companion' of *Temnocephala fasciata* [= *Temnosewellia fasciata*] on *Astacopsis serratus* [= *Euastacus* spp.].

MATERIAL. HOLOTYPE AMW388 (WM) from *Astacopsis serratus* [= *Euastacus* spp.], NSW, unknown fixation/U(?). OTHER MATERIAL. From *Astacopsis serratus* [= *Euastacus* spp.] VIC: [unreg. host], NMVF 93695–93697 (CP), Headwaters of Lederberger R., Blackwood (37°35'S 144°24'E), 15.10.1956, unknown fixation/Fau.

From *Euastacus armatus*? [juvenile]. NSW: [QMW26580] QMG219687–219688 (CP), Cudgegong R. at junction with Mill Ck, Wollemi NP (32°50.7'S 150°14.4'E), 20.10.1991, L.R.G. Cannon & K.B. Sewell, Form/Fau.

From *Euastacus australasiensis*. NSW: [QMW27492] QMG221202 (CP) Leura Falls Creek, at Leura Cascades, Blue Mts NP Leura Falls Ck, at Leura Cascades Picnic Area, Blue Mountains NP NSW (33°43.4'E 150°19.5'E) 8.01.2004, D. Blair & R.D. Sewell, alc/Fau.

From *Euastacus brachythorax*. NSW: [QMW26592], QMG219699 (WM), Rutherford Ck crossing on Niten Rd, Brown Mtnn, Glenbog SF (36°36.4'S 149°24.4'E), 13.10.1991, L.R.G. Cannon & K.B. Sewell, HW/Form/Hx; QMG219700–219705 (WM), HW/Form/Un; QMG219706–219707 (WM), HW/Form/Hx; QMG219708–219712 (CP), HW/Form/Fau; QMG219713 (LS[2]), Bouin/ H&E; QMG219714 (LS[2]), Form/H&E.

From *Euastacus clarkae*. NSW: [QMW26598], QMG219715 (WM), Cockerawombeeba Ck at Rimau Rd crossing, Werrikimbe NP (31°11.4'S 152°22.2'E), 23.10.1991, L.R.G. Cannon & K.B. Sewell, HW/Form/Hx; QMG219716 (WM), HW/Form/Un; [QMW26597], QMG219717–219720 (WM), 7.02.2002, K.B. Sewell & R.D. Sewell, 70% alc/Un; [QMW26598], QMG219721–219722 (WM), 23.10.1991, L.R.G. Cannon & K.B. Sewell, HW/Form/Un (WM); [QMW26597], QMG219723 (CP), 7.02.2002, K.B. Sewell & R.D. Sewell, 100% alc/Fau; QMG219724–219726 (CP), 70% alc/Fau; QMG219727–219731 (CP), Fau; [QMW26598], QMG219732–219733 (CP), 23.10.1991, L.R.G. Cannon & K.B. Sewell, HW/Form/Fau.

From *Euastacus dangadi*. NSW: [QMW26606], QMG219734–219735 (WM), Eungai Ck trib., at Cedar Crossing, Ngaamba NR, Ingalba SF (30°53.9'S 152°47.3'E), 4.10.1991, L.R.G. Cannon & K.B. Sewell, HW/Form/Hx; [QMW26605] QMG219736 (WM), 6.02.2002, K.B. Sewell & R.D. Sewell, Bouin/Un; [QMW26606], QMG219737 (WM), 4.10.1991, L.R.G. Cannon & K.B. Sewell, HW/Form/Hx; QMG219738 (WM), HW/Form/Un; QMG219739 (WM), HW/Form/Hx; [QMW26604], QMG219740–219741 (CP), 24.03.2002, K.B. Sewell, 100% alc/Fau; [QMW26606], QMG219742–219745 (CP), 4.10.1991, L.R.G. Cannon & K.B. Sewell, HW/Form/Fau; QMG219746–219747 (LS[3,1]), HW/Form/H&E.

From *Euastacus dharawalus*. NSW: [QMW26607], QMG219748 (WM), Wildes Meadow Ck crossing on Wildes Meadow Rd, Wildes Meadow (34°36.4'S 150°31.1'E), 13.02.2002, K.B. Sewell & R.D. Sewell, 70% alc/Un; QMG219749–219750 (WM), Bouin/Un; QMG219751–219754 (CP), 100% alc/Fau.

From *Euastacus gamilaroi*. NSW: [QMW26620], QMG219755 (WM), Burrows Ck, Sheeba Dams Recreation Reserve, near Hanging Rock (31°30.0'S 151°11.9'E), 22.10.1991, L.R.G. Cannon & K.B. Sewell, HW/Form/Hx; QMG219756 (WM), HW/

Form/Un; [QMW26621], QMG219757, 8.02.2002, Sewell K.B.& Sewell R.D., Fau.

From *Euastacus gumar*. NSW: [QMW26622], QMG219758–219762 (WM), Culmaron Ck, Richmond Ra. NP (28°50.5'S 152°44.1'E), 4.03.2002, K.B. Sewell, S.G. Sewell & J.A. Coughran, 100% alc/Bouin/Hx; QMG219763 (CP), 100% alc/Fau; QMG219764–771 (CP), Fau.

From *Euastacus guwinus*? (c.f. *dharawalus*). NSW: [QMW26623]; QMG219772–219777 (WM), Tianjarra Ck, above Tianjarra Falls, Morton NP (35°06.7'S 150°19.8'E) 16.02.2002, K.B. Sewell & R.D. Sewell, Bouin/Un; QMG219778–219782 (CP), Fau.

From *Euastacus hirsutus*. [unreg. host], QMG219799 (WM), Belmore Falls, in stream above falls (34°38.5'S 150°33.3'E CALC), 9.03.1939, Unknown collector, Hx; QMG220246 (LS [2]), unknown fixative/H&E; QMG221010 (LS [1]), unknown fixative/H&E.

From *Euastacus jagara*. Qld: [QMW6471], QMG219800–219802 (WM), Flaggy Ck, Mistake Mts, via Laidley (27°55'S 152°18'E), 2.02.1973 G.B. Monteith & S.R. Monteith., 70% alc/Hx; QMG219803–219804 (WM), 70% alc/Un.; QMG219805–219807 (CP), 70% alc/Fau; QMG219808 (LS[7]), 70% alc/H&E.

From *Euastacus maidae*. Qld: [QMW25590], QMG219809–219811 (WM), Tallebudgera Ck trib., Tallebudgera Valley (near '1000m mark on main track' (28°14.0'S 153°18.5'E) 22.04.2001 D.J. Cook, hot Bouin/Un; QMG219812 (CP), hot Bouin/Fau; [QMW26632], QMG219813 (CP), upper Tallebudgera Ck, at 'Fern Gully' (28°13.7'S 153°18.5'E) 22.04.2002, D.J. & L.V. Cook, L.RG. Cannon, K.B. & S.G. Sewell, 100% alc/Fau.; [QMW26631], QMG219814–219819 (WM), upper Currumbin Creek, upstream of old sawmill, 2km E of Mt Cougal (28°14.3'S 153°20.8'E), 11.01.1992, L.R.G. Cannon, K.B. Sewell & J.W. Short, HW/Form/Hx, QMG219820–219822 (LS[1,1,1]), Form/H&E; QMG219823–219829 (CP), HW/Fau/Hx.

From *Euastacus mirangudjin*. NSW: [QMW26633], QMG219830 (WM), Ironpot Ck, Toonumbar NP (28°36.4'S 152°42.1'E), 4.03.2002, K.B. Sewell, S.G. Sewell & J.A. Coughran, 100% alc/Un; QMG219831–219833 (CP), 100% alc/Fau.

From *Euastacus neohirsutus*. NSW: [QMW26637], QMG219834–219836 (WM), Little Nymboida R., junction of Lowamnna and Coramba Rds (30°14.0'S 152°55.3'E), 15.02.1992, K.B. Sewell & S.G. Sewell, HW/Form/Hx; [QMW26636], QMG219837–219841 (WM), 16.03.2002, K.B. Sewell, 100% alc/Un; [QMW26637], QMG219842 (WM), 15.02.1992, K.B. Sewell & S.G. Sewell, HW/Form/Hx; [QMW26636], QMG219843–219844 (CP),) 16.03.2002, K.B. Sewell, 100% alc/Fau; [QMW26638], QMG219845–219846 (CP), 5.02.2002 K.B. Sewell & R.D. Sewell; 100% alc/Fau; [QMW26637], QMG219847–219848 (CP), 15.02.1992, K.B. Sewell & S.G. Sewell; QMG219849 (LS[3]), Bouin/H&E; [QMW27494] QMG221201 (CP), 10.02.2004, D. Blair & R.D. Sewell, alc/Fau.

From *Euastacus polysetosus*. NSW: [QMW26641], QMG219850–219853 (WM), Dilgry R., at Dilgry River Picnic Area, Barrington Tops NP, (31°53.6'S 151°31.3'E), 21.10.1991, L.R.G. Cannon & K.B. Sewell, HW/Form/Hx; [QMW26640], QMG219854–219855 (WM), 9.02.2002, K.B. Sewell & R.D. Sewell, 100% alc/Un; [QMW26641], QMG219856–219858 (WM), HW/Form/Hx; QMG219859 (LS[4]), Form/H&E.

From *Euastacus setosus*. NSW: [QMW26648], QMG219875 (WM), Greenes Falls, at first creek junction downstream, Maiala NP, (27°19.4'S 152°45.8'E), 25.02.1991, L.R.G. Cannon & K.B. Sewell, HW/Form-Acetic/Hx; QMG219876–219877 (WM), HW/Form-Acetic/Un; QMG219878 (WM), HW/Form-Acetic/Hx; QMG219879–219880 (CP), HW/Form-Acetic/Fau; [QMW26649], QMG219881–219884 (CP), 1.10.2002, K.B. Sewell & S.G. Sewell, 100% alc/Fau.

From *Euastacus* sp. NSW: [QMW26581], QMG219675–219680 (WM), Cudgegong R. at junction with Mill Ck, Wollemi NP (32°50.7'S 150°14.4'E), 11.02.2002 K.B. Sewell & R.D. Sewell, 100% alc/Un; QMG219681 (CP), 100% alc/Fau; QMG219682–219686 (CP), Fau.

From *Euastacus spinichelatus*. NSW: [QMW26653], QMG219885–219888 (WM), Joyces Ck, Oxley Hwy crossing, 6km SE of Yarrowitch, Enfield SF (31°16.7'S 151°58.3'E), 23.10.1991, L.R.G. Cannon & K.B. Sewell, HW/Form/Hx; [QMW26652], QMG219889 (WM), 6.02.2002, K.B. Sewell & R.D. Sewell, hot Bouin/Un; QMG219890 (WM), 23.10.1991, L.R.G. Cannon & K.B. Sewell, HW/Form/Hx; QMG219891–219893 (WM), HW/Form/Un; [QMW26652], QMG219894–219896 (CP), 6.02.2002, K.B. Sewell & R.D. Sewell 100% alc/Fau; [QMW26653], QMG219897–219903 (CP), 23.10.1991, L.R.G. Cannon & K.B. Sewell, HW/Form/Fau; QMG219904 (LS[2]), Form/Hx; QMG219905 (LS[2]), Bouin/H&E.

From *Euastacus spinifer*. NSW: [QMW26585], QMG219689–219694 (WM), Jamieson Ck, 0.5 km above Wentworth Falls, beside Darwin's Walk, (33°43.6'S 150°22.5'E), 12.02.2002, K.B. Sewell & R.D. Sewell, 100% alc/Un; QMG219695 (CP), 100% alc/ Fau; QMG219696–219698 (CP), Fau; [QMW26642], QMG219860 (WM), Problem Ck crossing on Frying Pan Rd, trib. of Telegherry R., Chichester SF, 1km E of Telegherry FP (32°13.6'S 151°45.8'E), 10.02.2002, K.B. Sewell & R.D. Sewell, 70% alc/Un; QMG219861–219862 (WM), hot Bouin/Un; QMG219863–219864 (WM), 70% alc/Un; QMG219865 (WM) hot Bouin/Un; QMG219866 (WM) 70% alc/Un; QMG219867–219874 (CP), 100% alc/Fau; [QMW27490], QMG221203 (CP), 9.01.2004, D. Blair & R.D. Sewell, alc/Fau; [QMW26654], QMG219906–219910 (WM), Mammy Johnsons Ck, at road bridge near Nature Reserve just SE of Stroud Road township (32°21.1'S 151°56.1'E),

21.11.1996, K.B. Sewell & R.D. Adlard., Bouin/Hx; QMG219911–219913 (MP), QMG219914–219921 (CP), 100% alc/Fau; [QMW20765], Karuah R. at Washpool Bridge (32°19'S 151°57'S), 28.08.1995, J. & R. Powell; QMG219922 (WM) hot Bouin/Un; QMG219923 (CP), 70% alc/Fau.

From *Euastacus sulcatus*. Qld: [QMW18000 & QMW26656], QMG219929–219931 (WM), Mosses Well, Spicers Gap, Main Ra. NP (28°04.0'S 152°26.3'E), 25.11.1991, K.B. Sewell & C. Lee, HW/Form/Hx; QMG219932–219933 (WM), Bouin/Un; QMG219934 (WM), HW/Form/Hx; QMG219935 (WM) HW/70% alc/HX; QMG219936 (LS[2]), HW/70% alc/H&E; QMG219937–219938 (LS[1,1]), HW/Form/H&E; QMG219939 (CP), HW/70% alc/Fau; [unreg. host, ident. Dr John Short, QM], 1.09.1994, K.B. Sewell, QMG219940–219946 (CP), HW/deF. [unreg. host, ident. Dr John Short, QM], QMG219947–219948 (WM), Mt Huntley (spring beside walking track nr summit), Main Ra. NP (28°08.8'S 152°26.6'E), 30.01.1993, G.B. Monteith, HW/Bouin/Hx; QMG219949 (LS[1]), HW/Bouin/H&E. [QMW26658], QMG219950–219954 (WM), upper Tallebudgera Ck, at 'Fern Gully' (28°13.7'S 153°18.5'E), 22.04.2002, D.J. & L.V. Cook, L.RG. Cannon, K.B. & S.G. Sewell, 100% alc/Un; QMG219955–219956 (CP), 100% alc/Fau; [QMW26657] QMG219957 (WM), upper Tallebudgera Ck, at '1000m mark on main track' (28°14.0'S, 153°18.5'E), 22.04.2002, D.J. & L.V. Cook, L.RG. Cannon, K.B. & S.G. Sewell, 100% alc/Un; QMG219958 (CP), 100% alc/Fau. [QMW6462], Levers plateau via Rathdowney (28°20'S 152°52'E), 6.10.1973, S.R. Monteith, QMG219959–219960 (WM), 70% alc/Hx; QMG219961–219963 (LS[1,1,1]), 70% alc/H&E. NSW: [QMW26655], QMG219964–219966 (WM), Bundoozle Flora Reserve, Richmond Ra. NP (28°36.4'S 152°42.1'E), 4.3r.2002, K.B. Sewell, S.G. Sewell & J.A. Coughran, 100% alc/Un; QMG219967 (WM), 100% alc/Bouin/Un; QMG219968–219969 (CP), 100% alc/Fau; QMG219970–219972 (CP), Fau.

From *Euastacus suttoni*. Qld: [QMW26660], QMG219973–219974 (WM), beside rd to The Pyramids, Girraween NP (28°49.1'S 151°58.8'E), 18.04.1990, S. Cook, AFA/Hx; QMG219975–219979 (CP), HW/70% alc/Fau; QMG219980 (CP), Bouin/Fau; QMG220173, QMG219981 (LS[2,1]) Bouin/H&E; QMG219982, QMG212984 (LS[2,2]), Formal-Acetic/H&E; QMG219985 (LS[2]), Bouin/H&E. NSW: [QMW26661], QMG219986–219987 (WM), Washpool Ck, nr Thunderbolts Hideout, N of Tenterfield, (28°58.4'S 152°04.4'E), 19.12.2001, K.B., S.G., R.D. & M.R. Sewell, 70% alc/Un; [QMW26663], QMG219988–219990 (WM), 4.02.2002, K.B. Sewell & R.D. Sewell, 70% alc/Un; [QMW26661], QMG219991–219992 (WM), 19.12.2001, K.B., S.G., R.D. & M.R. Sewell, 70% alc/Un; [QMW26663], QMG219993 (WM), 70% alc/Un; QMG219994 (WM), 4.02.2002, K.B. Sewell & R.D. Sewell, hot Bouin/Un; [QMW26661], QMG219995–219996 (CP), 19.12.2001, K.B., S.G., R.D. & M.R. Sewell, 100% alc/Fau; QMG219997–220001 (CP), Fau; QMG220002–220003 (CP), 70% alc/Fau. [QMW6469], QMG220004–220005 (WM), Poverty Point, nr Tenterfield (29°08'S 152°20'E), 23.10.1973, S.R. Monteith, 70% alc(?)/Hx; QMG220006–220007 (LS [1,1]), 70% alc(?)/H&E; QMG220008–220011 (CP), 70% alc(?)/Fau. [QMW6468], QMG220012–220013 (WM), Gibralter Ra. NP (29°35'S 152°13'E), 19.12.1972, S.R. Monteith, 70% alc(?)/Hx; QMG220014 (CP), 70% alc(?)/Fau; QMG220015–220017 (LS[1,1,4]), 70% alc(?)/H&E. [QMW26662], QMG220018–220019 (WM), Glen Innes, Dec. 1976, I. Kneipp, 70% alc/Hx; QMG220020 (CP), 70% alc/Fau; QMG220021–220022 (LS[1,1]), 70% alc/H&E.

From *Euastacus valentulus*. Qld: [QMW26666], QMG220023–220025 (WM), D.J. Cook, 2.02.1990 Tallebudgera Valley (28°08'S 153°26'E), 2.02.1990, D.J. Cook, 70% alc/Hx; QMG220026–220067 (LS[1,2]), 70% alc/H&E; [QMW26668], QMG220028 (WM), Cougal Ck, in cleared paddock nr 'Twin Pools', upper Tallebudgera Valley (28°12.8'S 153°20.4'E), 22.04.2002, D.J. & L.V. Cook, L.RG. Cannon, K.B. & S.G. Sewell; QMG220029–220032 (CP), 100% alc/Fau; [QMW25589], QMG220033 (CP), 8.11.2000, D.J. Cook, Fau; [QMW26667], QMG220034–220039 (WM), upper Tallebudgera Ck, at 'Fern Gully' (28°13.7'S 153°18.5'E), 22.04.2002, D.J. & L.V. Cook, L.RG. Cannon, K.B. & S.G. Sewell, 100% alc/Un; QMG220040–220041 (CP), 100% alc/Fau. NSW: [QMW6459], QMG220042–220047 (WM), Rocky Ck rainforest, Whian Whian SF, (28°40'S 153°18'E), Jul. 1974, G.B. Monteith & S.R. Monteith., 70% alc/Un; QMG220048–220053 (CP), 70% alc/Fau.

From *Euastacus yanga*. NSW: [QMW26626], QMG219783–219785 (WM), Burrawang Ck at road crossing, 3km NW Belmore Falls, Morton NP, (34°37.1'S 150°32.5'E), 13.02.2002, K.B. Sewell & R.D. Sewell, 70% alc/Un; [QMW26627], QMG219786–219789 (WM),19.10.1991, L.R.G. Cannon & K.B. Sewell, HW/Form/Hx; [QMW26626], QMG219790 (WM), 13.02.2002, K.B. Sewell & R.D. Sewell, 70% alc/Un; QMG219791 (CP), 100% alc/Fau; QMG219792–219797 (CP), Fau; [QMW26627], QMG219798 (LS[3]), 19.10.1991, L.R.G. Cannon & K.B. Sewell, Form/H&E.

From *Caridina* sp. (*nilotica*?) (Crustacea; Decapoda; Atyidae). [Spurious record, see remarks below]. Qld: [unreg. host] QMGL 14579 (WM), ex, Aplin Weir, on Ross R., Townsville, Qld (19°22'S 146°44'E), L. Winsor, Form/Picrocarmine.

From *Hyridella (Hyridella) depressa* (Lamark, 1819). (Mollusca; Bivalvia; Unionoidea: Hyriidae) [spurious record, see remarks]. VIC: [unreg. host], NMVF 93698–93702 (CP), Forrest (38°31'S 143°43'E), 1948, A. Wilhelms, unknown fixation/Fau; NMVF 93704–93705 (LS[1,1,1]) unknown fixation/H&E(?).

DESCRIPTION. Characteristics of genus and essentially as described by Haswell (1893;

1924) in lacking body pigment, but occasionally with thin scatter of pigment between the eyes as figured by Cannon (1993: fig. 7a). Selected body measurements of type specimen from *Astacopsis serratus* [*Euastacus* spp.] are: AMW388 (TYPE): B(2142 × 1122), LE(1479), PH(285 × 472), SD(488), PD(244). Selected body measurements of specimens from *Euastacus spinifer* are: QMG219689: B(2142 × 1122), LE(1408), PH(388 × 408), SD(408), PD(204); QMG219690: B(2040 × 1081), LE(1428), PH(326 × 449), SD(469), PD(245); QMG219691: B(2101 × 1122), LE(1530), PH(408 × 490), SD(490), PD(286); QMG219692: B(1999 × 1020), LE(1346), PH(326 × 490), SD(449), PD(204); QMG219693: B(2081 × 1489), LE(1510), PH(347 × 530), SD(510), PD(286).

Reproductive system. *Female*. Vagina: Outer region weakly sclerotised, lacks teeth; vaginal cavity as figured by Haswell (1924: plate LVI, fig. 16), 'sac-like' with expanded (bulging) equatorial region, folded into obvious longitudinal and circumferential rows of small papillate crenulations, with pattern similar to knitted sock top.

Male. Cirrus: General form as figured by Haswell (1893: plate XIII, fig. 15). Shaft cone-shaped. Introvert essentially as figured by Haswell (1893: plate XIII, fig. 16), with sharply-narrowed introvert base, scoop-shaped; distal opening oblique. Small introvert spines appear optically in rows oriented diagonal to long axis of introvert (i.e. reminiscent of the surface topography of a pineapple as figured by Cannon (1993: fig 7b). Large spines (about 10 total [about 30–40 long]) positioned uniformly around and projecting distally from circumference of circular rim just distal to introvert base as figured by Cannon (1993: fig 7b). Unspined distal region about two thirds length of introvert longer side. Swelling very uneven, much larger on longer side, extending proximally well past introvert base on longer side and very short distance on the shorter side. Selected cirrus measurements of type specimen from *Astacopsis serratus* [*Euastacus* spp.] are: AMW388 (Type): S(309 × 122), I(114 × 26), U(71), IS(110 × 18).

Selected cirrus measurements of specimens from *Euastacus spinifer* are: QMG219695: S(389 × 114), I(130X 36), U(71), IS(127 × 18); QMG219696: S(232 × 77), I(106 × 26), U(77), IS(102 × 18); QMG219697: S(232 × 95), I(98 × 30), U(75), IS(128 × 14); QMG219698: S(217 × 93); I(108 × 30), U(65), IS(114 × 16).

Epidermal Mosaic. See generic diagnosis.

HOSTS. *Astacopsis serratus* (= *Euastacus* spp.], *Euastacus armatus*?, *E. brachythorax, E. clarkae, E. dangadi, E. dharawhalus, E. gamilaroi, E. gumar, E. guwinus*? (c.f. *dharawalus*?), *E. hirsutus, E. jagara, E. maidae, E. mirangudjin, E. neohirsutus, E. polysetosus, E. setosus,E.* sp., *E.* sp. nov.?, *E. spinichelatus, E. spinifer, E. sulcatus, E. suttoni, E. valentulus, E. yanga*.

DISTRIBUTION. Southern Qld to south-eastern VIC — widespread along the Great Dividing Ra..

REMARKS. The type specimen of *Temnohaswellia comes*, in conjunction with the species descriptions of Haswell (1893; 1924), allow us to confidently refer our specimens to the species. The description and figures of the female reproductive system by Haswell (1924) leaves little possibility of confusion with other species. Sections revealed the distal opening to the genital atrium to indeed be ringed by small papillae identifiable as the 'circlet of papillae' described and figured by Haswell (1924: page 512, plate LV, fig. 12; plate LVI, fig. 16) (Fig. 8F). These papillae are not easily seen in either whole mounted specimens or those cleared in Faure's medium. We were unable to find similar structures in any other species of *Temnohaswellia* examined in this study although we often had only limited sectioned material available. We cannot, therefore, exclude the possibility that similar papillae occur in other species.

Details of the cirrus are essentially as figured by Haswell (1893: plate XIII, figs 15 & 16) as can be seen from the Faure's preparations (Fig. 8A–C, E, G). The largest discrepancy with the original descriptions is that he (Haswell, 1893; 1924) did not mention the large spines that we observed invariably to be attached to the cirrus introvert base and which are definitely present in the type specimen (Fig. 8B). This oversight is surprising although Haswell (1893: plate XIII, fig. 6) did draw three longitudinal lines from the base of the introvert that are consistent with the position of these spines. The ejaculatory sac is present and as figured by Haswell (1893: plate XIII, fig. 15).

Temnohaswellia comes occurs on more host species than does any other member of the genus. The geographical distribution of the worm is extensive and overlaps most closely with that of *Temnohaswellia simulator*. The worm was observed to frequently co-occur with either *Temnohaswellia verruca* sp. nov. or *T. simulator,* and sometimes with *T. cornu* sp. nov., on the same host individual. The specimens selected for measurement and comparison, came from

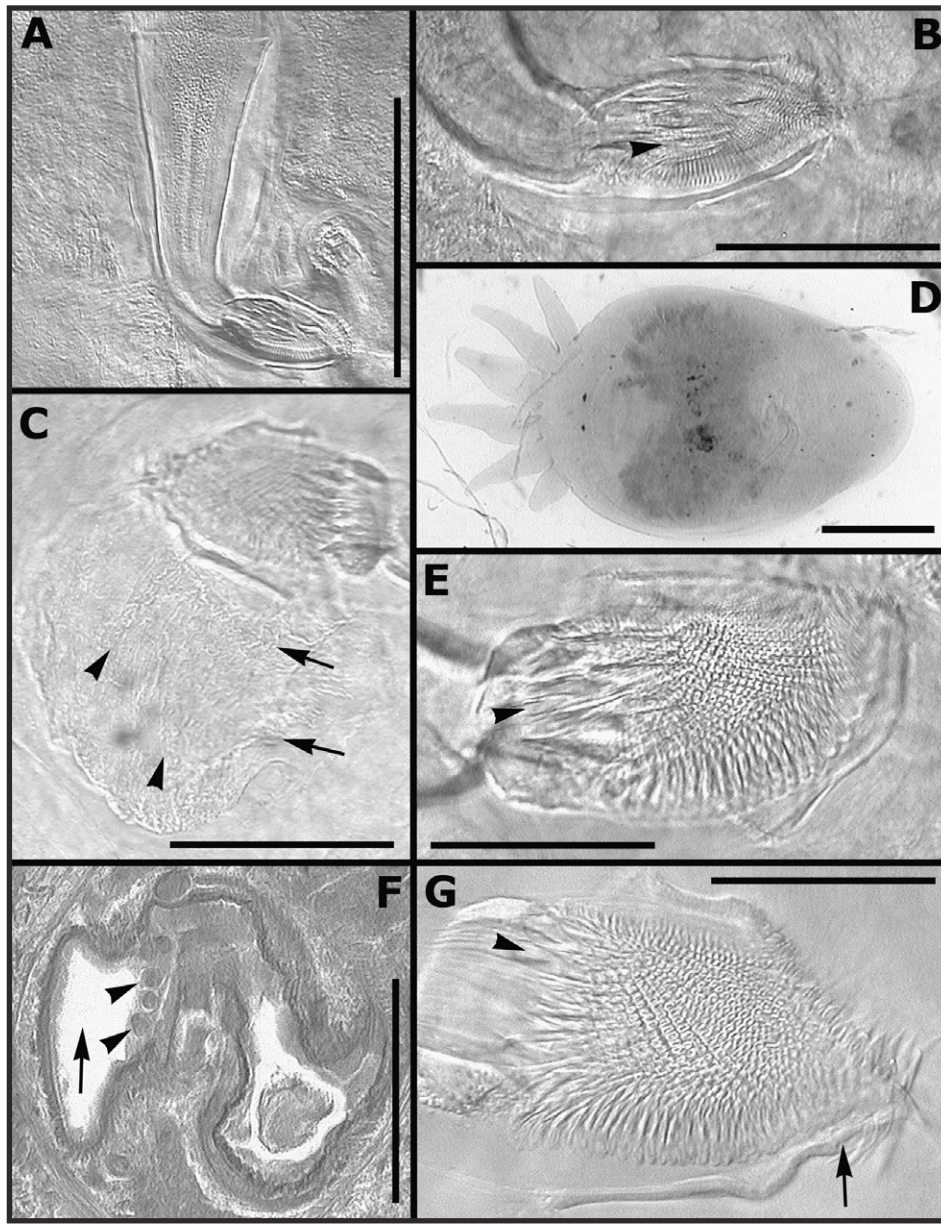


FIG. 8. *Temnohaswellia comes* A–C, E, G, Nomarski interference contrast photomicrographs of Faure's preparations. A, AMW388 (Holotype), whole cirrus (stitched image), scale = 250µm; B, AMW388, introvert showing large basal spines (arrowhead), scale = 100µm; C, QMG219695, specimen from Wentworth Falls, NSW, introvert and 'sac-like' vagina showing rows of longitudinal (arrows) circumferential (arrowheads) papillate crenulations, scale = 100µm; D, AMW388 (Type), Dorsal view of wholemount, scale = 500µm; E, QMG219958, introvert showing large basal spines (arrowhead), specimen from Tallebudgera Ck, Qld, scale = 50µm; F, QMG220173, longitudinal section through vagina showing putative 'circlet of papillae' (arrowheads) in the distal vagina at the opening to the genital atrium (arrow), specimen from Girraween NP, Qld, scale = 100µm; G.QMG219695, introvert showing large basal spines (arrowhead) and the junction of the unspined distal region (arrow) and the spiny introvert, scale = 50µm.

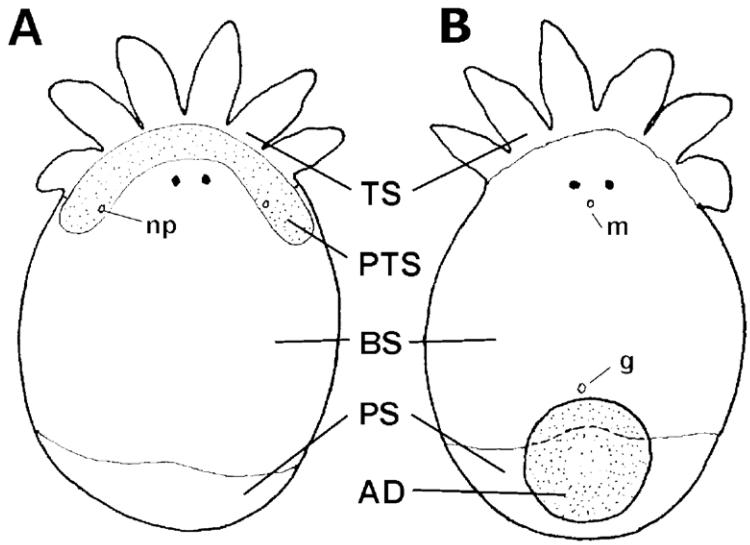


FIG 9. Mosaic of epidermal syncytia for *Temnohaswellia comes* from *Euastacus spinifer* [QMW26654] from the Karuah R., NSW in (A) dorsal view, (B) ventral view; AD, adhesive disc syncytium; BS, body syncytium; PS, peduncular syncytium; PTS, post-tentacular syncytium; TS, tentacular syncytium; g, gonopore; m, mouth; np, nephridiopore - derived from 3 specimens: QMG219911–219913.

a host, *Euastacus spinifer*, and a locality, Wentworth Falls, NSW near the middle of the known geographical range and from where we had good specimens.

The record from the freshwater, unionid bivalve, *Hyridella (Hyridella) depressa,* warrants discussion. Temnocephalans are associates of fresh water mollusc hosts in South America (see for example, Haswell, 1893; Damborenea & Cannon, 2001) but not in Australia. We believe, therefore, that it is very likely that the finding of temnocephalans with *Hyridella (Hyridella) depressa* is a consequence of placement of the mollusc and crayfish together in the same container during field collection and is thus an error. Temnocephalans are small, frequently unpigmented and readily detach from their hosts. The possibilty of cross contamination between 'hosts' must be carefully guarded against.

Cannon (1993) described *Temnohaswellia pugna* from a single holotype wholemounted specimen reputedly collected from the freshwater shrimp, *Caridina* sp. (*nilotica*?) at Townsville. After examination of the holotype of *Temnohaswellia pugna* and the type of *T. comes,* we now consider that the two species are one and the same based on the shape of the cirrus and the large basal spines on the introvert. We now also consider that the reported association of *Temnohaswellia pugna* with a shrimp host is an error in the light of the following evidence. Collection records kindly provided by L. Winsor for the batch of specimens that included *Temnohaswellia pugna*, also list temnocephalans from *Euastacus suttoni* [QMW26662], collected at Glen Innes, NSW, a host from which we have subsequently identified both *T. comes* and *T. simulator*. Our repeated attempts to obtain further specimens of this species (*Temnohaswellia pugna*) from extensive sampling of shrimps at the 'type locality' in Townsville have proven unsuccessful.

The epidermal mosaic of *Temnohaswellia comes* was revealed to be identical to that described and photographed from worms identified tentatively as *Temnohaswellia comes* by Joffe & Cannon (1998: fig. 2a, 3f). Now able to be confirmed as *Temnohaswellia comes*, these worms were obtained from *Euastacus sulcatus* collected on 1.09.1994, by K.B. Sewell at Spicers Gap, Main Ra. NP, Qld (28°04.0'S 152°26.3'E). The host was identified by Dr John Short, QM.

Temnohaswellia cornu sp. nov.
(Fig. 10A–D)

ETYMOLOGY. From *cornu* = horn (Latin, neuter) — a reference to the oxen horn-shaped cirrus.

MATERIAL. HOLOTYPE: QMG220314 (WM), from *Euastacus jagara* [QMW6471], Flaggy Ck, Mistake Mts, via Laidley, Qld, (27°55'S 152°18'E), 2.02.1973, G.B. Monteith & S.R. Monteith., 70% alc/Un. PARATYPES: QMG220315–220316 (WM) ,70% alc/Un; QMG220317–220318 (WM), 70% alc/Hx. OTHER MATERIAL FROM TYPE LOCALITY: QMG220319–220320 (WM), 70% alc/Hx; QMG220321–220322 (WM), 70% alc/Un; QMG220323–220329 (CP), 70% alc/Fau; QMG220330–220332 (LS[1,1,1]), 70% alc/H&E.

DESCRIPTION. Characteristics of genus but lacking body pigment. Selected body measurements of type specimens from *Euastacus jagara* are: QMG220314 (H): B(1016 × 585), LE(732), PH (195 × 240), SD(301), PD(130); QMG220315 (P): B(1398 × 732), LE(972), PH (268 × 301), SD(341), PD(187); QMG220316 (P): B(1398 × 837), LE(1000), PH (276 × 325), SD(390), PD(195); QMG220317 (P): B(1382 × 740), LE(919), PH (260 × 333), SD(301), PD(228); QMG220318 (P): B(1398 × 829), LE(1114), PH (325 × 333), SD(415), PD(228).

Reproductive system. *Female*. Vagina: Outer region weakly sclerotised, lacking teeth.

Male. Cirrus: Shaft cone-shaped. Introvert cylinder to scoop-shaped; distal opening not obviously oblique. Unspined distal region short, about one third length of introvert longer side. Swelling even, extending proximally moderate distance past introvert base on both sides, slightly farther on longer side. Selected cirrus measurements of specimens from *Euastacus jagara* from type locality are: QMG220323: S(126 × 75), I(51 × 24), U(18), IS(16 x 16); QMG220324: S(106 × 55), I(55 × 24), U(18); IS(12 X8); QMG220328: S(134 × 73), I(57 × 24), U(22), IS(24 X20); QMG220329: S(128 × 57), I(57 × 24), U(20), IS(24 X20).

HOST. *Euastacus jagara*.

DISTRIBUTION. South-eastern Qld — at Flaggy Ck, Mt Mistake, Main Ra. NP.

REMARKS. This worm resembles *Temnohaswellia simulator* in the shape and dimensions of the cirrus, however it lacks the distinctive vaginal teeth of *T. simulator*. Moreover, it lacks the concentration of pigment in the eye region. The distal vagina is thickly muscled compared to most Australian species and the cavity is frequently near-spherical.

Temnohaswellia crotalum sp. nov.
(Fig. 11A–E)

ETYMOLOGY. From *krotalon* = rattle (Greek, neuter); a reference to the prominent folds of the sclerotised inner lining of the distal region vagina reminiscent of the rattle of a rattle-snake.

MATERIAL. HOLOTYPE: QMG220208 (WM), from *Euastacus kershawi* [QMW26630], Labertouche Ck (Tarago R. trib.), on Old Telegraph Rd, W of Jindivick, VIC (38°03.2'S 145°50.1'E), 21.03.2002, K.B. Sewell, S.H. Lawler & G.N. Edney, 100% alc/Un. PARATYPES: QMG220209–220212 (WM), 100% alc/Un. OTHER MATERIAL FROM TYPE LOCALITY: QMG220213 (WM), 100% alc/Un; QMG220214–220217 (CP), 100% alc/ Fau. OTHER MATERIAL. From *Euastacus bispinosus*. VIC: [QMW26591], QMG220218 (WM), Jimmys Ck, at picnic ground 6.5 km WNW Mafeking (37°23'S 142°34'E), 5.10.1991, L.R.G. Cannon & K.B. Sewell, HW/Form/Hx; QMG220219–220220 (WM), HW/Form/Un; QMG220221 (CP), HW/Form/Fau.

From *Euastacus neodiversus*. VIC: [QMW26354], QMG220222–220228 (WM), Tarra R., 50 m above Tarra Falls, Tarra Valley NP (38°29'S 146°36'E) 10.10.1991, L.R.G. Cannon & K.B. Sewell, HW/Form/Hx; QMG220229–220234 (CP), HW/Form/Fau; QMG220235–220236 (LS[2,1]), Form/H&E; QMG220237–220238 (LS[3,4]), Bouin/H&E.

From *Euastacus woiwuru*. VIC: [QMW26669], QMG220239–220241 (WM), Dobsons Ck at crossing Alpine Rd nr junction with Mountain HigHwy, Ferntree Gully SF, Dandenongs (37°52.3'S 145°20'E), 22.03.2002, K.B. Sewell, 100% alc/Un; QMG220242–220244 (CP), 100% alc/Fau; [QMW26668], QMG220245 (LS[3]), 7.10.1991, L.R.G. Cannon & K.B. Sewell, Form/H&E.

From *Euastacus yarraensis*. VIC: [NMV J 6156], NMVF 93722 (CP), Bunyip River, top of road from Princes HigHwy (37°55'S 145°43'E), 18.02.1977, P.S. Lake, 70% alc(?)/Fau; [QMW26673], QMG220247–220248 (WM), Labertouche Ck (Tarago R. trib.), on Old Telegraph Rd, W of Jindivick (38°03.2'S 145°50.1'E), 8.10.1991, L.R.G. Cannon & K.B. Sewell, HW/Form/Hx; QMG220249–220250 (LS[1]), Bouin/H&E; [unreg. host], QMG 221204 (CP), Love Ck, at picnic ground, Kawarren, Otways (38°28.8'E 143°35.0'E), 1.01.2004, D. Blair, R.D. Sewell, S.H. Lawler & G.N. Edney, alc/Fau.

From 'fresh water cray' VIC: [unreg. host], NMVF 93706–93708, (WM), Fern Tree Gully (37°53'S 145°18'E), 18.02.1872, unknown fixation/Carmine(?); NMVF 93709–93718 (CP), unknown fixation/Fau;

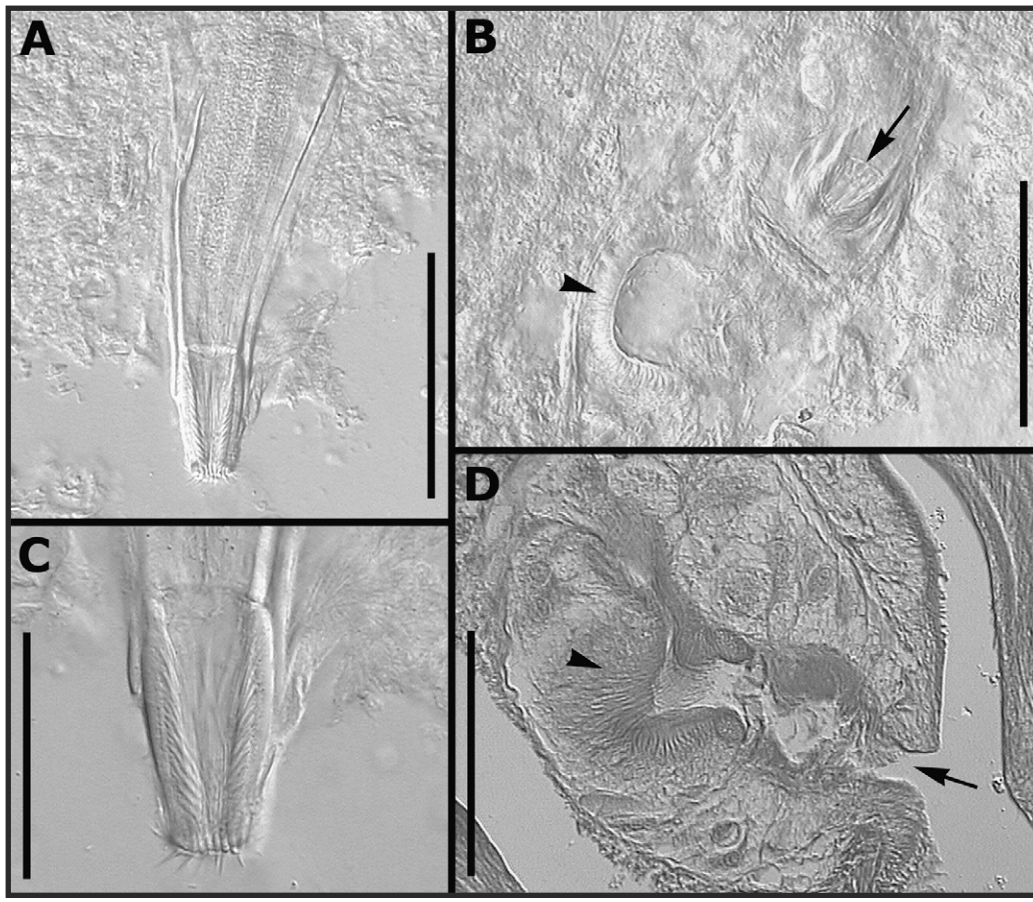


FIG. 10. *Temnohaswellia cornu* sp. nov. A–C, Nomarski interference contrast photomicrographs of Faure's preparations. A, QMG220323, whole cirrus, scale = 100µm; B, QMG220326, introvert (arrow) and vagina showing strong musculature in the distal region (arrowhead), scale = 100µm; C, QMG220323, introvert, scale = 50µm; D, QMG220326, longitudinal section through vagina showing strong musculature of the the distal vagina (arrowhead) and common gonopore (arrow), scale = 100µm.

NMVF 93719–93721 (LS[1,1,2]), unknown fixation/H&E(?).

DESCRIPTION. Sometimes large worm showing characteristics of genus but lacking body pigment except for occasionally a thinly scattered pigment between the eyes. Selected body measurements of type specimens from *Euastacus kershawi* are: QMG220208 (H): B(2978 × 2020), LE(2224), PH(714 × 877), SD(654), PD(428); QMG220209 (P): B(3162 × 2224), LE(2836), PH(796 × 775), SD(734), PD(510); QMG220210 (P): B(3121 × 1408), LE(2428), PH(694 × 816), SD(612), PD(367); QMG220211 (P): B(2917 × 1469), LE(2346), PH(653 × 796), SD(653), PD(388); QMG220212 (P): B(2754 × 1367), LE(1999), PH(571 × 571), SD(592), PD(306).

Reproductive system. Female. Vagina: Outer region tapers rapidly proximally, with block-like teeth increasingly larger proximally arranged in very obvious columns (8?) and rows (8?).

Male. Cirrus: Shaft cone-shaped. Introvert scoop-shaped; distal opening oblique. Unspined distal region about two thirds length of introvert longer side. Swelling uneven, extending proximally well past introvert base on both sides, considerably farther on longer side. Selected cirrus measurements of specimens from *Euastacus kershawi* from type locality are: QMG220214: S(209 × 108), I(94 × 26), U(61), IS(118 × 28);

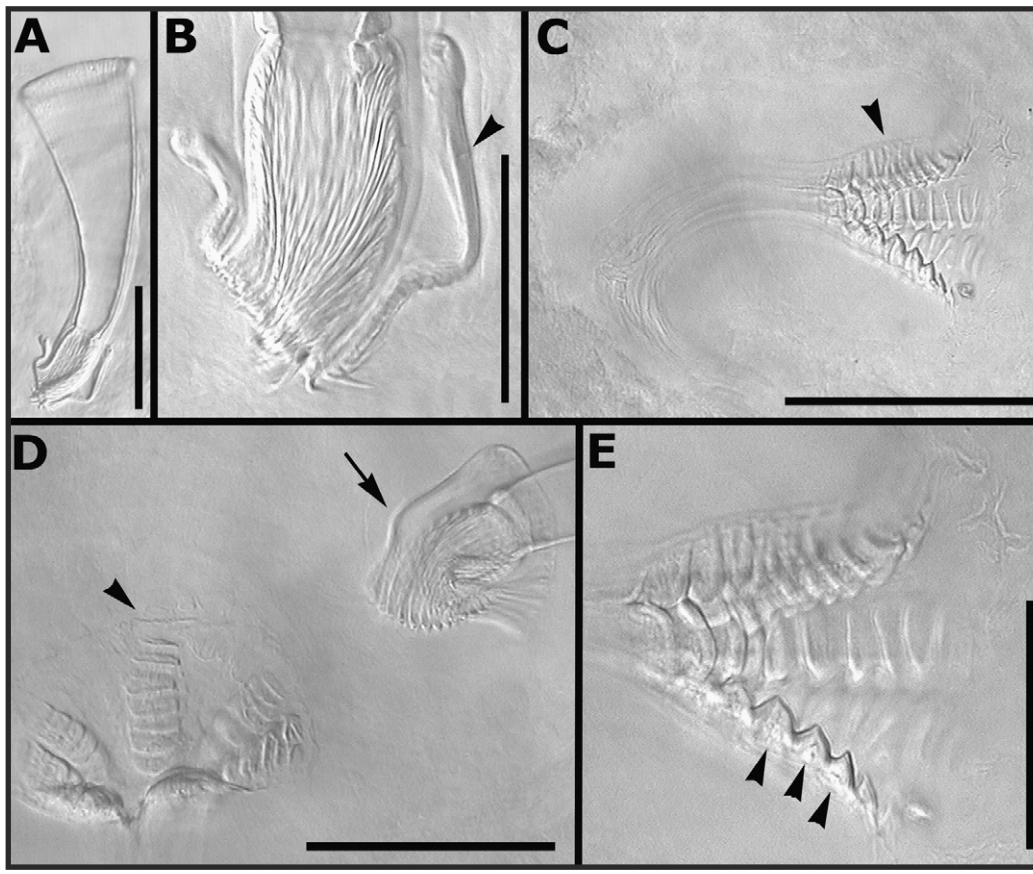


FIG. 11. *Temnohaswellia crotalum* sp. nov. A–E, Nomarski interference contrast photomicrographs of Faure's preparations. A, QMG220215, whole cirrus, scale = 100µm; B, QMG220215, introvert showing unspined distal region (arrowhead), scale = 50µm; C, QMG220215, vagina showing musculature and distinctive block-like teeth in the distal region arranged in columns and rows (arrowhead), scale = 100µm; D, QMG220217, introvert (arrow) and vagina showing distinct vaginal teeth (arrowhead), scale = 100µm; E, QMG220215, vagina showing distinctive block-like teeth arranged in the distal region arranged in rows (arrowheads), scale = 50µm.

QMG220215: S(224 × 96), I(100 × 24), U(69), IS(144 × 65); QMG220216: S(230 × 116), I(94 × 30), U(65), IS(118 × 14); QMG220217: S(242 × 110), I(96 × 28), U(61), IS(112 × 51).

HOSTS. *Euastacus bispinosus, E. kershawi, E. neodiversus, E. woiwuru, E. yarraensis*.

DISTRIBUTION. Southern VIC — from Tarra Vally NP at Tarra Falls; W of Jindivick at Labertouche Ck; Dandenongs Ra. at Fern Tree Gully; near Bunyip, at Bunyip R. South-western VIC — from Grampians NP at Jimmys Ck.

REMARKS. The distinctive shape and arrangement of the distal vagina serve to clearly distinguish this species, and make it one of the easiest to identify when the teeth are present and clearly seen. Young worms with undeveloped vaginal teeth, or females viewed with the vagina in a position where the vaginal teeth are not seen, can be misidentified as *Temnohaswellia verruca* sp. nov. Despite the distinctive vaginal teeth of adult worms, the cirrus does not appear to have large spines that would relate directly to these structures. We have not, however, observed the spines with the cirrus everted.

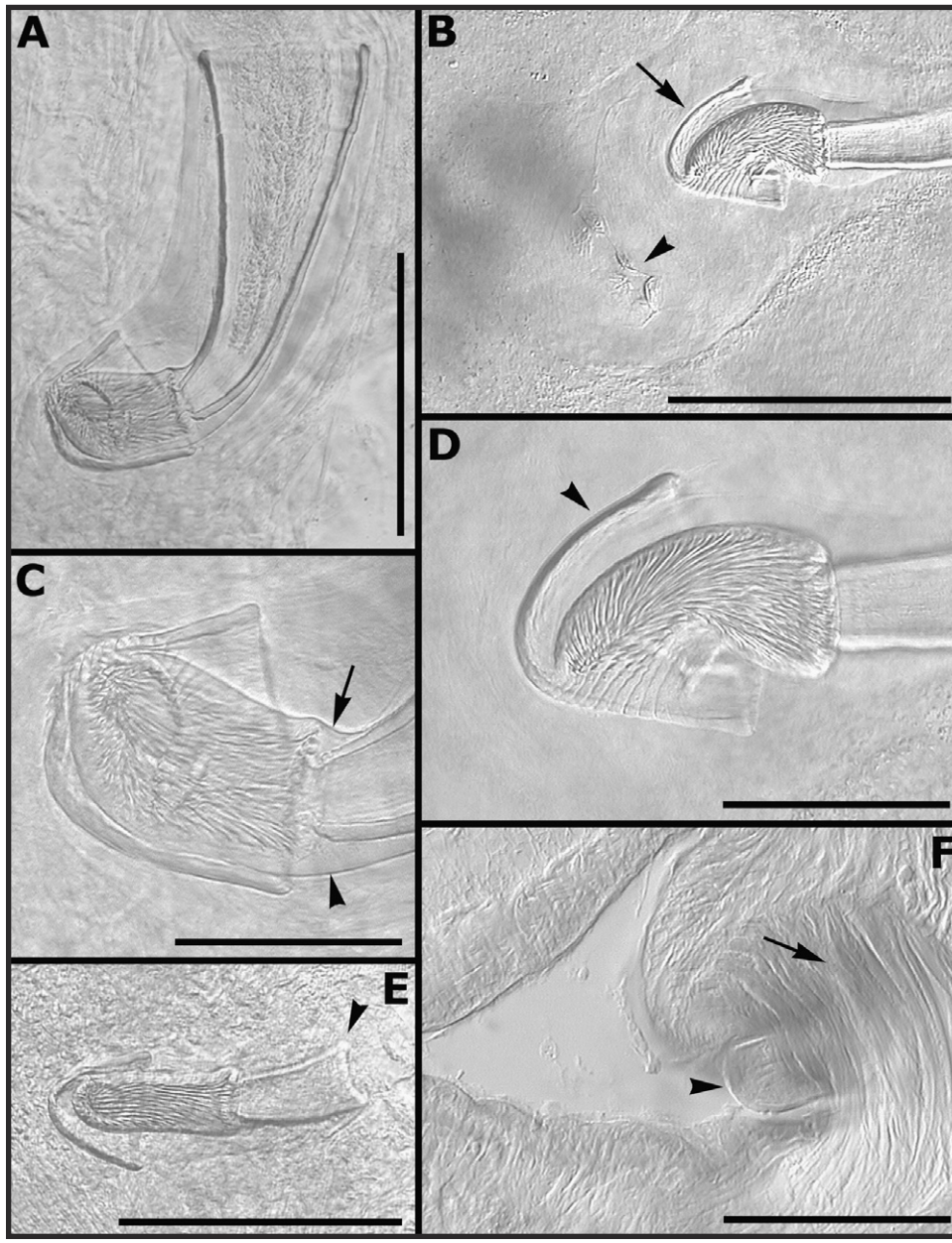


FIG. 12. *Temnohaswellia munifica* sp. nov. A–E, Nomarski interference contrast photomicrographs of Faure's preparations. A, QMG220254, whole cirrus, scale = 250µm; B, QMG220260, introvert (arrow) and vagina showing large teeth (arrowhead) in the outer region of the distal vagina, scale = 250µm; C, QMG220254, introvert showing uneven swelling extending well past the introvert base on the longer side (arrowhead) and just past the introvert base on the shorter side (arrow), scale = 100µm; D, QMG220260, introvert showing unspined distal region (arrowhead) that appears like a semicircular cap, scale = 100µm; E, QMG220255, introvert of young specimen showing short shaft with a narrow proximal opening (arrowhead), scale = 250µm; F, QMG220257, vagina longitudinal section showing large tooth structure (arrowhead) and strong proximal muscular sphincter (arrow), scale = 50µm.

Temnohaswellia munifica sp. nov.
(Fig. 12A–F)

ETYMOLOGY. From *munifica* = noble (Latin); a reference to the noble cirrus.

MATERIAL. HOLOTYPE: QMG220251 (WM), from *Euastacus hystricosus* [unreg. host], Booloumba Ck, 'beauty spot 100', Conondale Ra. (26°39'S 152°39'E), 18.06.1986, Unknown collector, 70% alc(?)/Un. PARATYPES: QMG220252–220253 (WM), 70% alc(?)/Un. OTHER MATERIAL FROM TYPE LOCALITY: QMG220254 (CP), 70% alc(?)/Fau. [QMW6461], QMG220255–220256 (CP), Booloumba Ck, Conondale Ra. (26°39.0'S 152°38.7'E), 29.11.1974, G.B. Monteith & S.R. Monteith, 70% alc/Fau. OTHER MATERIAL. From *Euastacus hystricosus*. Qld: [unreg. host], QMG220259 (WM); Little Yabba Ck, Conondale SF, 17.11.1983, L.R.G. Cannon & J.B. Jennings, Form-Acetic/Hx; QMG220257–220258 (LS[10, 4]), Form-Acetic/H&E; [unreg. host, ident. Dr Mark Ponniah, Griffith University], QMG220260 (CP), Stony Ck, Stony Ck SF (26°51.7'S 152°44.0'E), 100% alc/Fau.

DESCRIPTION. Large worm lacking body pigment. Selected body measurements of type specimens from *Euastacus hystricosus* are: QMG220251 (H): B(3835 × 2020), LE(2958), SD(836), PD(490), PH(1081 × 898); QMG220252 (P): B(4223 × 2224), LE(3672), SD(1020), PD(775), PH(1530 × 1306); QMG220253 (P): B(3060 × 2081), LE(2856), SD (673), PD(428), PH(1530 × 959).

Reproductive system. Female. Vagina: Outer region with large triangular teeth, increasingly and rapidly smaller proximally, arranged in columns (6?) and rows (4?).

Male. Cirrus: Shaft cone-shaped. Introvert scoop-shaped with sharply narrowed introvert base; distal opening very oblique. Unspined distal region slightly less than length of introvert longer side. Swelling uneven to very uneven, extending proximally well past introvert base on longer side and shorter distance past introvert base on shorter side. Selected cirrus of specimens from *Euastacus hystricosus* from type locality are: QMG220254: S(380 × 150), I(163 × 37), U(132), IS(106 x 30); QMG220255 [juvenile]: S(122 × 57), I(144 × 35), U(136), IS(na x na); QMG220256 [juvenile]: S(37 × 57), I(170 × 39), U(130), IS(na x na).

Selected cirrus measurements of specimens from other *Euastacus hystricosus* are: QMG220260: S(217 × 41); I(153 × 41), U(132), IS(>55 x 71).

HOST. *Euastacus hystricosus*.

DISTRIBUTION. South-eastern Qld — from the Conondale Ra. region: Conondale SF & NP, at Booloumbah Ck; and Stony Ck SF, at Stony Ck.

REMARKS. This species reaches a large size and has a large and robust cirrus. The unspined distal region has very thick walls and in some cirrus preparations appears like a semicircular cap covering the spined region of the introvert.

Temnohaswellia pearsoni sp. nov.
(Fig. 13A–E)

ETYMOLOGY. For Steve Pearson who as head ranger at Eungella NP in 1990 assisted LRGC and KBS to locate and collect the host from which the first specimen was recognised.

MATERIAL. HOLOTYPE: QMG220279 (WM), from *Euastacus eungella* [QMW26610], Cattle Ck trib., 1.5 km SE Mt William, Eungella NP, Qld (21°01.8'S, 148°36.2'E), 22.09.1990, L.R.G. Cannon & K.B. Sewell, Form/Un. PARATYPES: QMG220280–220281 (WM), Form/Un; QMG220282–220283 (WM), HW/Form-Acetic/Hx. OTHER MATERIAL FROM TYPE LOCALITY: QMG220284–220285 (WM), Carn/Hx; QMG220286–220287 (WM), HW/Form-Acetic/Hx; QMG220288–220289 (WM)., Form/Un; QMG220290–220294 (CP), Form/Fau; [QMW26609], QMG220295–220296 (CP), 8.09.2002, D. Blair & D. Hansman, 100% alc/Fau.

DESCRIPTION. Characteristics of genus but lacking body pigment and (apparently) eyes. Selected body measurements of type specimens from *Euastacus eungella* are: QMG220279 (H): B(1894 × 740), LE(na), PH (260 × 455), SD(301), PD(130); QMG220280 (P): B(1897 × 755), LE(na), PH (306 × 449), SD(326), PD(143); QMG220281 (P): B(1897 × 918), LE(na), PH (326 × 530), SD(367), PD(184); QMG220282 (P): B(1350 × 545), LE(na), PH (195 × 268), SD(236), PD(130); QMG220283 (P): B(1795 × 959), LE(na), PH (306 × 510), SD(347), PD(224).

Reproductive system. Female. Vagina: Outer region with rounded teeth arranged in columns (6?) and rows (6?).

Male. Cirrus: Shaft cone-shaped. Introvert cylinder-shaped; distal opening transverse. Unspined distal region about as long as introvert longer side. Swelling even, extending proximally just past introvert base on both sides. Selected cirrus measurements of specimens from *Euastacus eungella* from type locality are: QMG220290: S(161 × 47), I(55 × 16), U(43), IS(na × na);

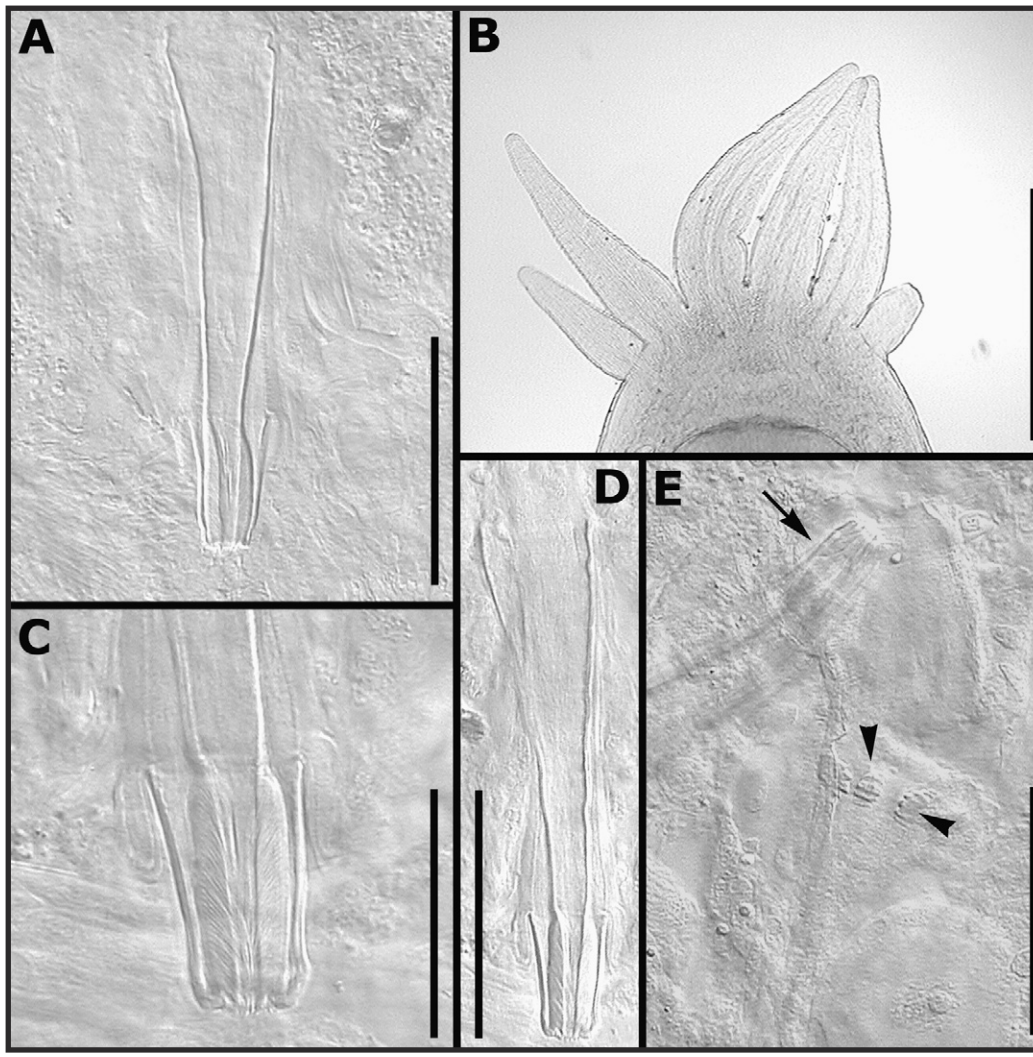


FIG. 13. *Temnohaswellia pearsoni* sp. nov. A, C–E, Nomarski interference contrast photomicrographs of Faure's preparations. A, QMG220292, whole cirrus (stitched image), scale = 100µm; B, QMG220280, anterior end of wholemounted specimen showing the absence of eyes, scale = 500µm; C, QMG220291, introvert, scale = 50µm; D, QMG220290, whole cirrus, scale = 100µm; E, QMG220291, introvert (arrow) and vagina showing rounded teeth (arrowheads) in the outer region of the distal vagina, scale = 100µm.

QMG220291: S(152 × 47), I(49 × 15), U(47), IS(na × na); QMG220292: S(159 × 45), I(50 × 16), U(51), IS(14 × 10); QMG220295: S(165 × 35), I(46 × 14), U(39), IS(6 × 6); QMG220296: S(171 × 47), I(42 × 16), U(43), IS(8 × 5).

HOST. *Euastacus eungella*.

DISTRIBUTION. Mid-eastern Qld — from Eungella NP, SE Mt William, at upper Cattle Ck.

REMARKS. This species apparently lacks eyes, a character which separates it from all other known species of *Temnohaswellia*. Cannon & Sewell (2001) reported that occassional eyeless specimens of temnocephalans are encountered as a result of teratology. In this study, however, covering a large number of specimens and a wide range of hosts collected over broad spectrum of dates, we saw no obvious teratologies. Nevertheless, it is pertinent to note that in the

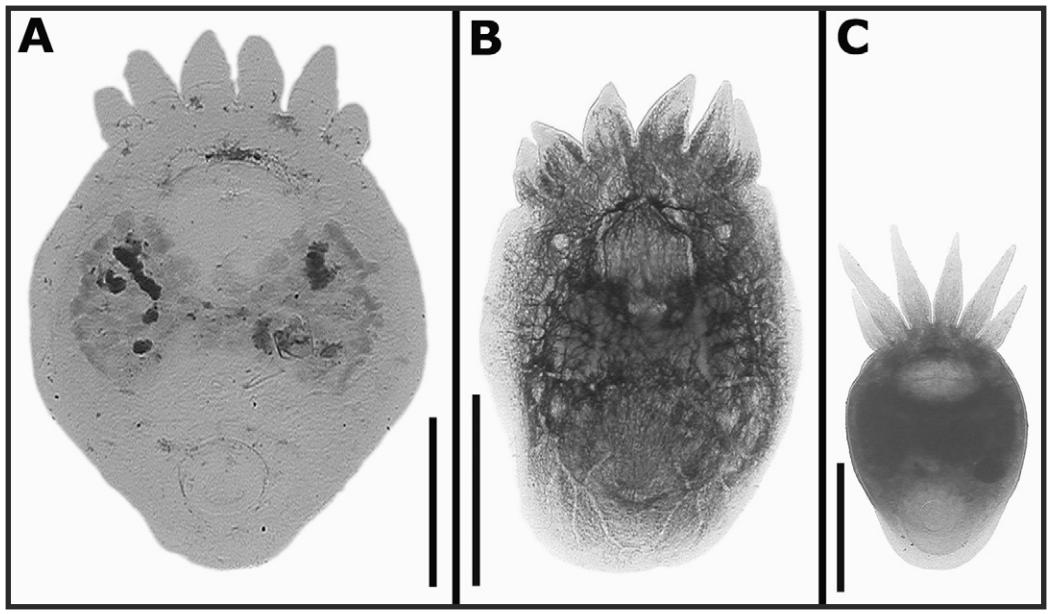


FIG. 14. *Temnohaswellia simulator.* A-C. Photomicrographs of whole specimens showing pigment variation between localities; A, QMG220067, Faures preparation of specimen (slightly compressed) from the locality showing no body pigment except that concentrated near eyes, scale = 1mm; B, QMG220199, wholemounted specimen from Whian Whian SF, NSW showing the dense tracery of body pigment through most of the dorsal body, scale = 1mm; C, QMG220075, small wholemounted specimen from Wollemi NP, NSW showing the dense tracery of body pigment through most of the dorsal body, scale = 500µm.

case of *Temnohaswellia pearsoni* sp. nov. only a single locality was sampled. It is worth noting too that *Temnohaswellia capricornia* sp. nov. from Kroombit Tops has very tiny eyes. These are the two most northerly species recorded in the genus.

All of the Australian temnocephalan species described previously known to either lack, or to have extremely small, eyes are, not surprisingly, from deep burrowing hosts that are presumed to rarely emerge during daylight (Haswell, 1893, 1900; Williams, 1980; Cannon & Sewell, 2001).

Damborenea & Cannon (2001) observed that the red pigment eyes of *Temnocephala* spp. from South America disappeared soon after placement in alcohol-based fixative. We can not exclude this phenomenon for *Temnohaswellia pearsoni* sp. nov., as live specimens were not examined for the presence of eyes.

The introvert is also distinctive, being armed with small, fine spines.

Temnohaswellia simulator (Haswell, 1924) (Figs 14A–C, 15A–G)

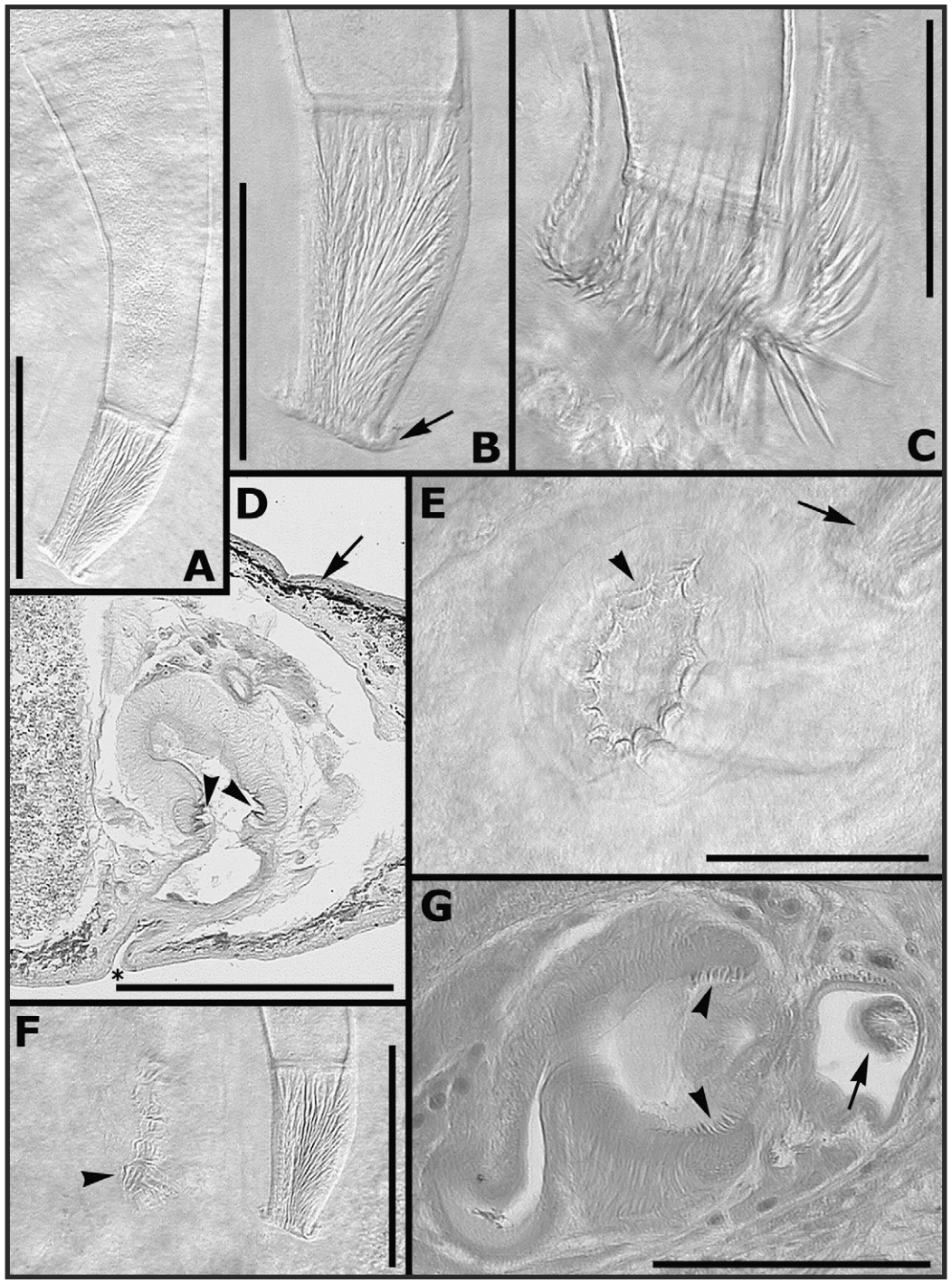
Temnocephala simulator Haswell, 1924: 512–513, pl. 55 fig 12, pl. 56 fig. 16

Temnohaswellia simulator Pereira & Cuocolo, 1941: 103.

Temnohaswellia tetrica Cannon, 1993: 31–33, fig. 8.

ETYMOLOGY. Haswell (1924) provided no derivation of the name. There can be little doubt that

FIG. 15. (opposite page) *Temnohaswellia simulator.* A-C, E-F, Nomarski interference contrast photomicrographs of Faure's preparations. A, QMG220072, whole cirrus, scale = 100µm; B, QMG220072, introvert with short unspined distal region (arrow), scale = 50µm; C, QMG220071, introvert partly everted showing spines, scale = 50µm; D, QMG220194, longitudinal section through vagina showing teeth in the outer region of the distal vagina (arrowheads); dense pigment in the dorsal body (arrow); and the common gonopore (*), scale = 250µm; E, QMG220064, introvert (arrow) and vagina with teeth (arrowhead) in the outer region of the distal vagina showing the in a 'spider web' pattern, scale = 100µm; F, QMG220072, introvert and vagina with teeth (arrowhead) in the outer region of the distal vagina, scale = 50µm; G, QMG220174, longitudinal section showing teeth in the outer region of the distal vagina (arrowheads) and the distal region of the introvert (arrow), scale = 50µm.


A
B
C
D
E
F
G
*

it is from *simulator* = mimic (Latin); a reference to the similarity between *Temnohaswellia simulator* and *T. comes*. Haswell (1924) noted that both worms have six tentacles, and he stated that the entire reproductive system of *Temnohaswellia simulator* 'closely resembles' that of *T. comes*.

MATERIAL. NEOTYPE: From *Euastacus neohirsutus* [QMW26650], QMG220056 (WM), Middle Ck trib., beside road 6 km upstream from Corritts Water (30°21.4'S 152°29.1'E), 6.02.2002, K.B. Sewell & R.D. Sewell, hot Bouin/Un. OTHER MATERIAL FROM TYPE LOCALITY: [QMW26650], QMG220057–220058 (WM), hot Bouin/Un; [QMW26651], QMG220059–220060 (WM), 15.02.1992, K.B. Sewell & S.G. Sewell, HW/Form/Hx; [QMW26650], QMG220061–220061 (WM), 6.02.2002, K.B. Sewell & R.D. Sewell, hot Bouin/Un; [QMW26651], QMG220063 (WM), 15.02.1992, K.B. Sewell & S.G. Sewell, HW/Form/Hx; [QMW26650], QMG220064 (CP), 6.02.2002, K.B. Sewell & R.D. Sewell, 100% alc/Fau; QMG220065–220071 (CP), Fau; [QMW26651], QMG220072 (CP) 15.02.1992, K.B. Sewell & S.G. Sewell; QMG220073–220074 (LS[3,2]), Bouin/H&E. OTHER MATERIAL. From *Euastacus armatus*? [juvenile]. NSW: [QMW26580], QMG220075–220078 (WM), Cudgegong R. at junction with Mill Ck, Wollemi NP (32°50.7'S 150°14.4'E), 20.10.1991, L.R.G. Cannon & K.B. Sewell Form/MB/Hx; QMG220079 (CP), Form/Fau; QMG220080 (LS[2]), Form/H&E.

From *Euastacus dangadi*. NSW: [QMW26605], QMG220081–220083 (WM), Eungai Ck trib., at Cedar Crossing, Ngaamba NR, Ingalba SF (30°53.9'S 152°47.3'E), 6.02.2002, K.B. Sewell & R.D. Sewell, hot Bouin/Un; QMG220084–220085 (CP) 100% alc/Fau; QMG220086–220090 (CP), Fau.

From *Euastacus gumar*. NSW: [QMW26622], QMG220091–220094 (WM), Culmaron Ck, Richmond Ra. NP, (28°50.5'S 152°44.1'E), 4.03.2002, K.B. Sewell, S.G. Sewell & J.A. Coughran, 100% alc/Bouin/Un; QMG220095–220096 (CP), 100% alc/Fau; QMG220097 (CP), Fau.

From *Euastacus neohirsutus*. NSW: [QMW26638], QMG220141–220142 (WM), Little Nymboida R., junction of Lowamnna and Coramba Rds, Bindarri NP (30°14.0'S 152°55.3'E), 5.02.2002, K.B. Sewell & R.D. Sewell, 70% alc/Un; QMG220143–220144 (CP), 100% alc/Fau; [QMW26637]; QMG220145–220146 (CP), 15.02.1992, K.B. Sewell & S.G. Sewell, Bouin/Fau; QMG220147–220148 (LS[2,2]), Form/H&E.

From *Euastacus spinichelatus*. NSW: [QMW26652], QMG220157 (WM), Joyces Ck, Oxley Hwy crossing, 6km SE of Yarrowitch, Enfield SF, (31°16.7'S 151°58.3'E), 8.02.2002, K.B. Sewell & R.D. Sewell, 100% alc/Un; QMG220158 (WM), hot Bouin/Un; [QMW26653], QMG220159 (WM), 23.10.1991, L.R.G. Cannon & K.B. Sewell, HW/Form; [QMW26652], QMG220160 (WM), 8.02.2002, K.B. Sewell & R.D. Sewell, 70% alc/Un; QMG220161–220162 (CP), 100% alc/Fau; QMG220163–220164 (CP), HW/Form/Fau.

From *Euastacus sulcatus*. Qld: [QMW26657], QMG220165 (WM), upper Tallebudgera Ck, at '1000m mark on main track' (28°14.0'S 153°18.5'E), 22.04.2002, D.J. & L.V. Cook, L.RG. Cannon, K.B. & S.G. Sewell; QMG220166–220167 (CP), 100% alc/Fau; [unreg. host, ident. Dr John Short, QM], QMG220168–220169 (CP), Mosses Well, Spicers Gap, Main Ra. NP (28°04.0'S 152°26.3'E), 25.11.1991, K.B. Sewell, Fau. NSW: [QMW26655], QMG220170 (WM), Bundoozle Flora Reserve, Richmond Ra. NP (28°36.4'S 152°42.1'E), 4.03.2002, K.B. Sewell, S.G. Sewell & Coughran J.A., 100% alc/Un.

From *Euastacus suttoni*. Qld: [QMW26660], QMG220171 (WM), beside rd to The Pyramids, Girraween NP (28°49.1S 151°58.8'E), 18.04.1990, S. Cook, Form-Acetic/Hx; QMG220172 (CP), Form-Acetic/Fau; QMG220174–220176 (LS[2,2,6]) Bouin/H&E. [QMW26663], QMG220177–220179 (WM), Washpool Ck, nr Thunderbolts Hideout, N of Tenterfield (28°58.4'S 152°04.4'E), 4.02.2002, K.B. Sewell & R.D. Sewell, hot Bouin/Un; [QMW26662], QMG220180 (CP), Glen Innes, Dec. 1976, I. Kneipp, Fau.

From *Euastacus valentulus*. Qld: [QMW26666], QMG220186–220188 (WM), Tallebudgera Valley (28°08'S 153°26'S), D.J. Cook, 70% alc/Hx; QMG220189–220192 (CP), 70% alc/Fau, QMG220193–220195 (LS[1,1,2]), 70% alc/H&E. NSW: [QMW6459] QMG220196–220200 (WM), Rocky Ck rainforest, Whian Whian SF, (28°40'S 153°18'E), Jul. 1974, G.B. Monteith & S.R. Monteith., 70% alc/Hx; QMG220201–220207 (CP), 70% alc/Fau.

From *Caridina* sp. (*nilotica*?) (Crustacea; Decapoda; Atyidae) [spurious record, see remarks], Qld: [unreg. host] QMGL 14580 (WM), From *Caridina* sp. (*nilotica*?), Aplin Weir, on Ross R., Townsville, Qld (19°22'S 146°44'E), L. Winsor, Form/Picrocarmine.

DESCRIPTION. Characteristics of genus but across its range varies from having dense concentration of pigment around and between the eyes (as figured by Cannon, 1993: fig. 8b), through to dense tracery of pigment extending over dorsal body and tentacles. Selected body measurements of specimens from *Euastacus neohirsutus* from type locality are: QMG220056 (N): B(2448 × 1387), LE(1652), PH(367 × 551), SD(408), PD(265); QMG220057: B(2183 × 1489, LE(1469), SD(530), PH(408 × 612), PD(306); QMG220058: B(3040 × 1754), LE(2081), PH(469 × 632), SD(632), PD(347); QMG220059: B(1652 × 653), LE(959), PH(224 × 352), SD(265), PD(102); QMG220060: B(1897 × 775), LE(1122), PH(265 × 306), SD(347), PD(143).

TABLE 1. Description of body pigment for *Temnohaswellia simulator* collected from different *Euastacus* hosts.

Host	Body pigment description
Euastacus armatus? [juvenile]	Dense, fine tracery over most of dorsal body, extends past bases of tentacles, with thicker tracts concentrated around eyes.
E. dangadi	Concentrated around and between eyes.
E. gumar	Concentrated around and between eyes.
E. neohirsutus	Concentrated around and between eyes.
E. spinichelatus	Small concentration around and between eyes.
E. sulcatus	Small concentration around and between eyes.
E. suttoni	Concentrated around and between eyes and extending farther in larger worms.
E. valentulus	Dense, course tracery over most of dorsal body surface, extends past bases of tentacles, with very thick tracts radiating from near eyes.

Reproductive system. Female. Vagina: Outer region with teeth (when folds are sufficiently compressed [as in a concertina]), arranged in numerous (>10) columns and 6(?) rows. When viewed distally to proximally, folds form pattern reminiscent of spider's web.

Male. Cirrus: General form as figured by Cannon (1993: fig. 8d, 11h). Shaft cone-shaped. Introvert cylinder-shaped (as figured by Cannon 1993: fig.8d). Unspined distal region short, about one quarter length of introvert longer side. Swelling near even, extending proximally well past introvert base, slightly farther on longer side; distal opening slightly oblique. Selected cirrus measurements of specimens from *Euastacus neohirsutus* from type locality are: QMG220066: S(207 × 98), I(75 × 35), U(18), IS(102 × 72); QMG220068: S(238 × 100), I(71 × 33), U(18), IS(85 × 81); QMG220069: S(193 × 91), I(71 × 27), U(18), IS(100 × 61); QMG220072: S(205 × 81), I(79 × 35), U(18), IS(85 × 67).

HOSTS. *Euastacus armatus*?, *Euastacus dangadi, E. gumar, E. neohirsutus, E. spinichelatus, E. sulcatus, E. suttoni, E. valentulus*.

DISTRIBUTION. South-eastern Qld to south-eastern NSW widespread along the Great Dividing Ra.

REMARKS. Neither type specimens of *Temnohaswellia simulator* nor specimens assigned to this species by Haswell were located. Nevertheless, the specimens we describe here conform essentially to the incomplete and informal description of *Temnohaswellia simulator* by Haswell (1924: page 513, footnote). In particular, the presence of body pigment and the form of the female reproductive system, we believe, confirm the validity of the species. *Temnohaswellia simulator* was described by Haswell (1924) from specimens removed from crayfish collected from Barrengarry Ck, above Belmore Falls. We did not find *Temnohaswellia simulator* in the Belmore Falls region, although we do report *T. comes* and describe *T. verruca* sp. nov. from the locality of Burrawang Ck, a close tributary of Barrengarry Ck.

There is, however, little chance that Haswell (1924) confused either of these two species with *Temnohaswellia simulator* as both lack body pigment.

Haswell (1924) stated that *Temnohaswellia simulator* had papillae near the distal opening of the vagina that 'assume the appearance of rudimentary teeth', a character he recognised as absent from *T. comes*. We observed that the outer vagina of *Temnohaswellia simulator* has distinctive sclerotised folds that appear as teeth and which are most clearly observed in sections (Fig. 15D, G).

Temnohaswellia simulator is the only Australian species of *Temnohaswellia* we encountered to have body pigment. Not all hosts, however, had worms with extensive body pigment, although all worms had a concentration of pigment around and between the eyes (Table 1).

Heavily pigmented specimens, i.e. those on *Euastacus armatus* from Wollemi NP and on *E. valentulus* from Tallebudgera Valley and Whian Whian SF, were otherwise morphologically indistinguishable from specimens from other hosts and localities across its range. The degree of body pigmentation does not appear to be related to the size (= age?) of the worms, except within populations collected from the same host

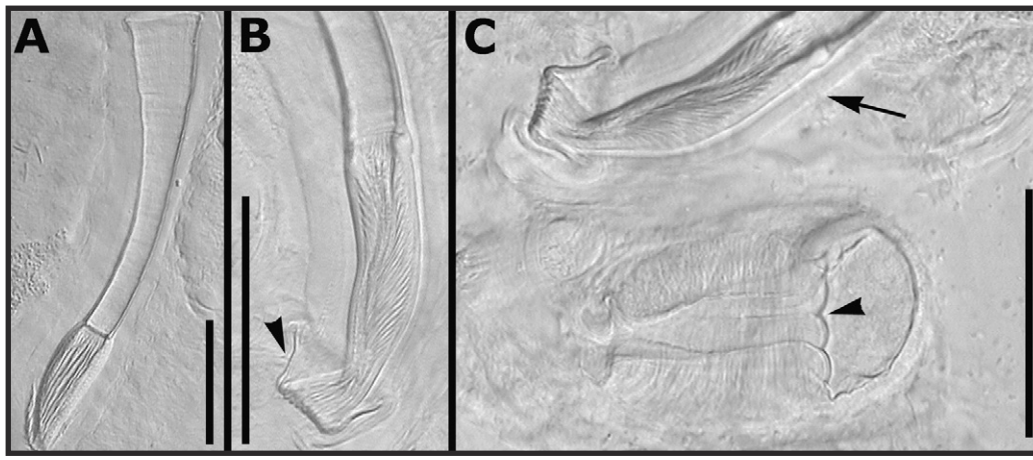


FIG. 16. *Temnohaswellia subulata* sp. nov. A–C. Nomarski interference contrast photomicrographs of Faure's preparations; A, QMG220308, whole cirrus with partially everted introvert (stitched image), scale = 100µm; B, QMG220311, introvert showing short unspined distal region (arrowhead), scale = 100µm; C, QMG220311, introvert (arrow) and vagina showing weak sclerotisation in the distal region (arrowhead), scale = 100µm.

at the same locality. For example, large worms from the type locality had slightly more pigment than smaller worms, but much less pigmentation than small worms from Wollemi NP.

The widespread distribution of *Temnohaswellia simulator* may result in some variation in body size and form between localities and hosts, including the degree of body pigment. Since nomenclatural instability could potentially develop, a neotype has been designated from near the approximate centre of the distribution recorded in this study.

Included here is the pigmented specimen that Cannon (1993) described as *Temnohaswellia tetrica* from a single holotype wholemounted specimen reputedly collected from the freshwater shrimp, *Caridina* sp. (*nilotica*?) at Townsville, Qld. We have examined the holotype of *Temnohaswellia tetrica* and consider that the specimen is *T. simulator*. For the same reasons as stated previously for *Temnohaswellia pugna* we believe that the determination of a shrimp host is an error, and that the specimen was probably from the crayfish host *Euastacus suttoni* [QMW26662], collected at Glen Innes, NSW.

Temnohaswellia subulata sp. nov.
(Fig. 16A–C)

ETYMOLOGY. From *subula* = awl (Latin); a reference to the relatively straight, even taper of the cirrus.

MATERIAL. HOLOTYPE: QMG220297 (WM), from *Euastacus australasiensis* (juvenile) [QMW26583], Govetts Leap Brook, James St crossing on Braeside Walk, Blackheath, Blue Mts NP, NSW (33°38.5'S 150°18.4'E), 20.10.1991, L.R.G. Cannon & K.B. Sewell, HW/Form/Hx. PARATYPES: QMG220298–220301 (WM), HW/Form/Hx. OTHER MATERIAL FROM TYPE LOCALITY: QMG220302–220306 (WM), HW/Form/Hx; [QMW26644], QMG220307 (WM), 12.02.2002, K.B. Sewell & R.D. Sewell, 100% alc/Un; QMG220308–220309 (CP), 100% alc/Un; [QMW26583], QMG220310–220313 (CP) 20.10.1991, L.R.G. Cannon & K.B. Sewell, HW/Form/Fau; [QMW27496], QMG221205–221206 (CP), 2.01.2004, D. Blair & R.D. Sewell, alc/Fau.

DESCRIPTION. Characteristics of genus but lacking body pigment except for occasionally thinly scattered pigment between the eyes. Selected body measurements of type specimens from *Euastacus australasiensis* are: QMG220297 (H): B(1659 × 805), LE(976), PH (252 × 333), SD(341), PD(138); QMG220298 (P): B(1967 × 959), LE(1138), PH (268 × 358), SD(390), PD(203); QMG220299 (P): B(1593 × 837), LE(967), PH (203 × 366), SD(366), PD(146); QMG220300 (P): B(1707 × 854), LE(1008), PH (236 × 366), SD(370), PD(163); QMG220301 (P): B(1496 × 699), LE(894), PH (244 × 317), SD(325), PD(146).

Reproductive system. Female. Vagina: Outer region weakly sclerotised, lacking teeth.

Male. Cirrus: Shaft cone-shaped. Introvert cylinder-shaped; distal opening not obviously oblique. Unspined distal region short, about one fifth length of introvert longer side. Swelling even, extending proximally just past introvert base on both sides, slightly farther on longer side. Selected cirrus measurements of specimens from *Euastacus australasiensis* from type locality are: QMG220308: S (280 × 69), I(126 × 24), U(24), IS(8 × 4); QMG220309: S (270 × 63), I(135 × 30); U(26), IS(10 × 4); QMG220311: S (248 × 59), I(137 × 26); U(26), IS(6 × 2); QMG220312: S (270 × 67), I(124 × 26); U(26), IS(8 × 3); QMG220313: S (250 × 69), I(126 × 28), U(26), IS(12 × 4).

HOST. *Euastacus australasiensis*.

DISTRIBUTION. Mid-eastern NSW — from the Blue Mountains NP, near Blackheath at Govetts Leap Brook.

REMARKS. The long thin awl-like cirrus is quite characteristic and unlike any other *Temnohaswellia* observed. This worm was not found to co-occur with other species of *Temnohaswellia* on the host from which it was collected.

Temnohaswellia umbella sp. nov.
(Fig. 17A–E)

ETYMOLOGY. From *umbella* = parasol (Latin); a reference to the unspined distal region of the introvert in appearance like a long folded parasol.

MATERIAL. HOLOTYPE: from *Euastacus guwinus* (c.f. *dharawalus*) [QMW26624], QMG220261 (WM), Tianjarra Ck, above Tianjarra Falls, Morton NP (35°06.7'S 150°19.8'E), 18.10.1991, L.R.G. Cannon & K.B. Sewell, HW/Form/Hx. PARATYPES: QMG220262–220264 (WM), HW/Form/Hx; [QMW26623], QMG220265 (WM), 18/2/2002, K.B. Sewell & R.D. Sewell, hot Bouin/Un. OTHER MATERIAL FROM TYPE LOCALITY: [QMW26624], QMG220266 (WM), 18.10.1991, L.R.G. Cannon & K.B. Sewell, HW/Form/Hx; QMG220267–220271 (CP), 100% alc/Fau; QMG220272 (CP), Fau; [QMW26625], QMG220275 (CP), 13.02.2002, K.B. Sewell & R.D. Sewell, 100% alc/Fau; [QMW26624], QMG220276–220277 (LS[1,2]), 18.10.1991, L.R.G. Cannon & K.B. Sewell, Form/H&E; QMG220278 (LS[2]), HW/Form/H&E.

DESCRIPTION. Characteristics of genus but lacking body pigment except for occasionally thinly scattered pigment between the eyes. Selected body measurements of type specimens from *Euastacus guwinus* are: QMG220261 (H): B(1836 × 938), LE(1122), PH(224 × 357), SD(347), PD(173); QMG220262 (P): B(1836 × 918), LE(1122), PH(275 × 347), SD(367), PD(184); QMG220263 (P): B(1897 × 928), LE(1040), PH(245 × 347), SD(367), PD(184); QMG220264 (P): B(1142 × 592), LE(857), PH(143 × 224), SD(235), PD(102); QMG220265 (P): B(1428 × 1020), LE(1000), PH(224 × 347), SD(326), PD(194).

Reproductive system. Female. Vagina: Outer region with blunt, comb-like teeth increasingly larger and more plate-like proximally, arranged in columns (6?) and rows (12?).

Male. Cirrus: Shaft cone-shaped. Introvert cylinder shaped; distal opening not obviously oblique. Unspined distal region very long and thin, nearly twice length of spined region on longer side, with prominent folds oriented parallel to long axis of introvert. Distal extremity of unspined region appears ruffled in appearance, analogous to rim of folded umbrella. Swelling not observed [obscured by unspined region of introvert]. Selected cirrus measurements of specimens from *Euastacus guwinus* (c.f. *dharawalus*) from type locality are: QMG220267: S(331 × 93), I(112 × 24), U(215), IS(na × na); QMG220268: S(409 × 122), I(132 × 28), U(234), IS(na × na); QMG220269: S(327 × 89), I(138 × 28), U(217), IS(na × na); QMG220270: S(346 × 89), I(136 × 26), U(234), IS(na × na); QMG220275: S(356 × 126), I(124 × 26), U(222), IS(na × na).

HOST. *Euastacus guwinus* (c.f. *dharawalus*).

DISTRIBUTION. Mid-eastern NSW — from W of Nowra, Morton NP, at Tianjarra Falls.

REMARKS. The cirrus and vagina of this species resemble most closely those of *Temnohaswellia breviumbella* sp. nov. The introvert, however, is longer, particularly the unspined distal region of the introvert which is about twice the length of that of *Temnohaswellia breviumbella* sp. nov. The function of the large unspined region is unknown.

Temnohaswellia verruca sp. nov.
(Fig. 18A–G)

ETYMOLOGY. From *verruca* = wart (Latin, feminine); a reference to the six wart-like sclerotised protruberences [cusp-like teeth] at the distal opening of the vagina.

MATERIAL. HOLOTYPE: QMG219548 (WM), from *Euastacus claytoni,* [QMW26599], Lowden Ck, in Lowden FP picnic area, Tallaganda SF, NSW (35°30.8'S 149°36.2'E), 17.10.1991, L.R.G. Cannon & K.B. Sewell, HW/Form/Un. PARATYPES:

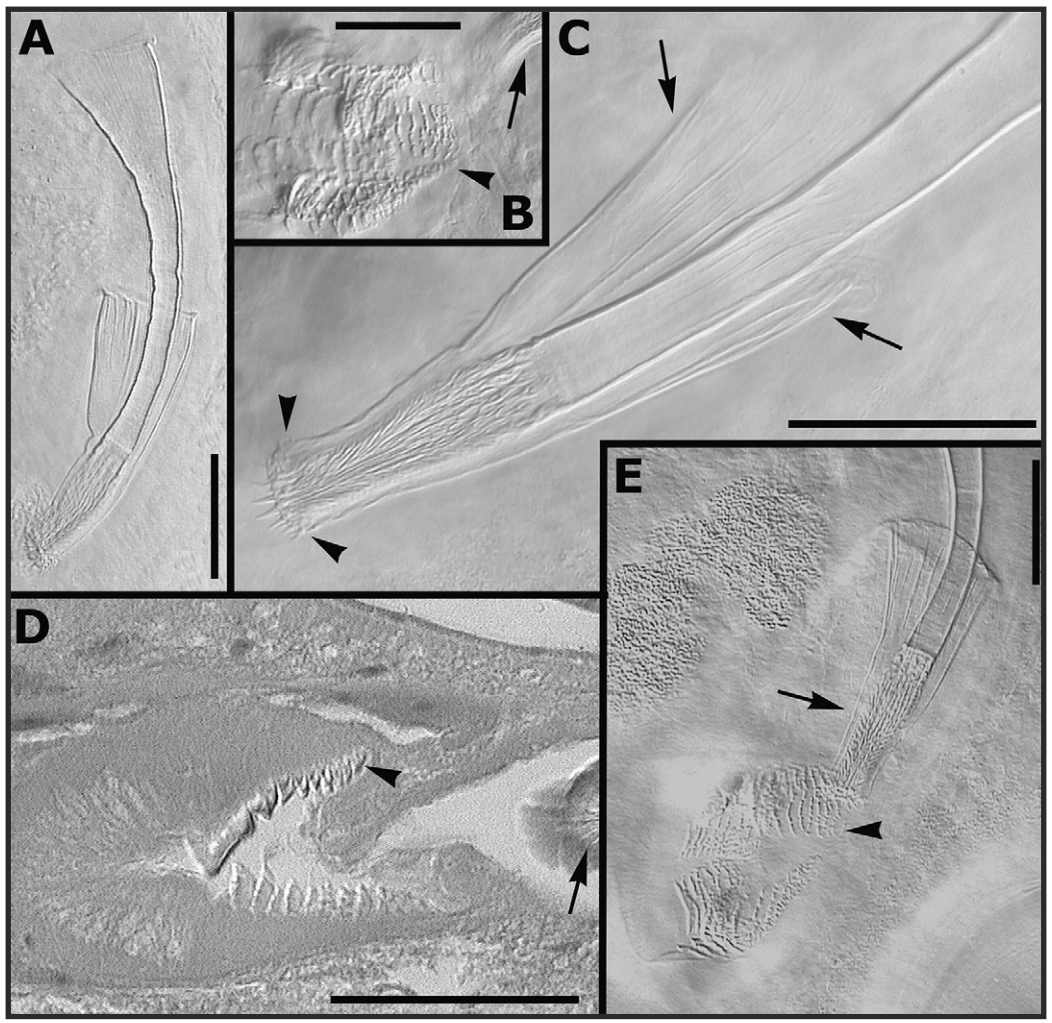


FIG. 17. *Temnohaswellia umbella* sp. nov. A–C, E. Nomarski interference contrast photomicrographs of Faure's preparations. A, QMG220270, cirrus, scale = 100µm; B, QMG220275, introvert (arrow) and vagina with rows of comb-like teeth in the distal region (arrowhead), scale = 100µm; C, QMG220268, introvert showing the long unspined distal region (arrows), the distal extremity of the introvert spined region is indicated by arrowheads, scale = 100µm; D, QMG220278, longitudinal section showing teeth in the outer region of the distal vagina (arrowhead) and the distal region of the introvert (arrow), scale = 50µm; E, QMG220275, vagina showing rows of comb-like teeth in the distal region (arrowhead) that increase in size proximally and the introvert (arrow), scale = 100µm.

QMG219549 (WM), QMG219550 (WM), HW/Form/Hx; [QMW26600], QMG219551–219552 (WM), 16.02.2002, K.B. Sewell & R.D. Sewell, 70% Alc/Un). OTHER MATERIAL FROM TYPE LOCALITY: QMG219553 (WM); [QMW26644], QMG219554 (LS [3]), 17.10.1991, L.R.G. Cannon & K.B. Sewell, Form/H&E; QMG219555 (LS [2]); [QMW26600], QMG219556 (CP), 16.02.2002, K.B. Sewell & R.D. Sewell, 100% alc/Fau; QMG219557–219561 (CP); [QMW26644], QMG219562–219563 (CP), 17.10.1991, L.R.G. Cannon & K.B. Sewell, HW/Form/Fau. OTHER MATERIAL. From *Euastacus armatus*. VIC: [unreg. host, ident. Dr Susan Lawler, Latrobe University, VIC], QMG219564–219565 (CP), Yackandandah Ck, (36°14'S 146°57'S), 20.11.2001, S.H. Lawler & G.N. Edney; [QMW26582], QMG219566–219570 (WM), Buffalo R., Shultz Track, 36km S of Buffalo (36°59.5'S 146°48.0'E),

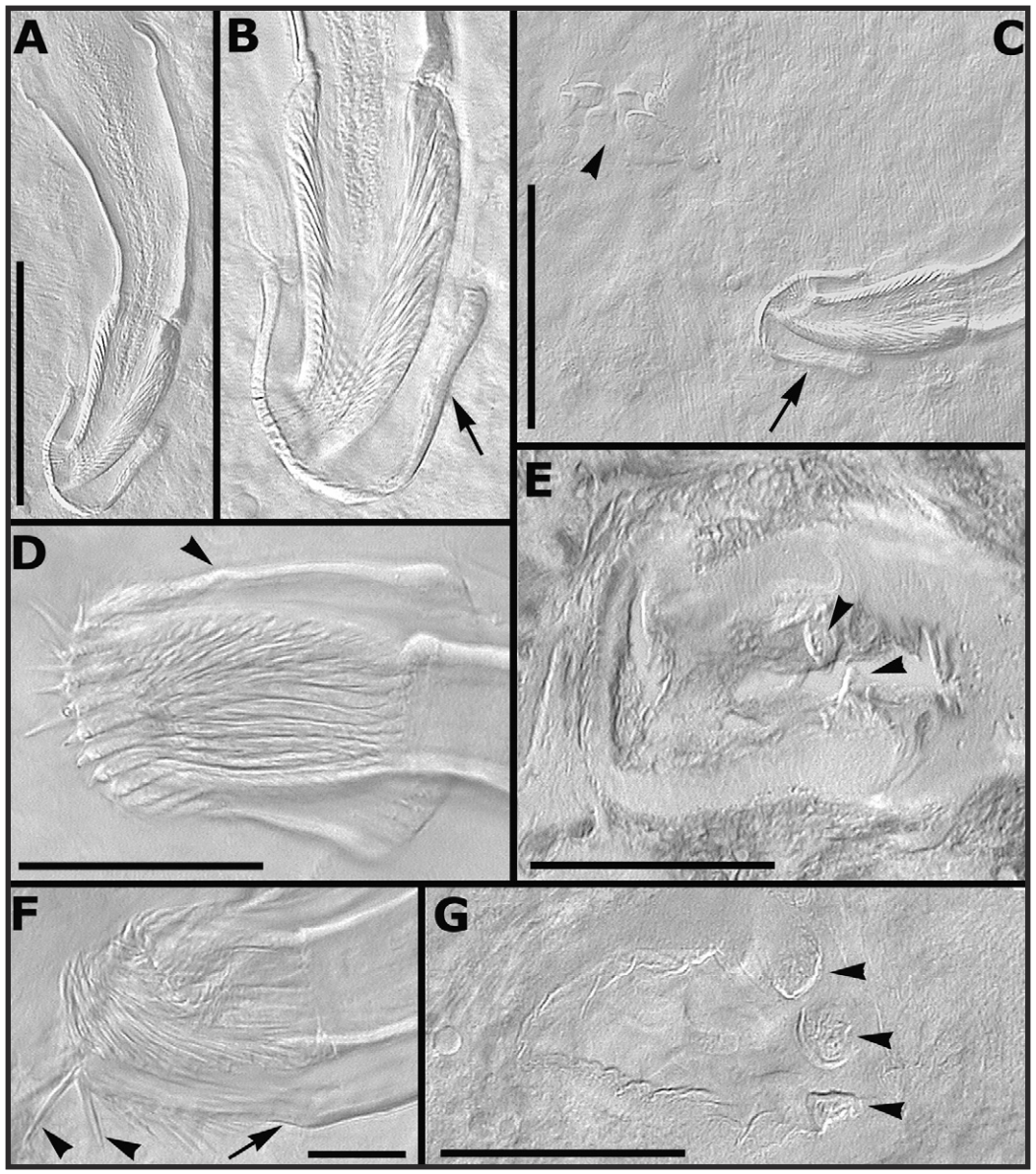


FIG. 18. *Temnohaswellia verruca* sp. nov. A-D, F-G, Nomarski interference contrast photomicrographs of Faure's preparations. A, QMG219578, cirrus, scale = 100µm; B, QMG220578, introvert showing unspined distal region (arrow), scale = 50µm; C, QMG219578, introvert (arrow) and vagina with cusp-like teeth in the outer region of the distal vagina (arrowheads), scale = 100µm; D, QMG219556, introvert showing the junction (arrowhead) between the spined region and unspined distal regions, scale = 50µm; E, QMG219554, longitudinal section showing cusp-like teeth in the outer region of the distal vagina (arrowheads), scale = 50µm; F, QMG219559, introvert partially everted showing long spines in the spined region (arrowheads) and the junction (arrow) between the spined region and unspined distal regions, scale = 20µm; G, QMG219558, vagina showing cusp-like teeth in the outer region of the distal vagina (arrowheads), scale = 50µm.

10.03.2002, G.N. Edney, 100% alc/Un; QMG219571–219577 (CP), 100% alc/Fau.

From *Euastacus bidawalus*. VIC: [QMW26588], QMG219578–219583 (WM), Dingo Ck, crossing on Euchre Valley Drive, Lind NP (37°34.7'S 148°58.2'E), 20.03.2002, K.B. Sewell, S.H. Lawler & G.N. Edney, 100% alc/Un; QMG219584–219586 (CP) 100% alc/Fau; [unreg. host ident. Dr Sue Lawler, Latrobe University, VIC], QMG219587–219589 (CP), 3.01.1997, Lawler S.H., 100% alc/Fau; [QMW27482], QMG221207 (CP), 5.01.2004, D. Blair, R.D. Sewell, S.H. Lawler & G.N. Edney, alc/Fau.

From *Euastacus brachythorax*. NSW: [QMW26593], QMG219590–219592 (CP), Rutherford Ck crossing on Niten Rd, Brown Mtnn, Glenbog SF (36°36.4'S 149°24.4'E), 18.03.2002, K.B. Sewell, 100% alc/Fau.

From *Euastacus crassus*. ACT: [QMW26603], QMG219593 (WM), Kangaroo Ck, rd crossing above Corin Dam, Namadgi NP (35°32.3'S 148°52.2'E), 16.10.1991, L.R.G. Cannon & K.B. Sewell, HW/Form/Un; QMG219594–219597 (CP), HW/Form/Fau. VIC: [QMW26601], QMG219598–219600 (WM), Buchan R. in Native Dog Flat camping ground, Alpine NP (36°53.9'S 148°05.3'E), 19.03.2002, K.B. Sewell, S.H. Lawler & G.N. Edney, 100% alc/Un; QMG219601–219603 (CP), 100% alc/Fau.

From *Euastacus dharawalus*. NSW: [QMW26607] QMG219604–219605 (WM), Wildes Meadow Ck crossing on Wildes Meadow Rd, Wildes Meadow (34°36.4'S 150°31.1'E), 13.02.2002, K.B. Sewell & R.D. Sewell, Bouin/Un; QMG219606 (WM), 70% alc/Un; QMG219607 (CP), 100% alc/Fau; QMG219608–219609 (CP), Fau.

From *Euastacus gamilaroi*. NSW: [QMW26620], QMG219610–219612 (WM), Burrows Ck, Sheeba Dams Recreation Reserve, near Hanging Rock (31°30.0'S 151°11.9'E), 22.10.1991, L.R.G. Cannon & K.B. Sewell, HW/Form/Hx; QMG219613–219614 (WM), HW/Form/Un; QMG219615–219620 (WM), HW/Form/Hx; QMG219621–219622 (WM), HW/Form/Un; [QMW26621], QMG219623–219625 (WM), 8.02.2002, K.B. Sewell & R.D. Sewell, Bouin/Un; QMG219626 (CP) 100% alc/Fau; QMG219627–219633 (CP), Fau.

From *Euastacus polysetosus*. NSW: [QMW26641], QMG219635–219637 (WM), Dilgry R., at Dilgry River Picnic Area, Barrington Tops NP (31°53.6'S 151°31.3'E), 21.10.1991, L.R.G. Cannon & K.B. Sewell, HW/Form/Hx; [QMW26640], QMG219638–219639 (WM), 9.02.2002, K.B. Sewell & R.D. Sewell, 100% alc/Un; [QMW26641], QMG219640–219644 (WM), 21.10.1991, L.R.G. Cannon & K.B. Sewell, HW/Form/Hx; QMG219645 (LS[2]), Form/H&E; QMG219646–219651 (CP) HW/Form/Fau; [QMW26640], QMG219652–219654 (CP), 9.02.2002, K.B. Sewell & R.D. Sewell, Fau; QMG219655–219659 (CP), 100% alc/Fau.

From *Euastacus reductus*. [QMW27488], QMG221209 (CP), Problem Ck crossing on Frying Pan Rd, trib. of Telegherry R., Chichester SF, 1km E of Telegherry FP NSW 32°13.6'S 151°45.8', 9.01.2004, D. Blair & R.D. Sewell, alc/Fau.

From *Euastacus spinifer*. [QMW27486], QMG221208 (CP), Piles Ck trib., beside the Great North Walk, Brisbane Waters NP NSW 33°26.2'E 151°16.4'E, 8.01.2004, D. Blair & R.D. Sewell, alc/Fau.

From *Euastacus yanga*. NSW: [QMW26627], QMG219634 (WM), Burrawang Ck at road crossing, 3km NW Belmore Falls, Morton NP (34°37.1'S 150°32.5'E), 19.10.1991, L.R.G. Cannon & K.B. Sewell, HW/Form/Hx; [QMW26671], QMG219660–219662 (WM), Monga NP, 2.7km along River Rd from Braidwood Rd junction (35°33.8'S 149°55.0'E), 16.02.2002, K.B. Sewell & R.D. Sewell, 100% alc/Un; [QMW26672], QMG219663–19665 (WM), 17.10.1991, L.R.G. Cannon & K.B. Sewell, HW/Form/Hx; [QMW26671], QMG219666 (WM), 16.02.2002, K.B. Sewell & R.D. Sewell, 100% alc/Un; QMG219667–219672 (CP), 100% alc/Fau.

From *Euastacus yarraensis*. VIC: [QMW26674], QMG219673 (WM), SF nr Cockatoo beside road in picnic area (37°56.6'S 145°29.6'E 145°29.6'E), 21.03.2002, K.B. Sewell, S.H. Lawler & G.N. Edney, 100% alc/Un; QMG219674 (CP), 100% alc/Fau.

DESCRIPTION. Characteristics of genus but lacking body pigment except for occasionally thinly scattered pigment between the eyes. Selected body measurements of type specimens from *Euastacus claytoni* are: QMG219548 (H): B(3182 × 1387), LE(2203), PH(652 × 591), SD(612), PD(286); QMG219549 (P): B(3060 × 1510), LE(2040), PH(530 × 714), SD(612), PD(326); QMG219550 (P): B(2591 × 1142), LE(1754), PH(469 × 612), SD(428), PD(245); QMG219551 (P): B(1836 × 959), LE(1326), PH(408 × 408), SD(428), PD(224); QMG219552 (P): B(1632 × 857), LE(1285), PH(338 × 367), SD(408), PD(235).

Reproductive System. Female. Vagina. Outer region with single row of cusp-like teeth, usually 6 seen.

Male. Cirrus. Shaft cone-shaped. Introvert cylinder to scoop shaped; distal opening oblique. Unspined distal region slightly more than half length of introvert longer side. Swelling uneven, extends proximally well past introvert base on both sides, farther on longer side. Selected cirrus measurements of specimens from *Euastacus claytoni* from type locality are: QMG219556: S(193 × 91), I(91 × 30), U(51), IS(110 ×

TABLE 2. *Temnosewellia* species from hosts other than *Euastacus*. Listed alphabetically by species of *Temnosewellia*. Data obtained from original species descriptions and from reviews in Cannon (1991), Cannon & Sewell (2001) and Damborenea & Cannon (2001).

Name and authority	Host genus	Country
Temnosewellia athertonensis (Cannon, 1993)	*Holthuisana*	Australia
Temnosewellia butlerae (Cannon, 1993)	*Holthuisana*	Australia
Temnosewellia caeca (Haswell, 1900)	*Phreatoicopsis*	Australia
Temnosewellia chaerapsis (Hett, 1925)	*Cherax*	Australia
Temnosewellia cita (Hickman, 1967)	*Parastacoides*	Australia
Temnosewellia dendyi (Haswell, 1893)	*Cherax*	Australia
Temnosewellia engaei (Haswell, 1893)	*Engaeus*	Australia
Temnosewellia geonoma (Williams, 1980)	*Phreatoicopsis*	Australia
Temnosewellia improcera (Cannon, 1993)	*Caridina*	Australia
Temnosewellia minor (Haswell, 1888)	*Cherax*	Australia
Temnosewellia minuta (Cannon, 1993)	*Paratya*	Australia
Temnosewellia neqae (Cannon, 1993)	*Macrobrachium*	Australia
Temnosewellia queenslandensis (Cannon, 1993)	*Macrobrachium*	Australia
Temnosewellia rouxii (Merton, 1913)	*Cherax*	Australia & Aru Islands
Temnosewellia semperi (Weber, 1890)	*Cherax*	SE Asia — from Indonesia to India
Temnosewellia acirra (Cannon & Sewell, 2001)	*Cherax*	Australia
Temnosewellia christineae (Cannon & Sewell, 2001)	*Cherax*	Australia
Temnosewellia punctata (Cannon & Sewell, 2001)	*Cherax*	Australia
Temnosewellia phantasmella (Cannon & Sewell, 2001)	*Cherax*	Australia

61); QMG219557: S(228 × 79), I(100 × 30), U(57), IS(na × na); QMG219558: S(128 × 55), I(91 × 26), U(51), IS(na × na); QMG219559: S(213 × 81), I(89 × 28), U(53), IS(108 × 73); QMG219560: S(219 × 77), I(91 × 26), U(51), IS(102 × 73).

HOSTS. *Euastacus armatus, E. bidawalus, E brachythorax, E. claytoni, E. crassus, E. dharawalus, E. gamilaroi, E. polysetosus, E. reductus, E. spinifer, E. yanga, E. yarraensis*.

DISTRIBUTION. Mid-eastern NSW to south-eastern VIC — widespread along the Great Dividing Ra.

REMARKS. The prominent sclerotised cusp-like teeth that ring the distal opening of the vagina of this species serve effectively to discriminate this species from *Temnohaswellia comes*, a worm of similar size and colour that co-occurs on several host species. Although there are considerable differences in the form of the cirrus introvert between these two species, they can, however, be somewhat disguised in wholemounted specimens, particularly if the introvert is compressed as a consequence of fixation. In such wholemounted specimens of *Temnohaswellia comes* the diagnostic large spines on the introvert base may be obscured. The unspined distal region has thick walls and in some cirrus preparations appears like a semicircular cap covering the spined region of the introvert.

Temnohaswellia sp.

MATERIAL. From *Euastacus urospinosus*. Qld: [QMW26665], QMG220182 (CP), Kondalilla Falls NP, at first creek from park entrance along walking track (26°41'S 152°52'E), 28.03.1991, L.R.G. Cannon & K.B. Sewell, HW/Form/Hx; QMG220183–220185 (LS[1,1,1]), HW/Form/Fau.

DESCRIPTION. Characteristics of genus but lacking body pigment.

REMARKS. This species appears close to *Temnohaswellia simulator* in the general form of the vagina and cirrus. Nevertheless, in the absence of additional specimens we are reluctant to describe this species formally.

Temnosewellia Damborenea & Cannon, 2001

Temnosewellia Damborenea & Cannon, 2001: 1115–1116.

TYPE SPECIES. *Temnocephala minor* Haswell, 1888, by original designation of Damborenea & Cannon, 2001. Gender is feminine. Host: *Cherax destructor* Clark, 1936.

DIAGNOSIS. Temnocephalinae reaching to c.10mm in length, five anterior tentacles and posterior pedunculate adhesive disc present; conspicuous papillate ridges or imbricating scales absent from tentacles or dorsal body; single dorsal pair of brown to dark brown pigmented eyes at base of tentacles; brown to dark-brown (melanin?) pigment (if present) in body. Gut appears dark. Vaginal cavity weakly sclerotised. Testes two pairs postero-lateral to gut; vasa deferentia enter seminal vesicle separately; ejaculatory sac semi-discrete.

Epidermal Mosaic (based on *Temnosewellia cypellum* sp. nov.). Epidermis composed of 5 syncytia: 1, tentacular; 2, a single, characteristically saddle-shaped post-tentacular plate; 3, body; 4, peduncular (stalk); and 5, adhesive disc. Post-tentacular syncytium anterior to nephridiopores which dorsally are contained in body syncytium (Fig. 38). Shallow groove marks border between dorsal and ventral surfaces along lateral margins of body and peduncular syncytia.

AUSTRALIAN SPECIES KNOWN FROM *EUASTACUS*

Temnosewellia acicularis sp. nov.
Temnosewellia alba sp. nov.
Temnosewellia albata sp. nov.
Temnosewellia aphyodes sp. nov.
Temnosewellia apiculus sp. nov.
Temnosewellia arga sp. nov.
Temnosewellia argeta sp. nov.
Temnosewellia argilla sp. nov.
Temnosewellia aspinosa sp. nov.
Temnosewellia aspra sp. nov.
Temnosewellia bacrio sp. nov.
Temnosewellia bacrioniculus sp. nov.
Temnosewellia batiola sp. nov.
Temnosewellia belone sp. nov.
Temnosewellia caliculus sp. nov.
Temnosewellia cestus sp. nov.
Temnosewellia comythus sp. nov.
Temnosewellia coughrani sp. nov.
Temnosewellia cypellum sp. nov.
Temnosewellia fasciata (Haswell, 1888)
Temnosewellia fax sp. nov.
Temnosewellia flammula sp. nov.
Temnosewellia gingrina sp. nov.
Temnosewellia gracilis sp. nov.
Temnosewellia keras sp. nov.
Temnosewellia maculata sp. nov.
Temnosewellia magna sp. nov.
Temnosewellia maxima sp. nov.
Temnosewellia minima sp. nov.
Temnosewellia muscalingulata sp. nov.
Temnosewellia possibilitas sp. nov.
Temnosewellia unguiculus sp. nov.
Temnosewellia sp.

REMARKS

The present paper deals only with *Temnosewellia* from Australian *Euastacus* hosts. *Temnosewellia* are, however, recorded from other crustacean hosts within and outside Australia (Table 2).

KEY TO SPECIES OF *TEMNOSEWELLIA* (FROM AUSTRALIAN *EUASTACUS* SPP. CRAYFISH)

1. Body pigment present (some specimens, especially juveniles, can have little pigment*) 2
   Lacking body pigment. 3
2. Body pigment punctate (sometimes not pronounced*) 9
   Body pigment fine and evenly distributed. 12
3. Cirrus introvert base (normally < 15µm wide) 4
   Cirrus introvert base (normally > 15µm wide) 6
4. Cirrus introvert swelling (IS) short along both sides of shaft . . . . . *T. aphyodes* sp. nov.
   Cirrus introvert swelling (IS) long along both sides of shaft 5
5. Cirrus introvert opening oblique . . . . . *T. argeta* sp. nov.
   Cirrus introvert opening very oblique . . *T. aspra* sp. nov.
6. Cirrus introvert swelling (IS) uneven, thicker on longer side of shaft . . . . . *T. albata* sp. nov.
   Cirrus introvert swelling (IS) even, equally thick on both sides of shaft 7
7. Cirrus introvert opening oblique . . . . . *T. argilla* sp. nov.
   Cirrus introvert opening very oblique 8
8. Cirrus introvert relatively large (Il:Ib= 5:1) . . *T. alba* sp. nov.
   Cirrus introvert relatively small (Il:Ib = 6:1) *T. arga* sp. nov.
9. Cirrus with aspinous introvert, very wide at base of shaft . . . . . *T. apicularis* sp. nov.
   Cirrus with spinous introvert. 10
10. Cirrus introvert cylindrical . . . . . *T. maculata* sp. nov.
    Cirrus introvert not cylindrical 11
11. Cirrus introvert goblet-shaped, large. . *T. cypellum* sp. nov.*
    Cirrus introvert cone-shaped, small . . *T. keras* sp. nov.*

12. Introvert obviously spinous. 19
Introvert not obviously spinous (sometimes very tiny spines present) 13
13. Introvert present, but reduced 14
Introvert not present 16
14. Cirrus shaft short, broad, introvert strongly hooked . . . . . *T. unguiculus* sp. nov.
Cirrus shaft long, tapering, introvert not greatly curved 15
15. Introvert cylindrical, though very thin *T. acicularis* sp. nov.
Introvert a tiny scoop. . . . . *T. gracilis* sp. nov.
16. Cirrus shaft distally with flared rim 17
Cirrus shaft distally with a blunt point 18
17. Cirrus shaft funnel-shaped . . . . . *T. aspinosa* sp. nov.
Cirrus shaft cone-shaped . . . . . *T. gingrina* sp. nov.
18. Cirrus shaft not much longer than base width (1:1) . . . . . *T. apiculus* sp. nov.
Cirrus shaft much longer than base width (3:1) . . . . . *T. belone* sp. nov.
19. Cirrus introvert length normally <100µm. 20
Cirrus introvert length normally >100µm 27
20. Cirrus introvert very small, not obvious 21
Cirrus introvert prominent, obvious 22
21. Cirrus introvert slightly flared, small flame-like introvert, opening oblique . . . . . *T. flammula* sp. nov.
Cirrus introvert not flared, opening not (or very slightly) oblique . . . . . *T. minima* sp. nov.
22. Cirrus introvert opening transverse to oblique 23
Cirrus introvert opening very oblique 25
23. Cirrus introvert scoop-shaped . . . . *T. coughrani* sp. nov.
Cirrus introvert tending to cylinder-shaped. 24
24. Cirrus introvert cylinder to cone-shaped . *T. keras* sp. nov.*
Cirrus introvert cylinder to scoop-shaped, flame-shaped, shaft often curved. . . . . *T. fax* sp. nov.
25. Introvert swelling uneven, opening almost lateral . . . . . *T. bacrio* sp. nov.
Introvert swelling even, opening very oblique 26
26. Cirrus introvert relatively small (IlxIb c. 60x13µm) . . . . . *T. bacrioniculus* sp. nov.
Cirrus introvert relatively large (IlxIb c. 85x20µm) . . . . . *T. cestus* sp. nov.
27. Cirrus shaft long and narrow, introvert has a distinctly flared distal region (appears like a fly's proboscis) . . . . . *T. muscalingulata* sp. nov.
Cirrus not as above 28
28. Cirrus introvert hardly less wide than proximal shaft 29
Cirrus introvert bulbous (goblet-shaped) 30
29. Introvert with distinctive narrow distal region (tapered) . . . . . *T. possibilitas* sp. nov.
Introvert distal region not tapered . *T. comythus* sp. nov.
30. Cirrus with longer side of introvert on shorter side of shaft, large worms, pigment slightly punctate . . . . . *T. cypellum* sp. nov.*
Cirrus typical with short side of introvert on short side of shaft 31
31. Cirrus shaft proximally not much broader than distally (ratio <2:1) . . . . . *T. caliculus* sp. nov.
Cirrus shaft proximally much broader than distally (ratio >2:1). 32
32. Introvert swelling even 33
Introvert swelling uneven 34
33. Shaft funnel-shaped, flares proximally (Sb:Ib > 5:1) . . . . . *T. magna* sp. nov.
Shaft cone-shaped (Sb:Ib c. 3:1) . . . . *T. maxima* sp. nov.
34. Introvert length >200µm. . . . . *T. batiola*
Introvert length < 200µm . . . . . *T. fasciata*

*[Note: Some species key out in more than one couplet since pigment distribution is not always a consistent character].

Temnosewellia acicularis sp. nov.
(Fig. 19A–E)

ETYMOLOGY. From *acicularis* = like a needle (Latin); a reference to the thin needle-like cirrus.

MATERIAL. HOLOTYPE: QMG221094 (WM) from *Euastacus bidawalus* [QMW26588], Dingo Ck, crossing on Euchre Valley Drive, Lind NP, VIC (37°34.7'S 148°58.2'E), 20.03.2002, K.B. Sewell, S.H. Lawler & G.N. Edney, 100% alc/Un. PARATYPES: QMG221095–221096 (WM), 100% alc/Un. OTHER MATERIAL FROM TYPE LOCALITY: QMG221097 (WM), 100% alc/Un; QMG221098–221101 (CP), 100% alc/Fau. OTHER MATERIAL: From *Euastacus crassus*. ACT: [QMW26603], QMG220994–220995 (WM), Kangaroo Ck, rd crossing above Corin Dam, Namadgi NP, ACT (35°32.3'S 148°52.2'E) 16.10.1991,L.R.G. Cannon & K.B. Sewell, Bouin/Hx; QMG220996–220997 (WM), Form/Hx; QMG220998–221004 (CP), HW/Form/Fau.; QMG221005 (LS[10]) Bouin/H&E; QMG221006–221007 (LS[7,2]) Form/H&E.

DESCRIPTION. Characteristics of genus and with typical pattern of body pigment. Selected body measurements of type specimens from *Euastacus bidawalus* are: QMG221094 (H): B(2856 × 1938), LE(1979), PH(407 × 650), SD(894), PD(407); QMG221095 (P): B(4284 × 3386), LE(3223), PH(423 × 577), SD(1138), PD(642); QMG221096 (P): B(3529 × 2550), LE(2509), PH(537 × 862), SD(1179), PD(488).

Reproductive System. Male. Cirrus: Shaft cone-shaped. Introvert cylinder to scoop-shaped; distal opening very oblique. Swelling uneven, wider on introvert longer side, does not extend proximally past introvert base on either side(?). Selected cirrus measurements of specimens from *Euastacus bidawalus* from type locality are: QMG221098: S(894 × 71), I(37 × 10), IS(na × na); QMG221099: S(303 × 30), I(37 × 10), IS(na × na); QMG221100: S(350 × 33), I(37 × 9), IS(na × na).

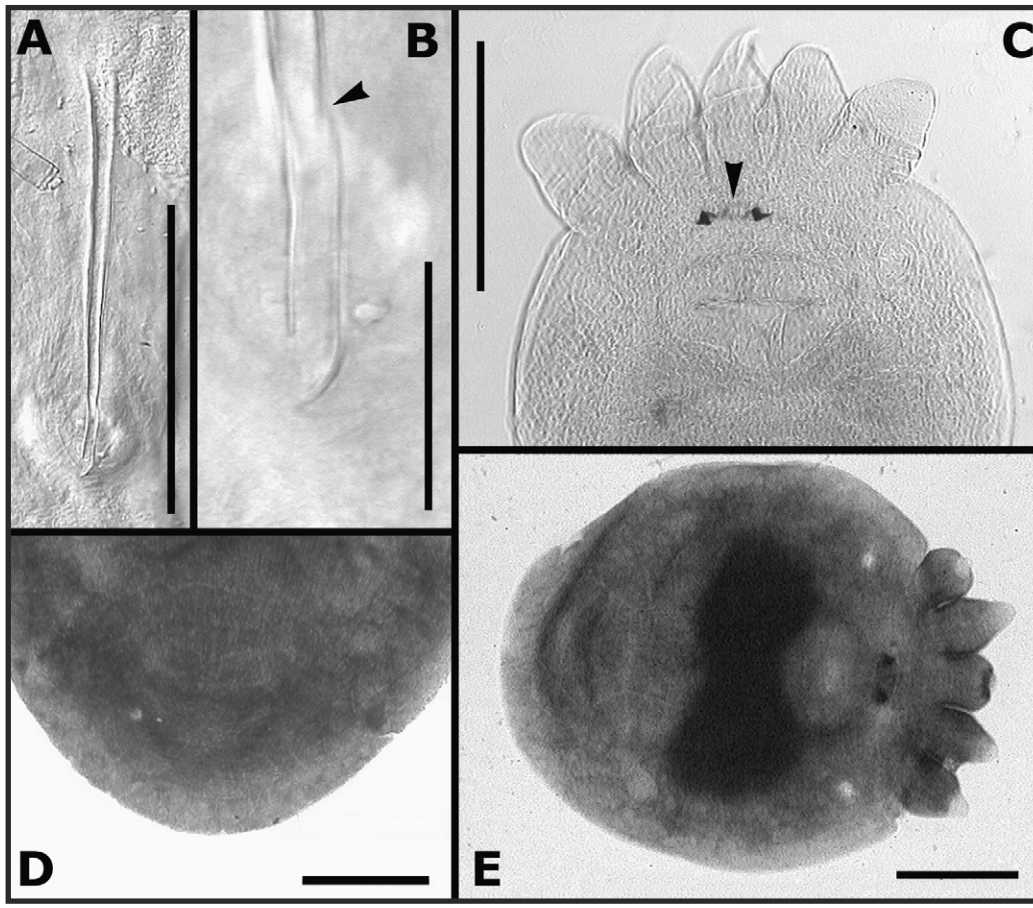


FIG. 19. *Temnosewellia acicularis* sp. nov. A-B, Nomarski interference contrast photomicrographs of Faure's preparations. A, QMG221099, whole cirrus, scale = 250µm; B, QMG221099, introvert showing the introvert base (arrowhead), scale = 50µm; C, QMG221097, anterior end of small worm showing lack of body pigment except for a thin scatter of pigment between eyes (arrowhead), scale = 500µm; D, QMG221098, posterior end of large worm showing typical dorsal body pigment distribution, compare with C. Scale = 1mm; E, QMG221095, adult worm showing typical pattern of body pigment, scale = 1mm.

HOSTS. *Euastacus bidawalus*, *E. crassus*.

DISTRIBUTION. ACT — from Namadgi NP, near Corin Dam at Kangaroo Ck. North-eastern VIC — from east Gippsland, Lind NP at Dingo Ck.

REMARKS. Small worms have little body pigment except for the region around the eyes (Fig. 19C). The cirrus of this species is very slender and details of the introvert especially the swelling are difficult to resolve. The spines are very tiny and at the limits of LM resolution. The cirrus is superficially similar to that of *Temnosewellia gracilus* sp. nov., but is smaller overall, with a longer and narrower introvert.

Temnosewellia alba sp. nov.
(Fig. 20A–D)

ETYMOLOGY. From *albus* = white (Latin); a reference to the colour of this non-pigmented worm.

MATERIAL. HOLOTYPE: QMG220333 (WM), from *Euastacus* c.f. *balanensis* [QMW26595] Mt Bartle Frere, South Peak, Summit Ck beside 'Top Western' campsite, Wooroonooran NP, Qld (17°23.8'S 145°48.9'E), 27.11.1995, N. Connolly, 70% alc(?)/Un. PARATYPES: QMG220334 (WM), 70% alc(?)/Un; [QMW26594], QMG220335–220337 (WM), Jun. 2002, D. Blair, D. Hansman, K.B. Sewell & M.S. Bryant, 100% alc/Un. OTHER MATERIAL FROM TYPE LOCALITY: [QMW26594], QMG220338–220339 (WM), Jun.

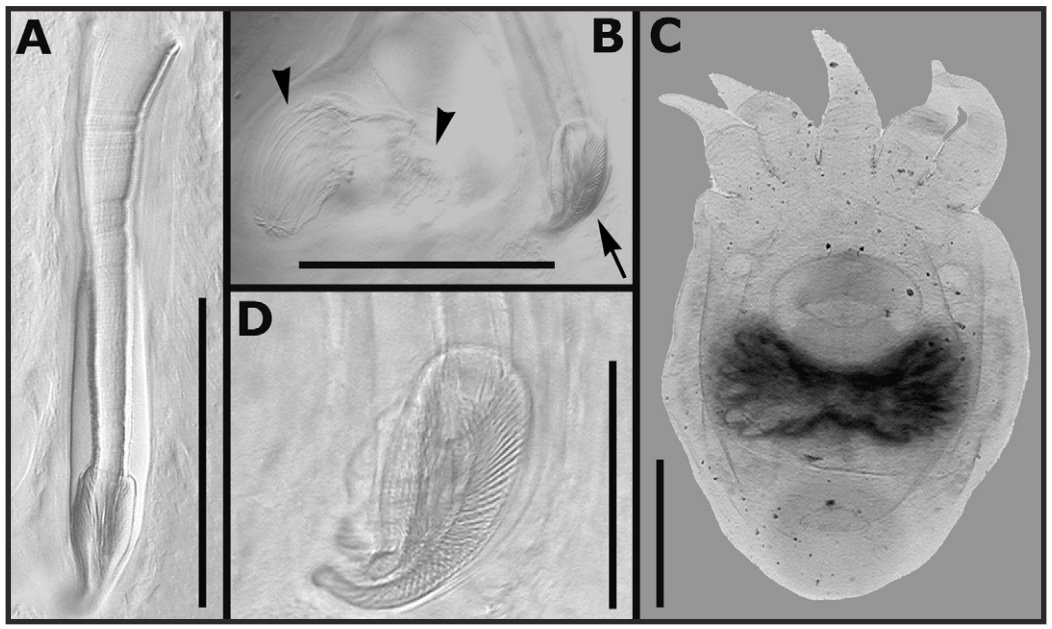


FIG. 20. *Temnosewellia alba* sp. nov. A-B, D. Nomarski interference contrast photomicrographs of Faure's preparations from *Euastacus* c.f. *balanensis*. A, QMG220343, whole cirrus, scale = 250µm; B, QMG2203432, introvert distal region (arrow) and weak sclerotisation in the distal vagina (arrowheads), scale = 250µm; C, QMG220334, adult worm (unstained) showing lack of dorsal body pigment, scale = 1mm; D, QMG220344, introvert, scale = 50µm.

2002, D. Blair, D. Hansman, K.B. Sewell & M.S. Bryant, 100% alc/Un; [QMW26595], QMG220340–220341 (WM), 27.11.1995, N. Connolly, 70% alc(?)/Un; [QMW26594], QMG220342–220345 (WM), Jun.2002, D. Blair, D. Hansman, K.B. Sewell & M.S. Bryant, 100% alc/Fau; [QMW26595], QMG220346–220357 (WM), 27.11.1995, N. Connolly, 70% alc(?)/Fau. OTHER MATERIAL. From *Euastacus balanensis*. Qld: [QMW26587], QMG220358–220361 (WM), Mt Haig, Kairi Ck trib., Lamb Ra. SF (17°06.0'S 145°35.5'E), 3.06.2002, D. Blair, D. Hansman, K.B. Sewell & M.S. Bryant, 100% alc/Un; [QMW17241 & QMW26677], QMG220362 (WM), 27.09.1990, L.R.G. Cannon & K.B. Sewell, Form-Acetic/Hx; [QMW26587], QMG220363 (WM), 3.06.2002, D. Blair, D. Hansman, K.B. Sewell & M.S. Bryant, 100% alc/Un; QMG220364–220369 (CP), 100% alc/Fau.

From *Euastacus fleckeri*. Qld: [QMW26611], QMG220370 (WM), Mt Lewis, Leichhardt Ck trib., at cement rd crossing above old forestry camp, Daintree River NP, Qld (16°35.8'S 145°16.7'E), 4.06.2002, D. Blair, D. Hansman, K.B. Sewell & M.S. Bryant, 100% alc/Un; QMG220371 (CP), Fau.

DESCRIPTION. Characteristics of genus but lacking body pigment. Selected body measurements of type specimens from *Euastacus* c.f. *balanensis* are: QMG220333 (H): B(3366 × 2224), LE(2040), PH(653 × 796), SD(796), PD(367); QMG220334 (P): B(3835 × 2407), LE(2448), PH(796 × 1040), SD(959), PD(510); QMG220335 (P): B(2591 × 1673), LE(1836), PH(469 × 694), SD(857), PD(286); QMG220336 (P): B(2203 × 1775), LE(1754), PH(510 × 694), SD(530), PD(265); QMG220337 (P): B(2509 × 1979), LE(1754), PH(510 × 694), SD(530), PD(265).

Reproductive System. Male. Cirrus: Shaft cone-shaped. Introvert scoop-shaped; distal opening very oblique, often folded into hourglass or irregular shape. Swelling near even, extends proximally well past introvert base on both sides (sometimes along almost entire length of narrow tubular distal region of shaft?). Selected cirrus measurements of specimens from *Euastacus* c.f. *balanensis* from type locality are: QMG220343: S(348 × 77), I(159 × 30), IS(169 × 159); QMG220344: S(553 × 183), I(161 × 33), IS(423 x 276); QMG220345: S(335 × 63), I(142 × 30), IS(148 X. 152).

HOSTS. *Euastacus balanensis, E.* c.f. *balanensis, E. fleckeri*.

DISTRIBUTION. North-eastern Qld — from the Atherton Tableland region, W of Cairns, at Mt Bartle Frere and Mt Haig; and from Mt Lewis, W of Mossman.

REMARKS. This worm reaches a relatively large size with specimens collected from the type locality being greater than 5 mm body length. Several large specimens were observed to occasionally have a very thin, short tracery of pigment posterior to one or both eyes. This worm has the largest cirrus of all the northern Queensland species. The cirrus is closest to *Temnosewellia arga* sp. nov. though the introvert is proportionally larger than in the latter. The weakly sclerotised inner surface of the distal vagina in Faures's medium has a finely ruffled appearance, but lacks teeth.

Temnosewellia albata sp. nov.
(Fig. 21A–F)

ETYMOLOGY. From *albatus* = dressed in white (Latin); a reference to the colour of this non-pigmented worm.

MATERIAL. HOLOTYPE: QMG220414 (WM), from *Euastacus robertsi* [QMW26646], Mt Finnigan, Horans Ck [trib of Annan R], Cedar Bay NP, Qld (15°49.1'S 145°16.7'E), 5.06.2002, L. Roberts, D. Blair, D. Hansman, K.B. Sewell & M.S. Bryant, 100% alc/Un. PARATYPES: QMG220415–220417 (WM), 100% alc/Un; [QMW5323–5324], QMG220418 (WM) 27–29.11.1975, L. Roberts, R. Monroe & G. Ingram. OTHER MATERIAL FROM TYPE LOCALITY: [QMW26646], QMG220419–220420 (WM), 5.06.2002, L.Roberts, D. Blair, D. Hansman, K.B. Sewell & M.S. Bryant, 100% alc/Un; [QMW5323–5324], QMG220421 (WM), 27–29.11.1975, L. Roberts, R. Monroe & G. Ingram, 70% alc(?)/Hx; [QMW26646], QMG220422–220427 (CP), 5.06.2002, L. Roberts, D. Blair, D. Hansman, K.B. Sewell & M.S. Bryant, 100% alc/Fau; [QMW5323–5324], QMG220428 (LS[2]), 27–29.11.1975, L. Roberts, R. Monroe & G. Ingram, 70% alc(?)/H&E. OTHER MATERIAL: From *Euastacus robertsi.* Qld: [QMW26647], QMG220429 220431 (WM), Mt Finnigan, Parrot Ck trib., Cedar Bay NP (15°49.4'S 145°16.5'E), 5.06.2002, L. Roberts, D. Blair, D. Hansman, K.B. Sewell & M.S. Bryant, 100% alc/Un; QMG220434–220435 (CP), 100% alc/Fau.

From *Cherax depressus* complex *sensu* Riek, 1951. Qld: [QMW26578] QMG221185 (CP), Mt Elliot, upper North Ck, Cape Bowling Green NP (19°28.1'S 146°57.9'E), 30.05.2002, K.B. Sewell & M.S. Bryant, 100% alc/Fau.

DESCRIPTION. Showing characteristics of genus but lacking body pigment except for the eyes. Selected body measurements of type specimens from *Euastacus robertsi* are: QMG220414 (H): B(2672 × 1673), LE(1795), PH(510 × 734), SD(673), PD(326); QMG220415 (P): B(2387 × 1306), LE(1632), PH(530 × 653), SD(592), PD(245); QMG220416 (P): B(2448 × 1734), LE(1734), PH(510 × 755), SD(612), PD(306); QMG220417 (P): B(2081 × 1693), LE(1550), PH(551 × 816), SD(530), PD(306); QMG220418 (P): B(2652 × 1530), LE(1754), PH(673 × 796), SD(469), PD(306).

Reproductive System. Male. Cirrus: Shaft cone-shaped. Introvert scoop shaped; distal opening very oblique, large. Swelling uneven, extends proximally well past introvert base on longer side (swelling on shorter side not observed clearly). Selected cirrus measurements of specimens from *Euastacus robertsi* from type locality are: QMG220422: S(352 × 77), I(63 × 14), IS (116 × na); QMG220424: S(321 × 77), I(71 × 16), IS (152 × 110(?)); QMG220425: S(301 × 55), I(71 × 16), IS (89 × 91(?)); QMG220426: S(325 × 71), I(71 × 16), IS (126 × 91(?)).

HOSTS. *Cherax depressus* complex *sensu* Riek, 1951, *Euastacus robertsi.*

DISTRIBUTION. North-eastern Qld — from S of Cooktown, at Mt Finnigan NP; and from the Townsville region, Cape Bowling Green NP, Mt Elliot, at upper North Ck.

REMARKS. The cirrus is similar to that of *Temnosewellia argilla* sp. nov. and *T. aspra* sp. nov., but is slightly smaller than the first and slightly larger than the second; furthermore the swelling is uneven, unlike the other two. The extent of the introvert swelling on the shorter side was consistently difficult to resolve with confidence.

The inner lining of the distal vagina, although sometimes obvious in Faure's preparations, is clearly far less sclerotised than that found in *Temnohaswellia* species.

We have included here the single specimen collected from a representative of the *Cherax depressus* complex at Mt Elliot. No temnocephalans were found on any of several small specimens of *Euastacus bindal* collected there as part of this study, nor from any specimens of this host lodged in the QM collections. We suspect, however, that *Temnosewellia albata* sp. nov. will eventually be shown to be associated with *Euastacus bindal* at Mt Elliot, given the fact the the worm is present in the ecosystem.

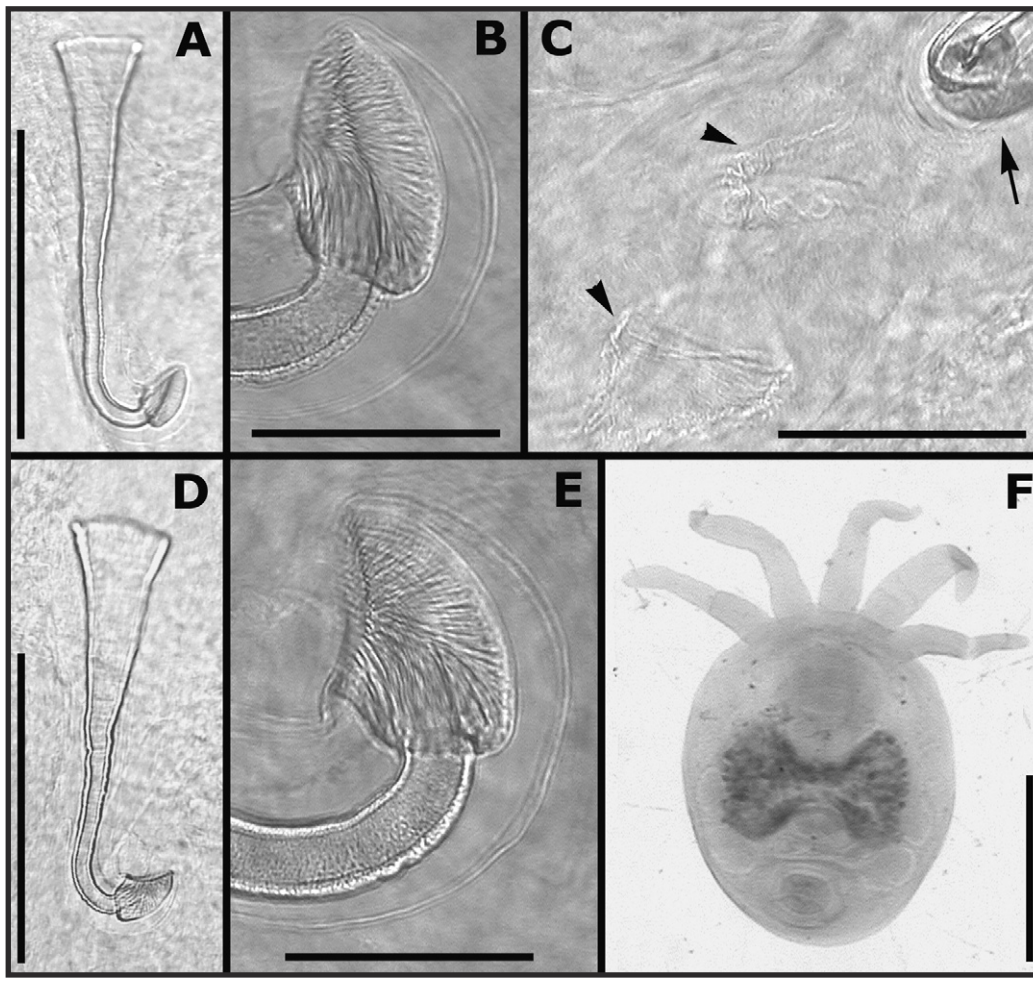


FIG. 21. *Temnosewellia albata* sp. nov. A–C. Nomarski interference contrast photomicrographs of Faure's preparations from *Euastacus robertsi*. A, QMG220423, whole cirrus, scale = 250µm; B, QMG220423, introvert, scale = 50µm; C, QMG220422, introvert distal region (arrow) and weak sclerotisation in the distal vagina (arrowheads), scale = 100µm; D, E. Nomarski interference contrast photomicrographs of Faure's preparations from *Cherax depressus*; D, QMG221185, whole cirrus, scale = 250µm; E, QMG221185, introvert, scale = 50µm; F, QMG220418, adult worm showing lack of dorsal body pigment, scale = 1mm.

Temnosewellia aphyodes sp. nov.
(Fig. 22A–C)

ETYMOLOGY. From *aphyodes* = whitish (Greek); a reference to the colour of this non-pigmented worm.

MATERIAL. HOLOTYPE: QMG220447 (WM), from *Euastacus fleckeri* [QMW26611], Mt Lewis, Leichhardt Ck trib., at Cement Rd crossing above old forestry camp, Daintree River NP, Qld (16°35.8'S 145°16.7'E), 4.06.2002, D. Blair, D. Hansman, K.B. Sewell & M.S. Bryant, 100% alc/Un. PARATYPES: QMG220448–220449 (WM), 100% alc/Un; [QMW26616], QMG220450 (WM), 26.09.1990, L.R.G. Cannon & K.B. Sewell, Carn/Hx. OTHER MATERIAL FROM TYPE LOCALITY: [QMW26611], QMG220451–220459 (CP), 4.06.2002, D. Blair, D. Hansman, K.B. Sewell & M.S. Bryant, 100% alc/Fau; [QMW26616], QMG220460 (CP), 26.09.1990, L.R.G. Cannon & K.B. Sewell, Carn(?)/Hx.

OTHER MATERIAL. From *Euastacus fleckeri*. Qld: [unreg. host], QMG220461–220462 (WM), Mt Lewis, in rain forest stream, (16°35'S 145°17'E), Jan. 1986, L. Winsor, 70% alc(?)/Hx; [QMW26613], QMG220469 (CP) Mt Lewis (16°35'S 145°17'E), 14.01.1990, ANZSES Expedition Daintree Falls

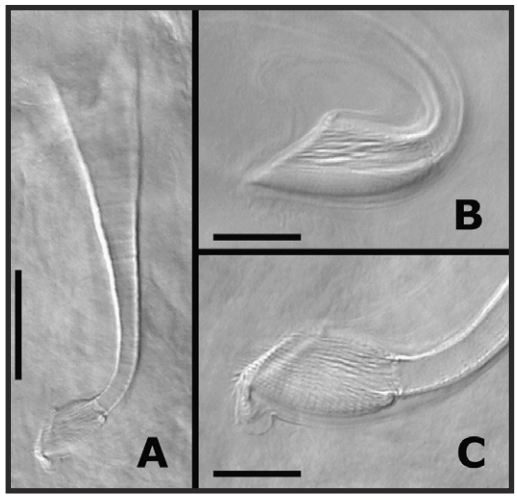


FIG. 22. *Temnosewellia aphyodes* sp. nov. A–C. Nomarski interference contrast photomicrographs of Faure's preparations from *Euastacus fleckeri*. A, QMG220455, whole cirrus, scale = 50µm; B, QMG220451, introvert, scale = 20µm; C, QMG220455, introvert, scale = 20µm.

1989/90, 70% alc(?)/Fau; QMG220463 (LS[1]); [QMW26612], QMG220464–220465 (WM), Dollins Ck, headwaters of Mossman R. (16°28'S 145°16'E) 23.12.1989, G.B. Monteith, 70% alc(?)/Hx; [QMW26615], QMG220466–220468 (WM), Pauls Luck, junction of Doolins & Platypus Cks, Daintree NP (16°26.5'S 145°15.2'E) 1.01.1990, ANZSES Expedition Daintree Falls, 70% alc(?)/Hx; QMG220470 (LS[1]), 70% alc(?)/H&E; [QMW26614], QMG220471 (WM), upper Cow Creek, 1.5km NE Mt Spurgeon (16°26'S 145°13'E) 21.10.1991, L. Roberts, 70% alc(?)/Hx; [QMW26618], QMG220472 (WM), upper Stewart Creek, 4 km NNE Mt Spurgeon (16°24'S 145°13'E), 20.10.1991, Monteith G.B. & Janetzki H., 70% alc(?)/Hx; [QMW26617], QMG220473–220474 (WM), upper Stony Creek, 2.5km NE Mt Spurgeon (16°22'S 145°13'E), 15.10.1991, G.B. Monteith & H. Janetzki, 70% alc(?)/Hx; QMG220475–220476 (LS[2,2]), 70% alc(?)/Hx; [unreg. host], QMG220477 (WM), Carbine (Hill?), NQ Tableland (16°31'S 145°08'E), 30.11.1990, Monteith G.B. & party, 70% alc(?)/Hx.

DESCRIPTION. Characteristics of genus but lacking body pigment. Selected body measurements of type specimens from *Euastacus fleckeri* are: QMG220447 (H): B(2672 × 1275), LE(1652), PH(408 × 500), SD(439), PD(224); QMG220448 (P): B(1520 × 816), LE(1061), PH(235 × 296), SD(367), PD(163); QMG220449 (P): B(1754 × 1040), LE(1204), PH(286 × 357), SD(286), PD(122); QMG220450 (P): B(2122 × 1122), LE(1469), PH(265 × 520), SD(551), PD(245).

Reproductive System. Male. Cirrus: Shaft cone-shaped. Introvert scoop-shaped; distal opening very oblique, often folded into hourglass or irregular shape. Swelling near-even, extends proximally slightly past introvert base on both sides, slightly further on longer side. Selected cirrus measurements of specimens from *Euastacus fleckeri* from type locality are: QMG220451: S(173 × 33), I(41X 8), IS(24 × 12); QMG220455: S(183 × 47), I(45X 8), IS(16 × 6); QMG220457: S(157 × 39), I(39X 8), IS(27 × na); QMG220459: S(150 × 39), I(45X 9), IS(16 × 16).

HOST. *Euastacus fleckeri*.

DISTRIBUTION. North-eastern Qld — from the region W of Mossman, in the areas of Mt Spurgeon, Mt Lewis and Mt Carbine.

REMARKS. This species has the smallest cirrus of all the northern Queensland species and its small size makes observation of fine details of the introvert difficult. The cirrus was often strongly curved in Faure's medium, but the cirrus of the holotype WM is straight. The cirrus is closest to that of *Temnosewellia aspra* sp. nov., but is slightly smaller overall and the introvert swelling, unlike that of *T. aspra* sp. nov., is short on both sides of the shaft.

Temnosewellia apiculus sp. nov.
(Fig. 23A–G)

ETYMOLOGY. From *apiculus* = a little apex (Latin); a reference to the small pointed structure at the apex of the cirrus shaft.

MATERIAL. HOLOTYPE: QMG221102 (WM), from *Euastacus kershawi* [QMW26630], Labertouche Ck (Tarago R. trib.), on Old Telegraph Rd, W of Jindivick, VIC (38°03.2'S 145°50.1'E), 21.03.2002, K.B. Sewell, S.H. Lawler & G.N. Edney, 100% alc/Un. PARATYPES: QMG221103–221107 (WM), 100% alc/Un. OTHER MATERIAL FROM TYPE LOCALITY: From *Euastacus kershawi.*VIC: [QMW26630], QMG221108–221116 (CP), 100% alc/Fau.

From unknown host. VIC: [unreg. host], NMVF 93838 (WM), Neerim, (37°58'S 145°57'E), 10.04.1906, Fulton S.W, unknown fixative/carmine(?).

From 'freshwater cray' VIC: [unreg. host], NMVF 93839–93841 (WM), Moe River, VIC, (38°11'S 145°59'E), 4.12.1886, unknown fixative/carmine(?); NMVF 93842–93845 (CP), unknown fixative/Fau;

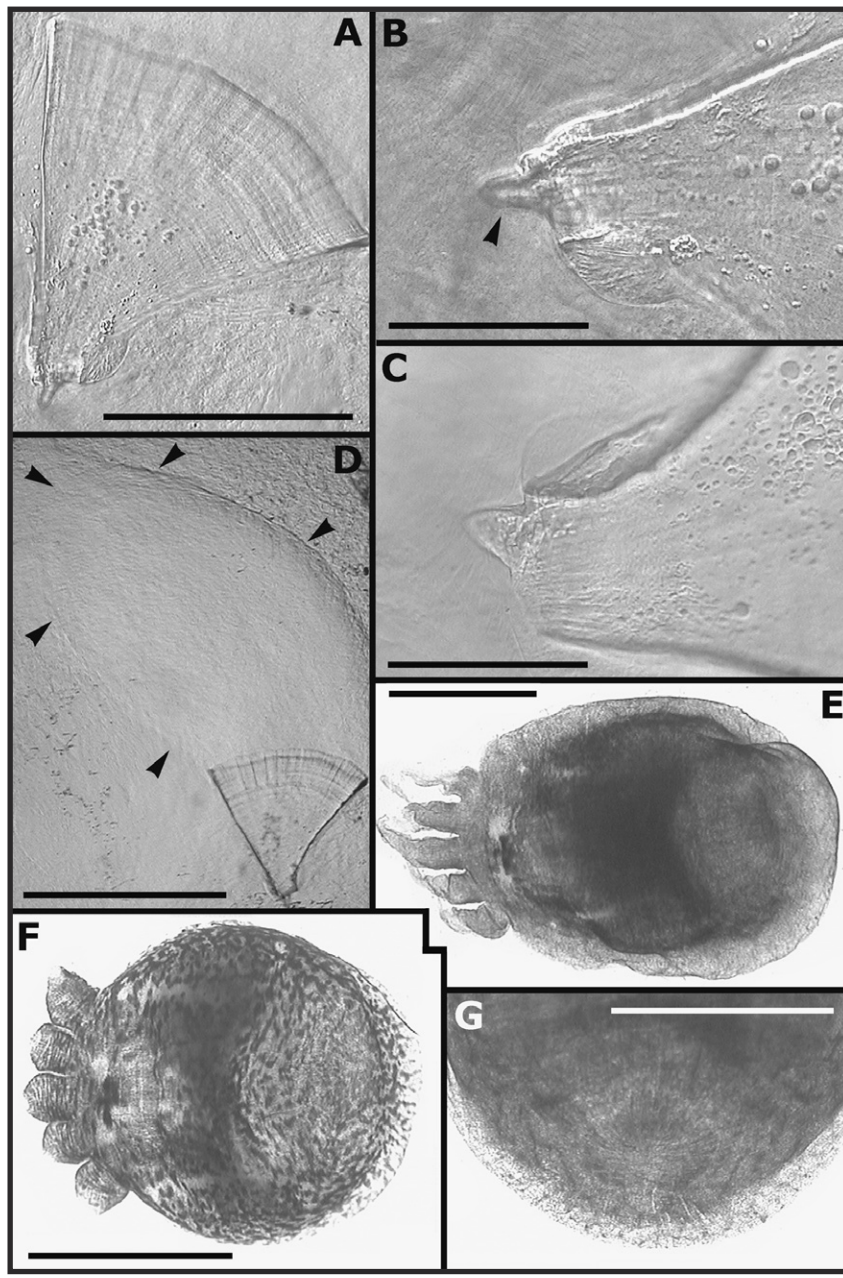


FIG. 23. *Temnosewellia apiculus* sp. nov. A–D. Nomarski interference contrast photomicrographs of Faure's preparations. A, QMG221112, whole cirrus, scale = 200µm; B, QMG221112, introvert showing the apical pointed structure (arrowhead), scale = 100µm; C, QMG221110, introvert showing the apical pointed structure, scale = 100µm; D, QMG221112, whole cirrus showing the large copulatory bulb (arrowheads). Scale = 500µm; E, QMG221105, dorsal view of worm showing non-punctate body pigment, scale = 2mm; F, QMG221107, dorsal view of worm showing punctate body pigment, scale = 2mm; G, GMG221108, posterior end of worm showing slightly punctate body pigment in the lateral margins of the body, scale = 2mm.

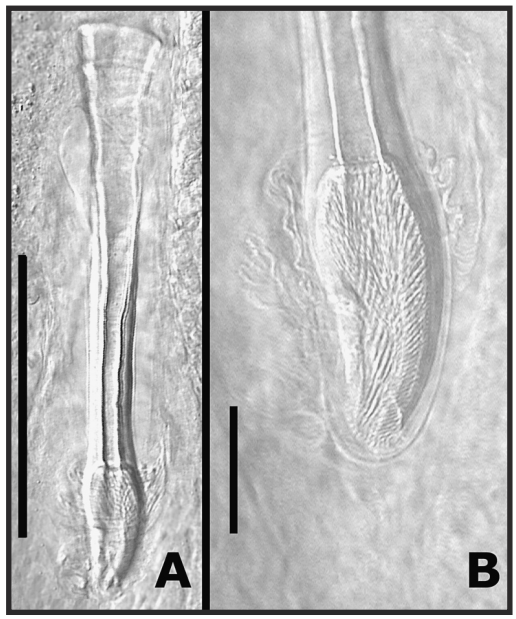


FIG. 24. *Temnosewellia arga* sp. nov. A-B, Nomarski interference contrast photomicrographs of Faure's preparations from *Euastacus yigara*. A, QMG220377, whole cirrus, scale = 250µm; B, QMG220377, introvert, scale = 20µm.

NMVF 93846–93851 (LS[6,4,6,6,7,5), unknown fixative/H&E(?).

DESCRIPTION. Characteristics of genus; pattern of pigmention variable often typical but occasionally punctate. Selected body measurements of type specimens from *Euastacus kershawi* are: QMG221102 (H): B(7426 × 3366), LE(6120), PH(734 × 1020, SD(1734), PD(877); QMG221103 (P): B(6079 × 2815), LE(4937), PH(714 × 836), SD(1428, PD(408); QMG221104 (P): B(6059 × 3754), LE(4427), PH(775 × 1040), SD(1734), PD(653); QMG221105 (P): B(6100 × 3733), LE(4529), PH(775 × 1020), SD(1836, PD(571); QMG221106 (P): B(6814 × 3101), LE(5284), PH(653 × 918), SD(1734), PD(714).

Reproductive System. Male. Cirrus: Shaft cone-shaped with wide proximal opening. Introvert lacks spined region, but has apical pointed structure (about 40 long) attached to introvert base. Swelling not observed [absent?]. Selected cirrus measurements of specimens from *Euastacus kershawi* from type locality are: QMG221109: S(372 × 453), I(- × 53), IS(na × na); QMG221110: S(447 × 407), I(- × 69), IS(na × na); QMG221111: S(244 × 193), I(- × 53), IS(na × na); QMG221112: S(321 × 392), I(- × 53), IS(na × na); QMG221113: S(370 × 372), I(- × 61), IS(na × na).

HOST. *Euastacus kershawi*.

DISTRIBUTION. From the central Gippsland region of VIC.

REMARKS. This worm is large, reaching close to 7.5mm body length. The pigment pattern is slightly variable (Figs 23E–F). Some specimens, not necessarily the largest, have only a slightly punctate pattern, most noticable in the lateral margins of the body (Fig. 23G). The cirrus nevertheless is unlike any other and serves to readily distinguish this species. It lacks an introvert but has in its place (apparently), an apical, pointed structure that lacks spines. The copulatory bulb is extremely large relative to the size of the cirrus (Fig. 23D). The wide proximal opening of the cirrus of this species was observed to widen even more over time when placed in Faure's medium.

Temnosewellia arga sp. nov.
(Fig. 24A–B)

ETYMOLOGY. From *arga* = white (Latinised Greek); a reference to the colour of this non-pigmented worm.

MATERIAL. HOLOTYPE: QMG220372 (WM), from *Euastacus yigara* [QMW26675], O'Leary Ck, trib. of the upper Tully R., at Old Culpa Rd concrete causeway, Koombooloomba FR, Qld (17°57.0'S 145°39.1'E), 31.05.2002, D. Blair, D. Hansman, K.B. Sewell & M.S. Bryant, 100% alc/Un. PARATYPES: QMG220373–220376 (WM), 100% alc/Un. OTHER MATERIAL FROM TYPE LOCALITY: QMG220377–220381 (CP), 100% alc/Fau; QMG220863 (CP), 100% alc/Fau.

DESCRIPTION. Characteristics of genus but lacking body pigment. Selected body measurements of type specimens from *Euastacus yigara* are: QMG220372 (H): B(2876 × 1632), LE(1693), PH(449 × 653, SD(632), PD(245); QMG220373 (P): B(2489 × 1734), LE(1652), PH(510 × 653), SD(612), PD(265); QMG220374 (P): B(2754 × 1652), LE(2040), PH(510 × 653), SD(673), PD(286); QMG220375 (P): B(2407 × 1734), LE(1693), PH(428 × 673), SD(571), PD(286); QMG220376 (P): B(2836 × 1754), LE(1877), PH(530 × 714), SD(612), PD(326).

Reproductive System. Male. Cirrus: Shaft cone-shaped. Introvert scoop-shaped; distal opening very oblique, often folded into hourglass or irregular shape. Swelling even, extends proximally well past introvert base on both sides (along entire length of narrow tubular distal

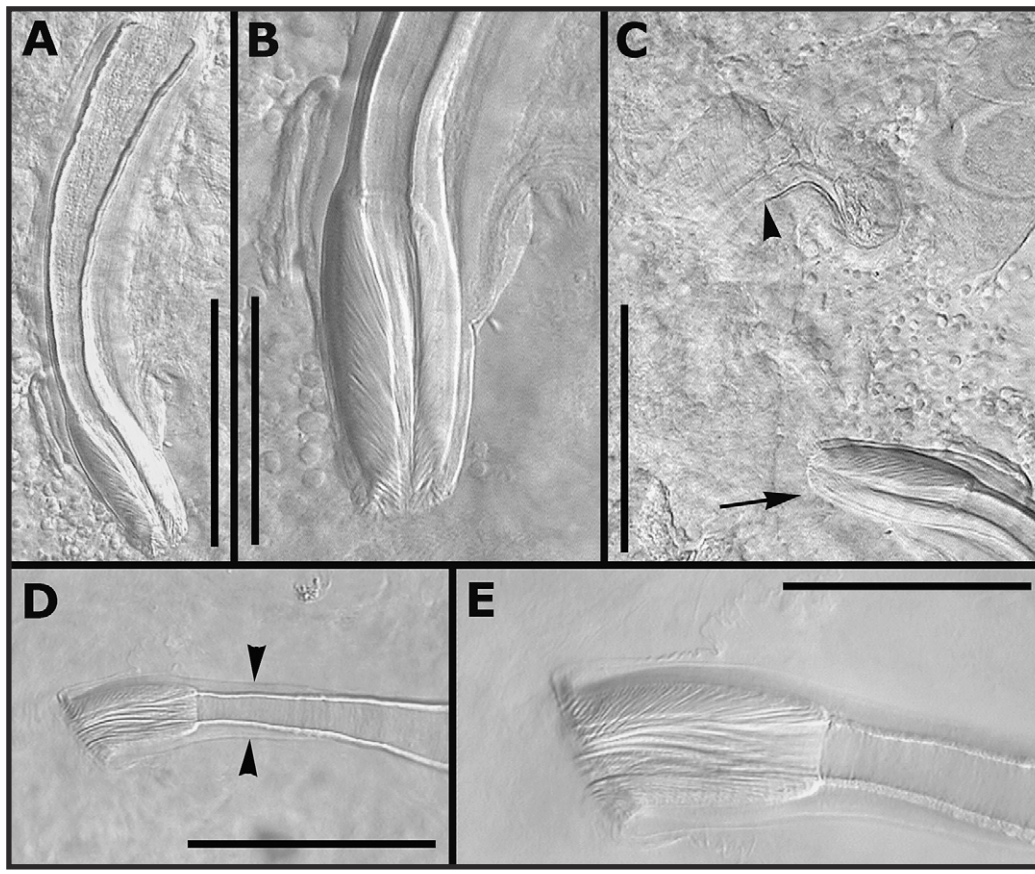


FIG. 25. *Temnosewellia argeta* sp. nov. A–C, Nomarski interference contrast photomicrographs of Faure's preparations from *Euastacus yigara*. A, QMG220485, whole cirrus, scale = 100μm; B, QMG220485, introvert, scale = 50μm; C, QMG220485, introvert distal region (arrow) and weak sclerotisation in the distal vagina (arrowhead), scale = 100μm; D–E, Nomarski interference contrast photomicrographs of Faure's preparations from *Cherax parvus*; D, QMG221186, cirrus distal region showing the near even introvert swelling swelling (arrowheads), scale = 100μm; E, QMG221186, introvert partially everted, scale = 50μm.

region of shaft). Selected cirrus measurements of specimens from *Euastacus yigara* from type locality are: QMG220377: S(386 × 77), I(124 × 19), IS(209 × 254); QMG220378: S(417 × 93), I(130 × 19), IS(234 × 250); QMG220380: S(419 × 75), I(118 × 20), IS(228 × 209); QMG220381: S(362 × 65), I(118 × 21), IS(189 × 224).

HOST. *Euastacus yigara*.

DISTRIBUTION. North-eastern Qld — from the Cardwell Ra., at O' Leary Ck, a tributary of the upper Tully R., in Koombooloomba FR.

REMARKS. The cirrus is most similar to that of *Temnosewellia alba* sp. nov. but is slightly smaller with a relatively smaller introvert.

Temnosewellia argeta sp. nov.
(Fig. 25A–E)

ETYMOLOGY. From *argetos* = white (Greek); a reference to the colour of this non-pigmented worm.

MATERIAL. HOLOTYPE: QMG220478 (WM), from *Euastacus yigara* [QMW18121], O'Leary Ck, trib. of the upper Tully R., at Old Culpa Rd concrete causeway, Koombooloomba FR, Qld (17°57.0'S 145°39.1'E), 7.11.1992, J.W. Short & P.J.F. Davie, Bouin/Un. PARATYPES: QMG220479–220482 (WM), Bouin/Un. OTHER MATERIAL FROM TYPE LOCALITY: QMG220483–220487 (CP), HW/Form/Fau; from *Cherax parvus* [QMW26639], QMG221186–221190 (CP), 31.05.2002, D. Blair, D. Hansman, K.B. Sewell & M.S. Bryant, 100% alc/Un.

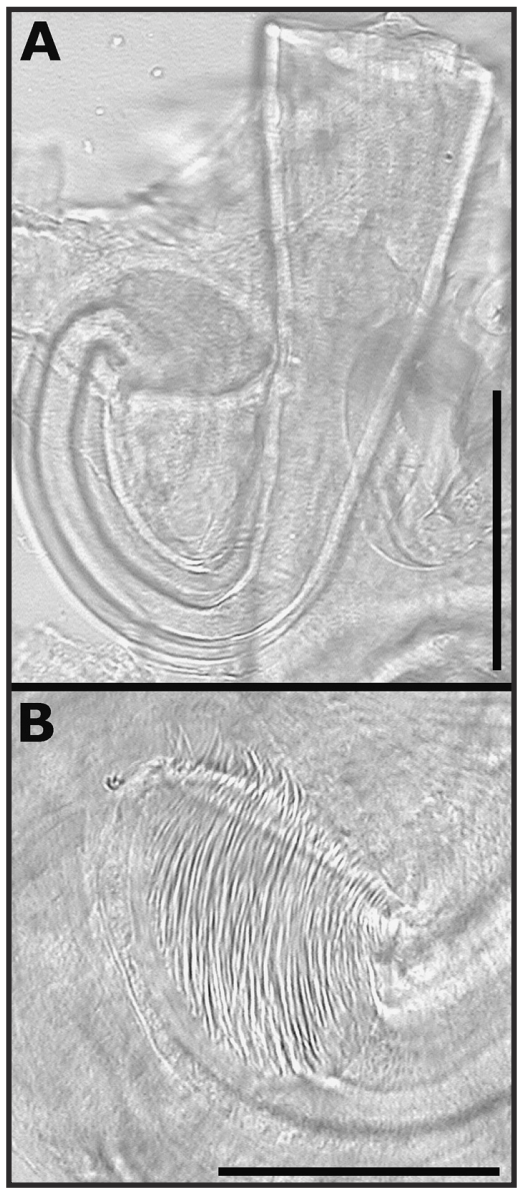


FIG. 26. *Temnosewellia argilla* sp. nov. from *Euastacus fleckeri.* A-B, Nomarski interference contrast photomicrographs of Faure's preparations. A, QMG220385, whole cirrus, scale = 100µm; B, QMG220385, introvert, scale = 50µm.

DESCRIPTION. Characteristics of genus but lacking body pigment. Selected body measurements of type specimens from *Euastacus yigara* are: QMG220478 (H): B(1098 × 732), LE(789), PH(163 × 301), SD(260), PD(130); QMG220479 (P): B(1024 × 659), LE(732), PH(171 × 293), SD(285), PD(114); QMG220480 (P): B(1049 × 691), LE(837), PH(203 × 301), SD(268), PD(122); QMG220481 (P): B(1406 × 927), LE(854), PH(195 × 366), SD(309), PD(154); QMG220482 (P): B(1033 × 789), LE(715), PH(220 × 341), SD(285), PD(126).

Reproductive System. Male. Cirrus: Shaft cone-shaped. Introvert cylinder to scoop-shaped; distal opening oblique. Swelling near-even, extends proximally well past introvert base on both sides, slightly further on shorter side. Selected cirrus measurements of specimens from *Euastacus yigara* are: QMG220483: S(193 × 37), I(67 × 14), IS(57 × 63); QMG220484: S(181 × 35), I(63 × 13), IS(45 × 45); QMG220485: S(171 × 33), I(63 × 13), IS(37 × 45); QMG220486: S(173 × 30), I(69 × 12), IS(59 × 37).

HOSTS. *Cherax parvus*, *Euastacus yigara*.

DISTRIBUTION. North-eastern Qld — from the Cardwell Ra., at O' Leary Ck, a tributary of the upper Tully R., in Koombooloomba FR.

REMARKS. *Temnosewellia argeta* sp. nov. is similar to the other non-pigmented north Queensland species. The cirrus is most like that of *T. aspra* sp. nov., but the introvert lacks the very oblique opening of the latter.

We found *Temnosewellia argeta* sp. nov. on both *Euastacus yigara* and *Cherax parvus* at the O'Leary Ck site. These two species of crayfish as well as the shrimps *Caridina zebra* Short, 1993 and *Macrobrachium* sp. are sympatric at this locality (Short & Davie, 1993). The latter two species listed were not, however, examined for temnocephalans.

Temnosewellia argilla sp. nov.
(Fig. 26 A–B)

ETYMOLOGY. From *argilla* = white clay, potter's clay (Latin, feminine); a reference to the colour of this non-pigmented worm.

MATERIAL. HOLOTYPE: QMG220382 (WM), from *Euastacus fleckeri* [QMW26616], Mt Lewis, Leichhardt Ck trib., at cement rd crossing above old forestry camp, Daintree River NP, Qld (16°35.8'S 145°16.7'E), 26.09.1990, L.R.G. Cannon & K.B. Sewell, Form-Acetic/Hx. PARATYPES: QMG220383–220384 (WM), Carn/Hx. OTHER MATERIAL FROM TYPE LOCALITY: QMG220385–220387, (CP) Form(?)/Fau. OTHER MATERIAL. From *Euastacus fleckeri.* Qld: [QMW26613], QMG220388–220389

(WM), Mt Lewis (16°35'S 145°17'E), 14.01.1990, ANZSES Expedition to Daintree Falls, 70% alc(?)/Hx; QMG220390–220392 (LS[3,3,4]), 70% alc(?)/H&E; [unreg. host], QMG220393 (WM), Mt Lewis (16°35'S 145°17'E), Jan. 1986, L. Winsor, 70% alc(?)/Hx; QMG220394 (LS[1]); [QMW26615], QMG220395 (WM), Pauls Luck, junction of Doolins & Platypus Cks, Daintree NP (16°26.5'S 145°15.2'E), 1.01.1990, ANZSES Expedition to Daintree Falls, 70% alc(?)/Hx; QMG220396–220398 (CP), 70% alc(?)/Fau; QMG220399–220402 (LS[1,2,4,2]), 70% alc(?)/H&E; [QMW26614], QMG220403–220404 (WM), upper Cow Creek, 1.5km NE Mt Spurgeon (16°26'S 145°13'E) 21.10.1991, L. Roberts, 70% alc(?)/Hx; QMG220405 (CP) 70% alc(?)/Fau; QMG220406–220407 (LS[2,1]), 70% alc(?)/H&E; [QMW26618], QMG220408–220409 (WM), upper Stewart Creek, 4 km NNE Mt Spurgeon (16°24'S 145°13'E), 20.10.1991, G.B. Monteith & H. Janetzki, 70% alc(?)/Hx; [QMW26612], QMG220410 (CP), Dollins Ck, headwaters of Mossman R. (16°28'S 145°16'E), 23.12.1989, G.B. Monteith, 70% alc(?)/Fau; QMG220411 (LS[1]), 70% alc(?)/H&E; [unreg. host], QMG220412–220413 (WM), Carbine (Hill?), NQ Tableland (16°31'S 145°08'E) 30.11.1990, G.B. Monteith and party, 80% alc/Hx.

DESCRIPTION. Showing characteristics of genus but lacking pigment except for eyes. Selected body measurements of type pecimens from *Euastacus fleckeri* are: QMG220382 (H): B(1999 × 1142), LE(1224), PH(306 × 388), SD(388), PD(204); QMG220383 (P): B(1632 × 1204), LE(1020), PH(224 × 408), SD(388), PD(204); QMG220384 (P): B(1816 × 1142), LE(1265), PH(245 × 490), SD(439), PD(235).

Reproductive System. Male. Cirrus: Shaft cone-shaped. Introvert scoop-shaped; distal opening oblique, large. Swelling near-even, extends proximally far past introvert base on both sides (along entire length of narrow tubular distal region of shaft). Selected cirrus measurements of specimens from *Euastacus fleckeri* from type locality are: QMG220385: S(411 × 89), I(77 × 18), IS(244 × 182); QMG220386: S(457 × 89), I(65 × 18), IS(285 × 209); QMG220387: S(na × na), I(77 × 18), IS(na × na).

HOST. *Euastacus fleckeri*.

DISTRIBUTION. North-eastern Qld — from the region W of Mossman, in the areas of Mt Spurgeon, Mt Lewis and Mt Carbine.

REMARKS. The cirrus is closest to that of *Temnosewellia albata* sp. nov. but is slighty larger overall and the spines are different. The introvert swelling is even, rather than uneven as in *Temnosewellia albata* sp. nov. Although the specimens examined here were not optimally preserved, the cirrus remains a reliable character.

Temnosewellia aspinosa sp. nov.
(Fig. 27A–C)

ETYMOLOGY. From *spina* = thorn (Latin, feminine); a reference to the introvert lacking spines.

MATERIAL. HOLOTYPE: QMG220689 (WM), from *Euastacus valentulus* [QMW26667], upper Tallebudgera Ck, at 'Fern Gully' (28°13.7'S 153°18.5'E), 22.04.2002, D.J. & L.V. Cook, L.RG. Cannon, K.B. & S.G. Sewell, 100% alc/Un. PARATYPES: QMG220690–220693 (WM), 100% alc/Un. OTHER MATERIAL FROM TYPE LOCALITY: QMG220695–220700 (CP), 100% alc/Fau. OTHER MATERIAL. From *Euastacus valentulus*. Qld: [QMW25589], QMG220701–220703 (WM), Cougal Ck, in cleared paddock nr 'Twin Pools', upper Tallebudgera Valley (28°12.8'S 153°20.4'E), 8.11.2000, D.J. Cook, hot Form/Un; [QMW26668], QMG220704–220707 (WM), 22.04.2002, D.J. & L.V. Cook, L.RG. Cannon, K.B. & S.G. Sewell, 100% alc/Un; QMG220708–220710 (CP), 100% alc/Fau; QMG220711–220713 (CP), Fau; [unreg. host, ident. Dr John Short, QM], QM 220714–220716 (WM) upper Tallebudgera Ck (28°13'S 153°20'E), 13.10.1990, G.B. Monteith, 70% alc(?)/MB/Hx; QM 220717–220719 (LS[5,5,6]), 70% alc(?)/H&E. NSW: [unreg. host] QMG220720–220722 (WM), Burringbar Ck at Greenvale Crt, NSW (28°27'S 153°28'E) 14.10.2001, I. Fox & P. Fox, hot Form/Un; QMG220723–220724 (CP), 100% alc/Fau; QMG220725–220726 (CP), hot Form/Fau; QMG220727–220728 (CP), Fau.

DESCRIPTION. Characteristics of genus; pattern of body pigment typical. Selected body measurements of type specimens from *Euastacus valentulus* are: QMG220689 (H): B(7160 × 4386), LE(5508), PH(1204 × 1693), SD(2122), PD(1020); QMG220690 (P): B(4243 × 2836), LE(3223), PH(673 × 1020), SD(1224), PD(612); QMG220691 (P): B(5651 × 4284), LE(4488), PH(653 × 1530), SD(1714), PD(796); QMG220692 (P): B(6814 × 3672), LE(5018), PH(979 × 1326), SD(1775), PD(775); QMG220693 (P): B(6242 × 3978), LE(4692), PH(1020 × 1734), SD(2244), PD(898).

Reproductive system. Male. Cirrus: Shaft cone-shaped. Introvert lacks spined region, but has low, rounded, cusp-like protuberences on rim of distal shaft; distal opening not oblique (i.e. corresponds to introvert base). Swelling even, extends proximally slightly past introvert base, about an equal distance on both sides. Selected cirrus measurements of specimens from *Euastacus valentulus* from type locality are: QMG220695; S(364 × 207), I(na × 71), IS(10 × 10); QMG220696; S(396 × 203), I(na

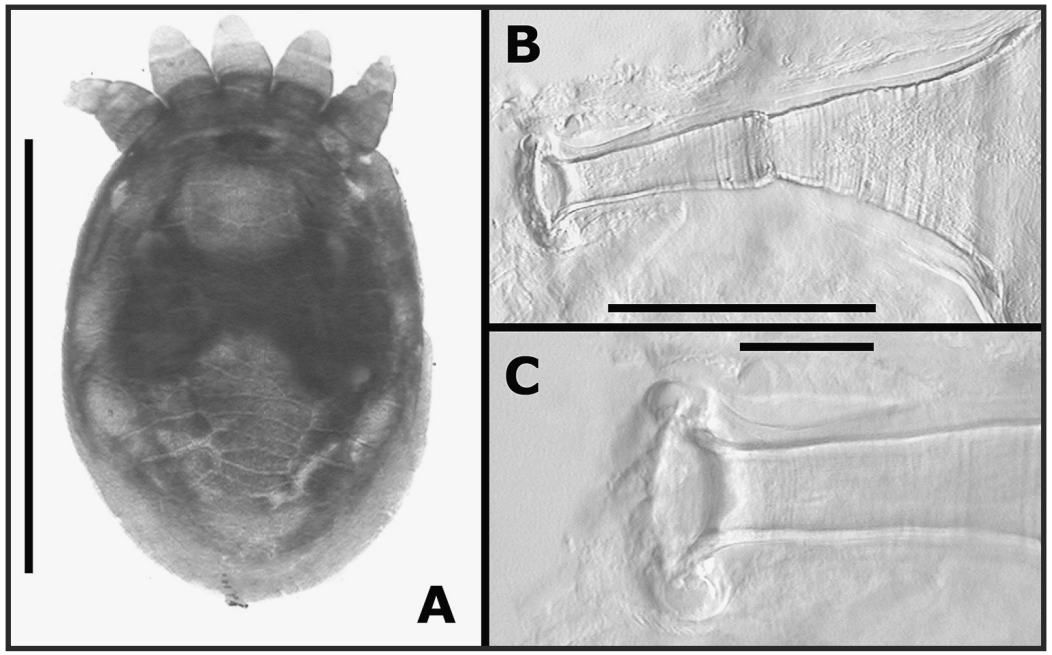


FIG. 27. *Temnosewellia aspinosa* sp. nov. from *Euastacus valentulus*. A, QMG220689, whole worm showing distribution of pigment, scale = 5mm; B–C, Nomarski interference contrast photomicrographs of Faure's preparations; B, QMG220696, whole cirrus scale = 200µm; C, QMG220696, introvert distal region, scale = 50µm.

× 65), IS(10 × 10); QMG220698; S(373 × 165), I(na × 53), IS(10 × 10); QMG220700; S(348 × 152), I(na × 53), IS(10 × 10).

HOST. *Euastacus valentulus*.

DISTRIBUTION. Known only from the southern border region of Qld and north-eastern NSW.

REMARKS. This species is large, with some specimens longer than 7mm. The introvert appears reduced to a series of short vestigal teeth, enclosed in a ring of bulbous cusps, presumably formed by the introvert swelling. Accurate assignment of homology for these structures would, however, require electron microscopy. The only other species with a similar reduced introvert is *Temnosewellia gingrina* sp. nov., in which the cirrus is much less robust. This species has a very large copulatory bulb.

In the gut of one specimen, QMG220695, was found an intact specimen of *Temnosewellia bacrioniculus* sp. nov. that was subsequently identified and registered as QMG220865. This predator-prey relationship between two species of *Temnosewellia* spp. on an individual host hints at the complex ecological interactions observed by Cannon & Jennings (1987) to occur between different temnocephalan species and genera on *Cherax* crayfish hosts. The discovery also highlights the potential need for care to avoid contamination of worm tissue used for DNA analysis.

Temnosewellia aspra sp. nov.
(Fig. 28A–C)

ETYMOLOGY. From *aspros* = white (Greek); a reference to the colour of this non-pigmented worm.

MATERIAL. HOLOTYPE: QMG220436 (WM), from *Euastacus balanensis* [QMW26587], Mt Haig, Kairi Ck trib., Lamb Ra. SF, Qld (17°06.0'S 145°35.5'E), 3.06.2002, D. Blair, D. Hansman, K.B. Sewell & M.S. Bryant, 100% alc/Un. PARATYPES: QMG220437–220438 (WM), 100% alc/Un; [QMW17241 & QMW26677], QMG220439–220440 (WM), 27.09.1990, L.R.G. Cannon & K.B. Sewell, Form-Acetic/Hx. OTHER MATERIAL FROM TYPE LOCALITY: [QMW26587], QMG220441–220442 (WM), 3.06.2002, D. Blair, D. Hansman, K.B. Sewell & M.S. Bryant, 100% alc/Un; QMG220443–220446 (CP), 100% alc/Fau.

DESCRIPTION. Characteristics of genus but lacking body pigment. Selected body measurements of type specimens from *Euastacus balanensis* are: QMG220436 (H): B(1073 × 626), LE(715), PH(203 × 268), SD(285), PD(138); QMG220437 (P): B(967 × 545), LE(659), PH(179 × 236), SD(244), PD(138); QMG220438 (P): B(1285 × 634), LE(715), PH(179 × 276), SD(293), PD(138); QMG220439 (P): B(1714 × 775), LE(1000), PH(245 × 367), SD(357), PD(173); QMG220440 (P): B(1106 × 764), LE(740), PH(179 × 252), SD(193), PD(130).

Reproductive System. Male. Cirrus: Shaft cone-shaped. Introvert scoop-shaped; distal opening very oblique, often folded into hourglass or irregular shape. Swelling near-even, extends proximally well past introvert base on both sides, further on longer side. Selected cirrus measurements of specimens from *Euastacus balanensis* from type locality are: QMG220443: S(191 × 43), I(51 × 10), IS(106 × 69); QMG220444: S(191 × 45), I(55 × 10), IS(118 × 75); QMG220445: S(189 × 49), I(70 × 9), IS(106 × 73); QMG220446: S(191 × 45), I(59X 10), IS(96 × 73).

HOST. *Euastacus balanensis*.

DISTRIBUTION. North-eastern Qld — from the Atherton Tableland region, W of Cairns, at Kairi Ck, Mt Haig.

REMARKS. The cirrus is similar to that of *Temnosewellia albata* sp. nov., though smaller, and to *T. aphyodes* sp. nov. and *T. argeta* sp. nov., being larger than *T. aphyodes* sp. nov. and with an opening of the introvert more oblique than *T. argeta* sp. nov.

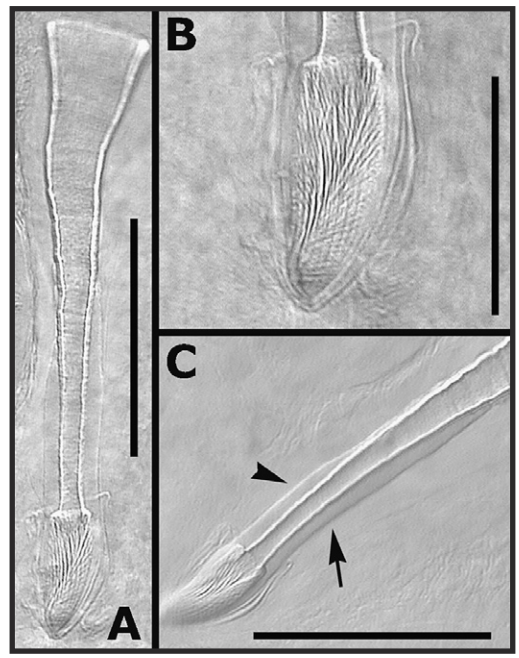


FIG. 28. *Temnosewellia aspra* sp. nov. A–C. Nomarski interference contrast photomicrographs of Faure's preparations from *Euastacus balanesis*. A, QMG220446, whole cirrus, scale = 100µm; B, QMG220446, introvert, scale = 50µm; C, QMG220444, introvert distal region showing introvert swelling on the introvert shorter side (arrowhead) and longer side (arrow), scale = 100µm.

Temnosewellia bacrio sp. nov.
(Fig. 29A–C)

ETYMOLOGY. From *bacrio* = ladle, long handled vessel (Latin, masculine); a reference to the shape of the cirrus.

MATERIAL. HOLOTYPE: QMG220630 (WM), from *Euastacus sulcatus* [QMW26658], upper Tallebudgera Ck, at 'Fern Gully' (28°13.7'S 153°18.5'E), 22.04.2002, D.J. & L.V. Cook, L.RG. Cannon, K.B. & S.G. Sewell, 100% alc/Un. PARATYPES: QMG220631–220632 (WM), 100% alc/Un. OTHER MATERIAL FROM TYPE LOCALITY: QMG220633–220634 (CP), 100% alc/Fau. OTHER MATERIAL. From *Euastacus maidae.* Qld: [QMW26632], QMG220635–220637 (WM), upper Currumbin Creek, upstream of old sawmill, 2km E of Mt Cougal (28°14.3'S 153°20.8'E), 11.01.1992, L.R.G. Cannon, K.B. Sewell & J.W. Short, HW/Form/Hx; QMG220638–220639 (WM), Form/Hx; QMG220640 (WM), HW/Form/Hx; QMG220641–220646 (WM) HW/Form/Fau; QMG220647 (LS[3]), Form/H&E; QMG220648–220650 (LS[3,4,2]), HW/Form/H&E.

From *Euastacus valentulus*. Qld: [QMW26667], QMG220694 (WM), upper Tallebudgera Ck, at 'Fern Gully' (28°13.7'S 153°18.5'E), 22.04.2002, D.J. & L.V. Cook, L.RG. Cannon, K.B. & S.G. Sewell, 100% alc/Un.

DESCRIPTION. Characteristics of genus; pattern of body pigment typical. Selected body measurements of type specimens from *Euastacus sulcatus* are: QMG220630 (H): B(1650 × 797), LE(1098), PH(236 × 285), SD(480), PD(203); QMG220631 (P): B(1829 × 1309), LE(1382), PH(244 × 390), SD(569), PD(236); QMG220632 (P): B(1602 × 919), LE(1098), PH(358 × 285), SD(472), PD(211).

Reproductive System. Male. Cirrus: Shaft cone-shaped. Introvert scoop-shaped; distal opening

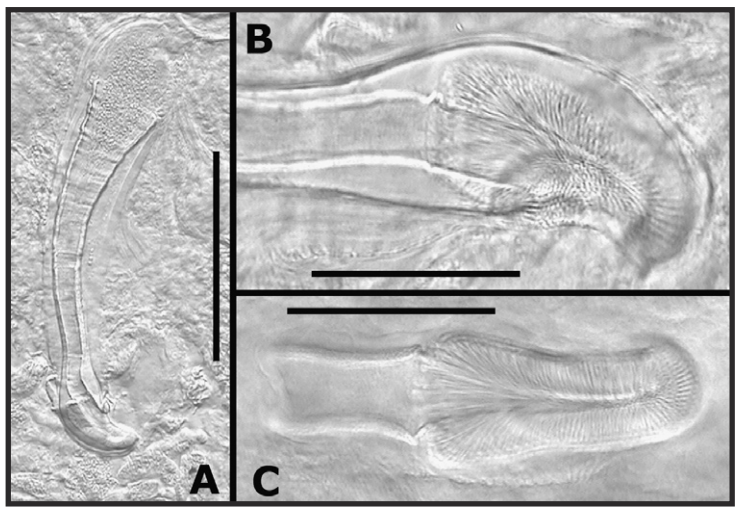


FIG. 29. *Temnosewellia bacrio* sp. nov. A–C, Nomarski interference contrast photomicrographs of Faure's preparations. A, QMG220641 from *Euastacus maidae,* whole cirrus, scale = 200µm; B, QMG220641, introvert distal region, scale = 50µm; C, QMG220634 from *Euastacus sulcatus,* introvert distal region, scale = 50µm.

very oblique, often folded into hourglass or irregular shape. Swelling uneven, extends proximally well past introvert base, about equally on each sides. Selected cirrus measurements of specimens from *Euastacus sulcatus* from type locality are: QMG220630 [WM]: S(228 × 47), I(98 × 18), IS(81 × 85); QMG220631 [WM]: S(217 × 57), I(96 × 20), IS(81 × na); QMG220633 [juvenile]: S(116 × 28), I(93 × 22), IS(61 × 53); QMG220634 [juvenile]: S(41 × 22), I(100 × 20), IS(na × na).

HOSTS. *Euastacus maidae, E. sulcatus, E. valentulus*.

DISTRIBUTION. South-eastern Qld — from the Macpherson Ra. region, in the area near Mt Cougal, at upper Currumbin Ck and upper Tallebudgera Ck.

REMARKS. The body pigment is well developed even in small juvenile specimens. The cirrus is most similar to that of *Temnosewellia bacrioniculus* sp. nov. but is overall larger and less funnel-shaped. Furthermore the introvert swelling is uneven in *Temnosewellia bacrio* sp. nov., but in *T. bacrioniculus* sp. nov. it is even. *Temnosewellia bacrio* sp. nov. was found on three different host species collected on the same day from the same small pool on Upper Tallebudgera Ck. This is evidence that the worms readily switch crayfish hosts.

Temnosewellia bacrioniculus sp. nov. (Fig. 30A–E)

ETYMOLOGY. From *bacrio* = ladle, long-handled vessel (Latin, masculine, diminutive); a reference to the shape of the cirrus and its small size.

MATERIAL. HOLOTYPE: QMG220651 (WM), from *Euastacus neohirsutus* [QMW26636], Little Nymboida R., junction of Lowanna and Coramba Rds, Bindarri NP, NSW (30°14.0'S 152°55.3'E), 16.03.2002, K.B. Sewell, 100% alc/Un. PARATYPES: QMG220652–220655 (WM), 100% alc/Un. OTHER MATERIAL FROM TYPE LOCALITY: QMG220656–220658 (CP), 100% alc/Fau. OTHER MATERIAL. From *Euastacus maidae.* Qld: [QMW25590], QMG220659–220664 (WM), Tallebudgera Ck trib., Tallebudgera Valley, near '1000m mark on main track' (28°14.0'S 153°18.5'E), 22.04.2002, D.J. & L.V. Cook, L.R.G. Cannon, K.B. & S.G. Sewell, hot Bouin/Un; QMG220665 (CP), 100% alc/Un; QMG220667–220669 (CP), hot Form/Fau; QMW220670–220672 (CP) Fau; [QMW26632], QM 220666 (CP) upper Tallebudgera Ck, at 'Fern Gully' (28°13.7'S 153°18.5'E), 22.04.2002, D.J. & L.V. Cook, L.R.G. Cannon, K.B. & S.G. Sewell, 100% alc/Un.

From *Euastacus setosus.* Qld: [QMW26648], QMG220673–220676 (WM), Greenes Falls, at first creek junction downstream from top falls, Maiala NP (27°19.4'S 152°45.8'E), 25.02.1991, L.R.G. Cannon & K.B. Sewell, HW/Form-Acetic/Hx; QMG220677 (WM), HW/Bouin/Hx; QMG220678–220680 (CP) HW/Form-Acetic/Fau; QMG220681 (CP) HW/Bouin/Fau; QMG220682 (LS[2]), HW/Form-Acetic/Fau; QMG220683 (LS[2]) HW/Bouin; QMG220684–220686 (LS[2,2,2,]), HW/Form-Acetic/Fau; [QMW26649] QMG221163–221164 (CP), 1.10.2002, K.B. Sewell & S.G. Sewell, 100% alc/Fau.

From *Euastacus sulcatus.* Qld: [QMW26658], QMG220687–220688 (CP), upper Tallebudgera Ck, at 'Fern Gully' (28°13.7'S 153°18.5'E), 22.04.2002, D.J. & L.V. Cook, L.RG. Cannon, K.B. & S.G. Sewell, 100% alc/Un.

From *Euastacus valentulus.* Qld: [QMW26667], QMG220865 (CP), upper Tallebudgera Ck, at 'Fern

Gully' (28°13.7'S 153°18.5'E) [removed from the gut of QMG220695; see remarks below], 22.04.2002, D.J. & L.V. Cook, L.RG. Cannon, K.B. & S.G. Sewell, 100% alc/Un.

DESCRIPTION. Showing characteristics of genus; pattern of body pigment typical. Selected body measurements of type specimens from *Euastacus neohirsutus* are: QMG220651 (H): B(1992 × 870), LE(1309), PH(366 × 467), SD(488), PD(203); QMG220652 (P): B(1650 × 837), LE(1057), PH(325 × 415), SD(366), PD(138); QMG220653 (P): B(1569 × 854), LE(1089), PH(293 × 431), SD(350), PD(187); QMG220654 (P): B(1693 × 1016), LE(1114), PH(313 × 488), SD(463), PD(179); QMG220655 (P): B(1789 × 894), LE(1220), PH(276 × 447), SD(415), PD(179).

Reproductive System. Female. Vagina: Weakly sclerotised at distal extremity.

Male. Cirrus: Shaft cone-shaped. Introvert scoop-shaped; distal opening very oblique, often folded into hourglass or irregular shape. Swelling even, extends proximally well past introvert base about equally so on each side. Selected cirrus measurements of specimens from *Euastacus neohirsutus* from type locality are: QMG220656: S(203 × 79), I(59 × 13), IS(65(?) x na); QMG220657: S(207 × 91), I(59 × 13), IS(81(?) × 65(?)); QMG220658: S(197 × 71), I(57 × 13), IS(na × na).

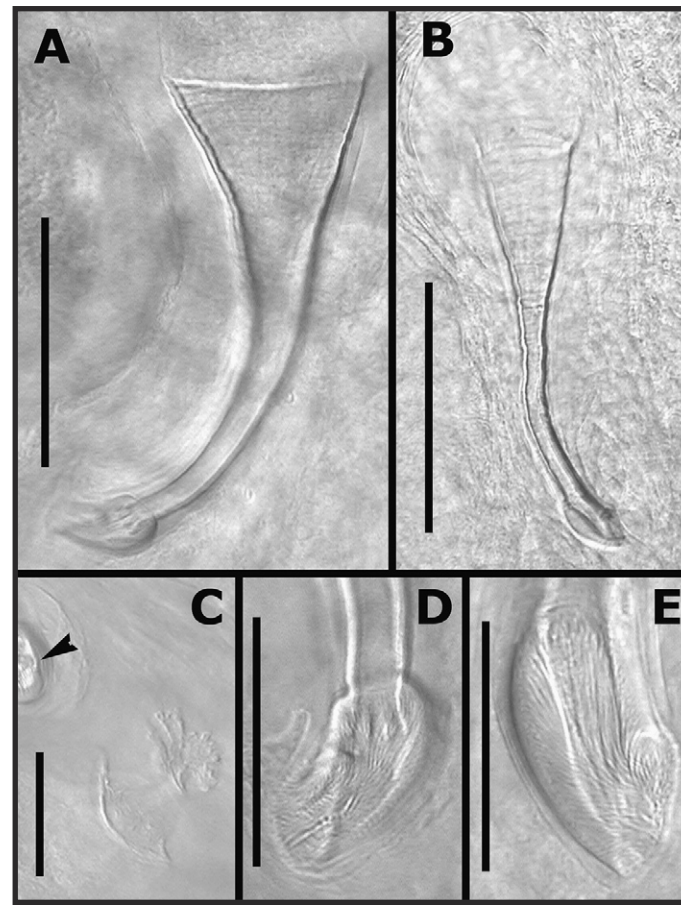


FIG. 30. *Temnosewellia bacrioniculus* sp. nov. A–E, Nomarski interference contrast photomicrographs of Faure's preparations. A, QMG220656, from *Euastacus neohirsutus,* whole cirrus, scale = 100µm; B, QMG221163 from *E. setosus*, whole cirrus, scale = 250µm; C, QMG220658, from *E. neohirsutus,* weakly sclerotised vagina, cirrus tip (arrowhead), scale = 50µm; D, QMG220656 from *E. neohirsutus,* introvert distal region with the oblique distal opening folded into an 'hourglass shape', scale = 50µm; E, QMG221163 from *E. setosus*, introvert distal region with the oblique distal opening not folded into either an 'irregular' or 'hourglass shape', scale = 50µm.

HOSTS. *Euastacus maidae*, *E. neohirsutus, E. setosus*, *E. sulcatus, E. valentulus.*

DISTRIBUTION. South-eastern Qld — from the the Macpherson Ra. region, near Mt Cougal; and from the D'Aguilar Ra., at Greenes Falls, near Mt Glorious. North-eastern NSW — from Bindarri NP, at Little Nymboida R., near Lowanna.

REMARKS. The cirrus of this species is most similar to that of *Temnosewellia bacrio* sp. nov. but is smaller and more funnel-shaped. The dimensions of the introvert swelling were difficult to determine confidently. It is a relatively widespread species that shows some slight regional variation. The type specimens from Little Nymboidea River NSW have a slightly smaller cirrus and slightly more body pigment than the Qld specimens. Small mature worms less than 2mm body length from the type locality

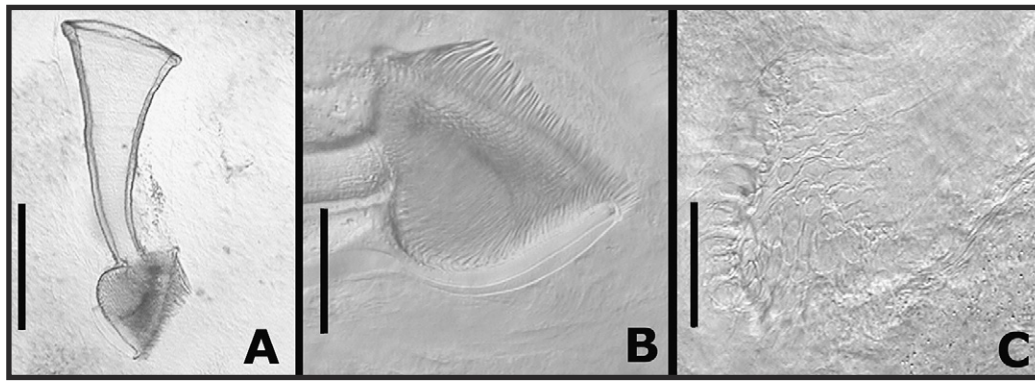


FIG. 31. *Temnosewellia batiola* sp. nov. from *Euastacus hystricosus*. A–C, Nomarski interference contrast photomicrographs of Faure's preparations. A, QMG220497, whole cirrus, scale = 250µm; B, QMG220497, introvert distal region, scale = 100µm; C, QMG220497, weakly sclerotised vagina, scale = 100µm.

typically had well developed body pigment. Although not nearly as obvious as with members of *Temnohaswellia*, the outer vagina does show some weak sclerotisation.

The Faure's mounted specimen of *Temnosewellia bacrioniculus* sp. nov (QMG220865) examined here was collected intact from the gut of *T. aspinosa* sp. nov. (QMG220695) that was obtained from the host *Euastacus valentulus* [QMW26667]. The latter host was collected in the same pool as *E. sulcatus* [QMW26658].

Temnosewellia batiola sp. nov.
(Fig. 31A–C)

ETYMOLOGY. From *batiola* = goblet (Latin, feminine); a reference to the large goblet-shaped introvert.

MATERIAL. HOLOTYPE: QMG220488 (WM), from *Euastacus hystricosus* [unreg. host, ident. Dr Mark Ponniah, Griffith University] Stony Ck, Stony Ck SF, Qld (26°51.7'S 152°44.0'E) 26.03.1992, M. Ponniah, 100% alc/Un. PARATYPES: QMG220489–220491 (WM), 100% alc/Un. OTHER MATERIAL FROM TYPE LOCALITY. QMG220492 (WM), 100% alc/Un; QMG220493–220498 (CP), 100% alc/Fau. OTHER MATERIAL. From *Euastacus hystricosus*. Qld: [QM 6461] QMG220499–220501 (WM), Booloumba Ck, Conondale Ra. (26°39.0'S 152°38.7'E), 29.11.1974, G.B. Monteith & S.R. Monteith., 70% alc/Hx; QMG220502–220504 (LS[3,7, 18]), 70% alc/H&E; [unreg. host] QMG220505–220506 (WM), Booloumba Ck, Conondale Ra. 29.11.1973, N. Gillespie, 70% alc(?)/Hx; QMG220507–220510 (LS[10,7,19,8]) 70% alc(?)/Hx; [unreg. host], QMG220511 (WM), Booloumba Ck, 'beauty spot 100', Conondale Ra. (26°39'S 152°39'E), 18.06.1986, 70% alc(?)/Hx; [QMG26628], QMG221165–221166 (CP), Booloumbah Ck, at road crossing near Booloumbah Falls car park, Conondale NP (26°41.2'S 152°37.1'E), 29.09.2002, D. Blair & K.B. Sewell, 100% alc/Fau; [unreg. host], QMG220517 (CP) Little Yabba Ck, Conondale SF, 17.11.1983, L.R.G.Cannon & J.B. Jennings, Bouin/Fau; QMG220512–220516, 220518–220523 (LS[1,1 ,2,7,1,5,3,13,8,8,1]), Bouin/H&E.

From *Euastacus urospinosus*. Qld: [QMW27489], QMG221210, 221212 (CP), Kondalilla NP, Skene Ck trib. at service rd concrete causeway nr NP boundary (26°40.5'S 152°52.1'), 12.01.2004, D. Blair & R.D. Sewell, alc/Fau; [QMW27499], QMG221211, (CP), alc/Fau.

DESCRIPTION. Characteristics of genus; pattern of body pigment typical. Selected body measurements of type specimens from *Euastacus hystricosus* are: QMG220488 (H): B(4998 × 2795), LE(3774), PH(632 × 1122), SD(1367), PD(551); QMG220489 (P): B(5814 × 3978), LE(4284), PH(836 × 1530), SD(1530), PD(632); QMG220490 (P): B(2713 × 1306), LE(1775), PH(306 × 500), SD(593), PD(333); QMG220491 (P): B(4529 × 2958), LE(3468), PH(428 × 1040), SD(1204), PD(571).

Reproductive System. *Female*. Vagina: Weakly sclerotised at distal extremity, resembling crumpled tissue paper.

Male. Cirrus: Shaft cone-shaped. Introvert goblet-shaped; distal opening oblique. Swelling slightly uneven, extends proximally well past introvert base on both sides, slightly further on longer side. Selected cirrus measurements of specimens from *Euastacus hystricosus* from type locality are: QMG220493: S(532 × 298),

I(242 × 62), IS(242 × 198); QMG220494: S(504 × 226), I(210 × 56), IS(242 × 181); QMG220495: S(431 × 169), I(242 × 65), IS(206 × 169); QMG220496: S(423 × 250), I(227 × 65), IS(254 × 190); QMG220497: S(492 × 250), I(238 × 60), IS(214 × 181).

HOSTS. *Euastacus hystricosus*, *E. urospinosus*

DISTRIBUTION. South-eastern Qld — from the Conondale Ra. region, in the areas W of Maleny and Beerwah.

REMARKS. This species is large, with some specimens examined close to 6mm body length. The cirrus is extremely large and robust. The numerous thin spines of the distal introvert that protrude from the distal opening give the inverted introvert an appearance reminiscent of the flower of a scotch thistle, e.g. *Onopordum acanthium*.

The cirrus is similar to that of *Temnosewellia fasciata* but there are several distinguishing characters. The longer side of the introvert of *Temnosewellia batiola* sp. nov. is longer and the shorter side is shorter than in the introvert of *T. fasciata*. Thus, the relative differences between the longer and shorter sides of the introvert are considerably more in *T. batiola* sp. nov. and the distal opening is more oblique as a consequence. The introvert thickening of *Temnosewellia batiola* sp. nov. extends less distance proximally past the introvert base, and the distal shaft lacks the collar of tissue observed in *T. fasciata*. The vagina is weakly sclerotised distally, but not as markedly as in members of the genus *Temnohaswellia*.

Temnosewellia belone sp. nov.
(Fig. 32A–B)

ETYMOLOGY. From *belone* = arrowhead, dart or needle (Greek, feminine); a reference to the arrowhead shaped distal region of the male organ.

MATERIAL. HOLOTYPE: QMG221135 (WM), from *Euastacus brachythorax* [[QMG26593], Rutherford Ck crossing on Niten Rd, Brown Mtnn, Glenbog SF, NSW (36°36.4'S 149°24.4'E), 18.03.2002, K.B. Sewell, 100% alc/Un. PARATYPES: [QMG26592], QMG221136 (WM), 13.10.1991, L.R.G. Cannon & K.B. Sewell, HW/Form/MB/Hx; QMG221137–221138 (WM), HW/Form/Hx; [QMG26593], QMG221139 (WM), 18.03.2002, K.B. Sewell, 100% alc/Un. OTHER MATERIAL FR0M TYPE LOCALITY: [QMG26593], QMG221140–221143 (WM), 18.03.2002, K.B. Sewell, 100% alc/Un; QMG221144–221149 (CP), 100% alc/Fau; [AMP 34055], AMW28695 (WM), Rutherford Ck trib., Brown Mtn Flora Reserve, (36°35'S 149°23'E) 2.11.1981, G.I. Morgan & S.J. Harders, 70% alc(?)/Hx.

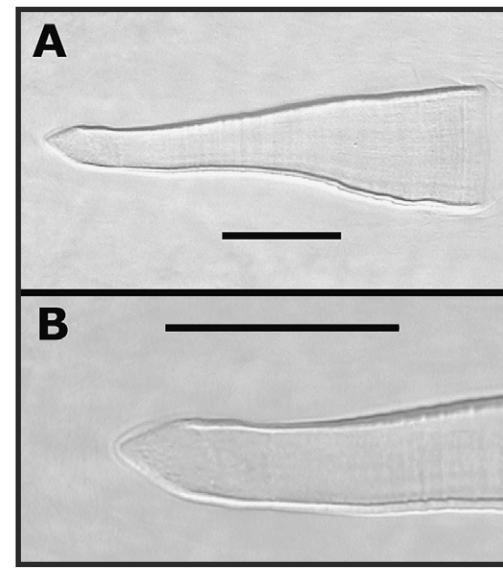


FIG. 32. *Temnosewellia belone* sp. nov. from *Euastacus brachythorax*. A-B, Nomarski interference contrast photomicrographs of Faure's preparations. A, QMG221145, whole cirrus, scale = 50µm; B, QMG221145, introvert distal region, scale = 50µm.

DESCRIPTION. Characteristics of genus; pattern of body pigment typical. Selected body measurements of type specimens from *Euastacus brachythorax* are: QMG221135 (H): B(4468 × 2693), LE(3080), PH(683 × 992), SD(1408), PD(569); QMG221136 (P): B(3733 × 1918), LE(2448), PH(490 × 745), SD(918), PD(439); QMG221137 (P): B(4264 × 2020), LE(2978), PH(551 × 734), SD(857), PD(408); QMG221138 (P): B(3060 × 1183), LE(1856), PH(390 × 439), SD(378), PD(167); QMG221139 (P): B(3305 × 2550), LE(2530), PH(592 × 908), SD(1102), PD(408).

Reproductive System Male. Cirrus: Shaft cone-shaped. Introvert lacks spined region but has striated, apical, pointed structure (about 20 long) attached to introvert base. Swelling not observed [absent?]. Selected cirrus measurements of specimens from *Euastacus brachythorax* from type locality are: QMG221145: S(175 × 51), I(19 × 17), IS(na × na); QMG221146: S(126 × 43), I(19 × 16), IS(na × na); QMG221147: S(159 × 55), I(18 × 13), IS(na × na); QMG221149: S(152 × 55), I(21 × 18), IS(na × na).

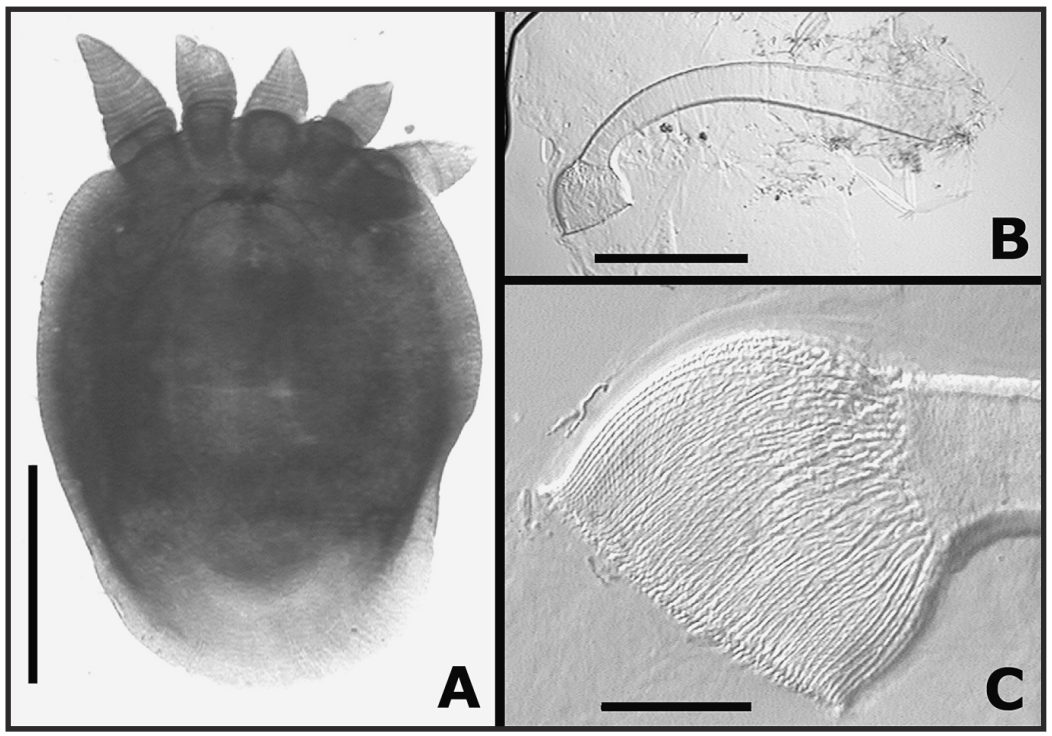


FIG. 33. *Temnosewellia caliculus* sp. nov. from *Euastacus kershawi*. A, QMG220901, whole worm (Holotype) showing pigment, scale = 1mm; B–C, Nomarski interference contrast photomicrographs of Faure's preparations; B, QMG220903, whole cirrus, scale = 250µm; C, QMG220903, introvert distal region, scale = 50µm.

HOST. *Euastacus brachythorax*.

DISTRIBUTION. From the region of Brown Mtn, W of Bemboka, SE NSW.

REMARKS. The vagina is of this species is very weakly sclerotised. The cirrus resembles that of *Temnosewellia apiculus* sp. nov. except that that the cirrus is overall much smaller in *T. belone* sp. nov. and more dagger-like in outline. The tooth-like structure has longitudinal striations which are possibly homologues of the ridges of spines that are typically found in other species. Neither spines nor introvert swelling were observed for this species.

Temnosewellia caliculus sp. nov.
(Fig. 33A–C)

ETYMOLOGY. From *calix* = a little goblet or cup (Latin, masculine, diminutive); a reference to the shape of the introvert.

MATERIAL. HOLOTYPE: QM 220901 (WM), from *Euastacus kershawi* [unreg. host, ident. Dr Susan Lawler, Latrobe University, VIC], Wongungarra R., (37°22'S 147°11'E), Jul. 2000, S.H. Lawler, hot Form/Un. PARATYPE: QM 220902 (WM), hot Form/Un. OTHER MATERIAL FROM TYPE LOCALITY: QM 220903–220906 (CP), Fau. OTHER MATERIAL. From '*freshwater cray*' [=*Euastacus woiwuru*?] VIC: [unreg. host], NMVF 93809–93810, (CP), Fern Tree Gully (37°53'S 145°18'E), 18.02.1872, unknown fixation/Fau.

DESCRIPTION. Characteristics of genus; pattern of body pigment typical. Selected body measurements of type specimens from *Euastacus kershawi* are: QMG220901(H): B(2978 × 2040), LE(2326), PH(439 × 577), SD(1071), PD(490); QMG220902(P): B(3835 × 1632), LE(2591), PH(488 × 467), SD(918), PD(428).

Reproductive system. Male. Cirrus: Shaft cone-shaped. Introvert goblet-shaped; distal opening oblique. Swelling uneven, extends proximally far past introvert base on longer side, not observed on shorter side.Selected cirrus measurements of specimens from *Euastacus kershawi* from type locality are: QMG220903: S(671 × 91), I(142

× 63), IS(na × na); QMG220904: S(665 × 77), I(134 × 51), IS(na × na); QMG220905: S(630 × 102), I(136 × 66), IS(na × na).

HOSTS. *Euastacus kershawi*, 'fresh water cray' probably either *E. woiwuru*? or *E. yarraensis*? (see Remarks).

DISTRIBUTION. VIC — from the east Melbourne region; and from the Wongungarra R. region.

REMARKS. The body pigment in some specimens of this species is connected to the pigment in the region of the eyes in single large tracts which are thicker than those observed for other species (Fig. 33A). The large cirrus is similar broadly to those of species such as *Temnosewellia fasciata* with a prominent goblet shaped introvert. However, the cirrus has a relatively longer and narrower shaft somewhat reminiscent of that in *Temnosewellia cypellum* sp. nov. The latter species is distinct in having the unique character of the longer side of the introvert on the shorter side of the shaft. Based on the approximate ranges of *Euastacus* species presented by Morgan (1986), the host listed as '*freshwater cray*' is most likely to be either *E. woiwuru* or *E. yarraensis* (pers. comm. Dr Susan Lawler, Latrobe University, VIC,). We did not find this species on *Euastacus woiwuru* we collected at Fern Tree Gully.

Temnosewellia cestus sp. nov.
(Fig. 34A–B)

ETYMOLOGY. From *caestus* = boxer's glove (Latin, masculine); a reference to the introvert resembling a boxing glove.

MATERIAL. HOLOTYPE: QMG220524 (WM), from *Euastacus urospinosus* [QMW26665] Kondalilla Falls NP, at first creek from park entrance along walking track, Qld (26°41'S 152°52'E) 28.03.1991, L.R.G. Cannon & K.B. Sewell, HW/Form/Hx. PARATYPES: QMG220525 (WM), HW/Form/Hx; QMG220526–220527 (WM) Form/Hx. OTHER MATERIAL FROM TYPE LOCALITY: QMG220528–220529 (WM) Form/Un; QMG220530–220533 (CP) HW/Form/Fau; QMG220534–220536 (LS[3,2,1]) Form/H&E. OTHER MATERIAL. From *Euastacus urospinosus.* Qld: [QMW24670], QMG220537–220538 (WM), Conondale Area on Maleny to Kenilworth Rd. nr property of J.F. & I.B. Sparshott (26°45'S 152°45'E), 19.07.1998, P.E., K.M. & J.F. Sparshott, hot Form/Un; QMG220539 (CP), 100% alc/Fau; QMG220540–220541 (CP), HW/Fau; [QMW26664], QMG220542 (WM), Mary Cairncross NP, Maleny, to right of walking track, 200m from park entrance (26°46.6'S 152°52.8'E), 28.03.1991, L.R.G. Cannon & K.B. Sewell, HW/Form/Hx. From *Cherax dispar* [unreg. host, ident. KBS] QMG221214 (CP), Booloumbah Ck, at road crossing near Booloumbah Falls car park, Conondale NP (26°41.2'S 152°37.1'E), 12.01.2004, D. Blair & R.D. Sewell, alc/Fau.

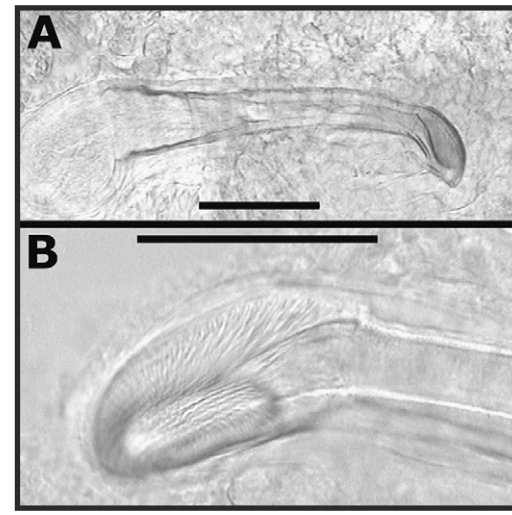


FIG. 34. *Temnosewellia cestus* sp. nov. from *Euastacus urospinosus*. A-B, Nomarski interference contrast photomicrographs of Faure's preparations. A, QMG220530, whole cirrus, scale = 100µm; B, QMG220539, introvert distal region, scale = 50µm.

DESCRIPTION. Characteristics of genus; pattern of body pigment typical. Selected body measurements of type specimens from *Euastacus urospinosus* are: QMG220524 (H): B(2472 × 1171), LE(1667), PH(341 × 504), SD(528), PD(244); QMG220525 (P): B(2089 × 1057), LE(1431), PH(309 × 423), SD(407), PD(203); QMG220526 (P): B(2938 × 1591), LE(2101), PH(388 × 673), SD(816), PD(347); QMG220527 (P): B(1979 × 1693), LE(1714), PH(388 × 704), SD(734), PD(347).

Reproductive System. Male. Cirrus: Shaft cone-shaped. Introvert scoop shaped; distal opening very oblique. Swelling near-even, extends proximally well past introvert base, about equal on both sides. Selected cirrus measurements of specimens from *Euastacus urospinosus* from type locality are: QMG220530: S(262 × 69), I(91 × 22), IS(na × na); QMG220531: S(175 × 39), I(93 × 22), IS(na × na); QMG220532: S(112 × 20), I(85 × 20), IS(na × na).

Selected cirrus measurements of other specimens from *Euastacus urospinosus* are: QMG220539: S(346 × 104), I(85 × 20), IS(118 × 93); QMG220540: S(352 × 102), I(85 × 18),

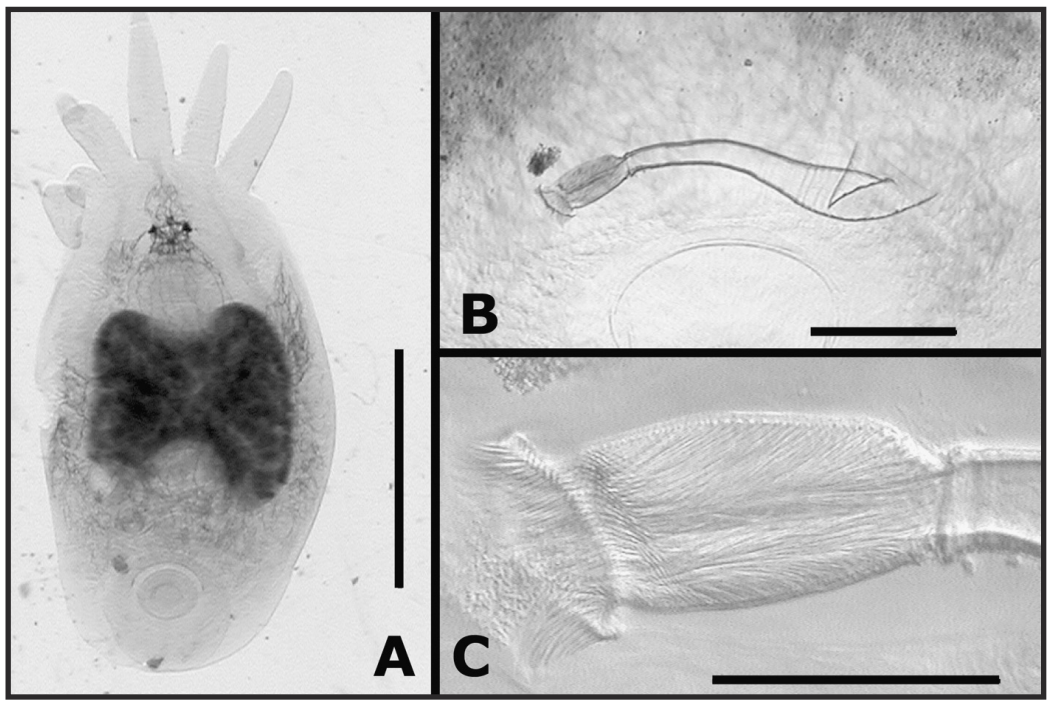


FIG. 35. *Temnosewellia comythus* sp. nov. from *Euastacus gumar*. A, QMG220824, whole worm (Holotype) showing pigmention pattern, scale = 1mm; B–C. Nomarski interference contrast photomicrographs of Faure's preparations; B, QMG220832, whole cirrus, scale = 250µm; C, QMG220832, introvert distal region, scale = 100µm.

IS(169 × 154); QMG220541: S(289 × 71), I(85 × 18), IS(138 × 148).

HOST. *Cherax dispar, Euastacus urospinosus*.

DISTRIBUTION. South-eastern Qld — from the Blackall Ra., at Kondallila Falls, near Flaxton; and from the Conondale Ra. region, near Maleny.

REMARKS. The largest specimens examined were about 4mm body length and had well developed but sparse dorsal body pigment that was not arranged in a close woven network. Adult worms about 2mm body length have only a slight concentration of pigment in the eye region and thus appear pale to the naked eye. The arrangement of large spines on the longer side of the introvert give the inverted introvert an appearance reminiscent of a boxing glove. The general shape of the cirrus resembles that of *Temnosewellia bacrioniculus* sp. nov. and especially *T. bacrio* sp. nov., but it is much larger.

The record of *Temnosewellia cestus* from a species of *Cherax* probably indicates an accidental host as in this locality both species of *Cherax* and *Euastacus* co-occur, a situation that is rarely found. Nevertheless, we acknowledge that much is still to be learned of the eclogy of these worms.

Temnosewellia comythus sp. nov.
(Fig. 35A–C)

ETYMOLOGY. From *komys* = bundle or sheaf (Greek); a reference to the appearance of the cirrus introvert.

MATERIAL. HOLOTYPE: QMG220824 (WM), from *Euastacus gumar* [QMW26662], Culmaron Ck, Richmond Ra. NP (28°50.5'S 152°44.1'E), 4.03.2002, K.B. Sewell, S.G. Sewell & J.A. Coughran, hot Bouin/Un. PARATYPES: QMG220825–220828 (WM), hot Bouin/Un. OTHER MATERIAL FROM TYPE LOCALITY: QMG220829 (WM), hot Bouin/Un; QMG220831–220832 (CP), 100% alc/ Fau. QMG220833–220839 (CP), Fau. OTHER MATERIAL. From *Euastacus gumar*. NSW: [QMW5666], QMG220830 (WM) Richmond Ra., 19.04.1976, R. Raven, 70% alc(?)/Hx.

From *Euastacus spinichelatus*. NSW: [QMW26652], QMG220840–220841 (WM), Joyces Ck, Oxley Hwy

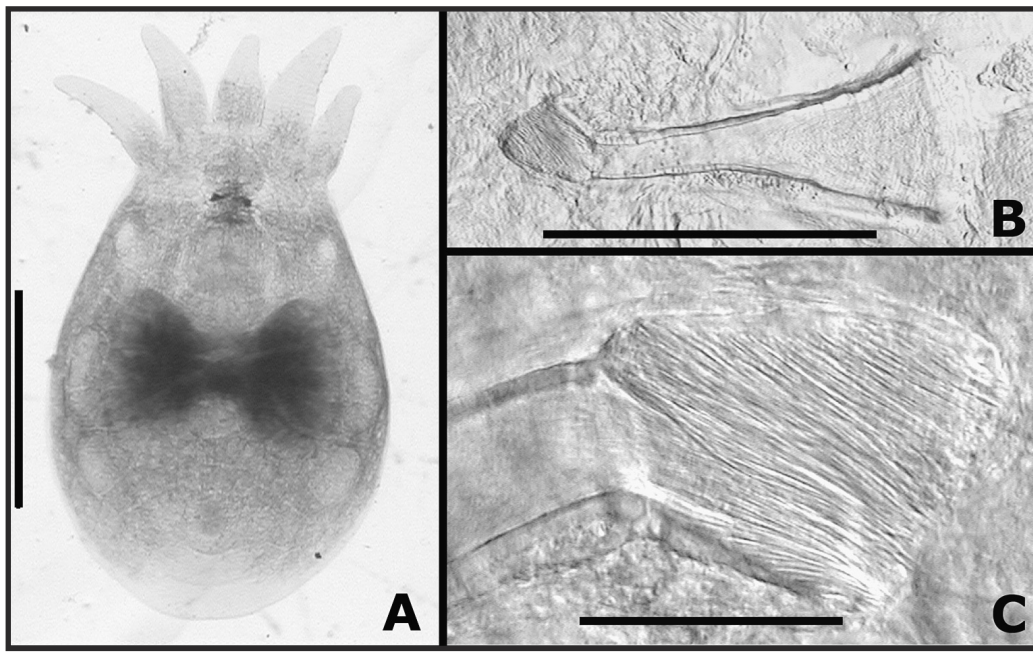


FIG. 36. *Temnosewellia coughrani* sp. nov. from *Euastacus sulcatus.* A–C, Nomarski interference contrast photomicrographs of Faure's preparations. A, QMG220555, whole worm (Paratype) showing pigmention pattern, scale = 1mm; B, QMG220570, whole cirrus, scale = 250µm; C, QMG220570, introvert distal region, scale = 50µm.

crossing, 6km SE of Yarrowitch, Enfield SF (31°16.7'S 151°58.3'E), 8.02.2002, K.B. Sewell & R.D. Sewell, hot Bouin/Un; [QMW26653], QMG220842–220845 (WM), 23.10.1991, L.R.G. Cannon & K.B. Sewell, HW/Form/Hx; [QMW26652], QMG220846–220849, 8.02.2002, K.B. Sewell & R.D. Sewell, hot Bouin/Un; [QMW26653], QMG220850 (WM), 23.10.1991, L.R.G. Cannon & K.B. Sewell, HW/Form/Hx; [QMW26652], QMG220851–220852, 8.02.2002, K.B. Sewell & R.D. Sewell, 100% alc/Fau; QMG220853–220857 (CP), Fau; [QMW26653], QMG220858–220859 (LS[4,5]), 23.10.1991, L.R.G. Cannon & K.B. Sewell, Bouin/H&E.

DESCRIPTION. Characteristics of genus; pattern of body pigment typical. Selected body measurements of type specimens from *Euastacus gumar* are: QMG220824 (H): B(2509 × 1132), LE(1734), PH(402 × 423), SD(447), PD(252); QMG220825 (P): B(2305 × 1510), LE(1632), PH(471 × 447), SD(496), PD(244); QMG220826 (P): B(2795 × 1224), LE(1856), PH(411 × 382), SD(528), PD(252); QMG220827 (P): B(2183 × 1418), LE(1469), PH(317 × 439), SD(537), PD(244); QMG220828 (P): B(1734 × 836), LE(1153), PH(333 × 289), SD(415), PD(187).

Reproductive System. Male. Cirrus: Shaft cone-shaped. Introvert cylinder to scoop-shaped; distal opening slightly oblique. Swelling slightly uneven, extends proximally far past introvert base, further on longer side. Selected cirrus measurements of specimens from *Euastacus gumar* from type locality are: QMG220831: S(486 × 150), I(175 × 39), IS(299 × 179); QMG220832: S(557 × 163), I(163 × 41), IS(350 × 220); QMG220833: S(447 × 136), I(148 × 41), IS(295 × 193); QMG220835: S(407 × 142), I(175 × 41), IS(191 × 207); QMG220838: S(394 × 81), I(175 × 39), IS(266 × 191).

HOSTS. *Euastacus gumar, E. spinichelatus*.

DISTRIBUTION. North-eastern NSW — from the Richmond Ra. region at Cumaron Ck; and from Enfield SF, near Yarrowitch, at Joyces Ck.

REMARKS. Smaller mature worms of this species have dense pigment concentrated only in the region around the eyes. As the worms become larger the pigment develops to become the typical dense woven tracery across the dorsal surface. The cirrus is large and in fixed specimens is typically folded over and creased on the longer

side of the proximal shaft (Fig. 36B). The cirrus resembles that of *Temnosewellia fax* sp. nov., though is larger and, like *T. fax* sp. nov., the introvert is not goblet shaped. However, the introvert of *Temnosewellia comythus* sp. nov. is relatively longer in comparison to the shaft than in *T. fax* sp. nov., and the opening is oblique.

Temnosewellia coughrani sp. nov.
(Fig. 36A–C)

ETYMOLOGY. For Jason Coughran who assisted greatly with the location and capture of hosts from which the first specimens were recognised.

MATERIAL. HOLOTYPE: QMG220554 (WM), from *Euastacus sulcatus* [QMW26655], Bundoozle Flora Reserve, Richmond Ra. NP, NSW (28°36.4'S 152°44.0'E), 4.03.2002, K.B. Sewell, S.G. Sewell & J.A. Coughran, 100% alc/Un. PARATYPES: QMG220555–220556 (WM), 100% alc/Bouin/Un; QMG220557–220558 (WM), 100% alc/Un. OTHER MATERIAL FROM TYPE LOCALITY: QMG220559 (WM), 100% alc/Bouin/Un; QMG220560–220562 (WM), 100% alc/Un; QMG220563–220566 (CP), 100% alc/Fau; QMG220567–220569 (WM), Fau; QMG220570–220572 (CP), 100% alc/Bouin/Fau. OTHER MATERIAL. From *Euastacus mirangudjin.* NSW: [QMW26633], QMG220573–220577 (WM), Ironpot Ck, Toonumbar NP (28°29.9'S 152°44.0'E), 4.03.2002, K.B. Sewell, S.G. Sewell & J.A. Coughran, 100% alc/Un; QMG220578–220580 (CP), 100% alc/Fau.

DESCRIPTION. Characteristics of genus; pattern of body pigment typical. Selected body measurements of type specimens from *Euastacus sulcatus* are: QMG220554 (H): B(2672 × 1408), LE(2020), PH(571 × 530), SD(734), PD(306); QMG220555 (P): B(2856 × 1652), LE(1999), PH(510 × 612), SD(694), PD(316); QMG220556 (P): B(2448 × 1530), LE(1775), PH(490 × 561), SD(551), PD(245); QMG220557 (P): B(2591 × 1550), LE(1693), PH(592 × 571), SD(694), PD(316); QMG220558 (P): B(2754 × 1469), LE(1958), PH(510 × 571), SD(592), PD(326).

Reproductive Sytem. Male. Cirrus: Shaft cone-shaped. Introvert scoop-shaped; distal opening oblique. Swelling not observed. Selected cirrus measurements of specimens from *Euastacus sulcatus* from type locality are: QMG2220565: S(266 × 144), I(85 × 30), IS(na × na); QMG2220566: S(230 × 128), I(83 × 30), IS(na × na); QMG2220569: S(240 × 110), I(81 × 28), IS(na × na); QMG2220570: S(266 × 128), I(85 × 30), IS(na × na); QMG2220571: S(238 × 130), I(81 × 28), IS(na × na).

HOSTS. *Euastacus mirangudjin, E. sulcatus*.

DISTRIBUTION. North-eastern NSW — from the Richmond Ra. region, at Culmaron Ck, Richmond Ra. NP and at Iron Pot Ck, Toonumbar NP.

REMARKS. Small specimens (i.e. less than 2.5mm body length) have only a slight concentration of dense pigment in the eye region despite the presence of diffuse dorsal body pigment, and thus appear pale, almost white, to the naked eye (Fig. 36A). The cirrus is similar to that of *Temnosewellia keras* sp. nov. though larger and the introvert opening is oblique, not transverse.

Temnosewellia cypellum sp. nov.
(Figs 37A–B, 38)

ETYMOLOGY. From *kypellum* = goblet (Greek); a reference to the large goblet-shaped introvert.

MATERIAL. HOLOTYPE: QMG220942 (WM), from *Euastacus spinifer* [QMW26654], Mammy Johnsons Ck, at road bridge near Nature Reserve just SE of Stroud Road township, NSW (32°21.1'S 151°56.1'E), 21.11.1996, K.B. Sewell & R.D. Adlard., 100% alc/Bouin/Un. PARATYPES: QMG220943–220946 (WM), 100% alc/Bouin/Un. OTHER MATERIAL FROM TYPE LOCALITY: QMG220947–220950 (MP), Euparol; QMG220951–220954 (CP), 100% alc/Fau; QMG220955–220959 (CP), Fau.

From *Euastacus spinifer.* NSW: [QMW20765], QMG220960–220961 (WM), Karuah R. at Washpool Bridge (32°21'S 151°55'S), 28.08.1995, J. Powell & R. Powell, hot Form/Un; QMG220962–220963 (WM), hot Bouin/Un; QMG220964–220965 (CP), hot Bouin/Fau; QMG220966–220967 (CP), hot Form/Fau; QMG220968 (CP), Fau. [AMP 33959], AMW28696 (WM), Cascade Ck at Girrakool, Brisbane Water NP (33°48'S 150°36'E), 9.10.1981, G.I. Morgan & S.J. Harders, unknown fixative/Hx; AMW28697 (CP), unknown fixative/Fau; AMW28698–28699 (LS[14,6]), unknown fixative/H&E; [AMP 33958], AMW28700 (LS[4]), (Euroka Ck, nr Euroka Clearing, Blue Mts NP, (33°48'S 150°36'E), 15.10.1981, G.I. Morgan, unknown fixative/H&E

DESCRIPTION. Characteristics of genus; pattern of body pigment slightly punctate. Selected body measurements of type specimens from *Euastacus spinifer* are: QMG220942 (H): B(6234 × 3203), LE(4937), PH(887 × 1204, SD(1530), PD(796); QMG220943 (P): B(2958 × 1550), LE(829), PH(407 × 618, SD(772), PD(415); QMG220944 (P): B(5263 × 2591), LE(3815), PH(816 × 1020, SD(1346, PD(612); QMG220945 (P): B(6222 × 2856), LE(4284), PH(755 × 1102, SD(1428, PD(653); QMG220946 (P): B(5610 × 2795), LE(4019), PH(755 × 1061, SD(1367, PD(694).

Reproductive System. Male. Cirrus: Shaft cone-shaped. Introvert goblet-shaped; distal opening slightly oblique. Swelling near even, extends proximally well past introvert base on both sides, further on shorter side. Selected cirrus measurements of specimens from *Euastacus spinifer* from type locality are: QMG220952: S(835 × 202), I(242 × 65), IS(149 × 347); QMG220953: S(847 × 223), I(246 × 79), IS(198 × 262); QMG220955: S(851 × 266), I(242 × 85), IS(290 × 456); QMG220956: S(968 × 282), I(238 × 81), IS(319 × 387).

Epidermal Mosaic. see generic diagnosis.

HOST. *Euastacus spinifer*.

LOCALITIES. Mid-eastern NSW — from the Karuah R. near Stroud Road; from Brisbane Waters NP at Cascade Ck, Girrakool; and from the Blue Mountains NP at Euroka Ck, near the Euroka Clearing.

REMARKS. The pigment of this species is dense and slightly punctate, even in young worms. The cirrus is unusual as in Faure's preparations it consistently shows it has the longer side of the introvert on the shorter side of the shaft (i.e. the shaft curves in the opposite direction to that observed generally). The insertion region of the introvert eversion muscle on the distal region of the introvert longer side is obviously bulbous and weakly sclerotised.

Otherwise, the cirrus is most similar in shape and size to that of *Temnosewellia batiolis* sp. nov. but the introvert distal opening is slighly more oblique in *T. batiolis* sp. nov. as a consequence of a relatively shorter introvert shorter side. The cirrus of *Temnosewellia cypellum* sp. nov. is also similar to the cirrus of *T. fasciata*, a worm whose distribution is geographically close. The cirrus of the present species is, however, larger overall, has a relatively longer introvert shorter side, and lacks a collar of tissue just proximal to the base of the introvert.

The epidermal mosaic of *Temnosewellia cypellum* sp. nov. is identical to that described and photographed from worms identified tentatively as *Temnocephala* sp. 3. by Joffe & Cannon (1998: fig. 3D). Now able to be confirmed as *Temnosewellia minima* sp. nov., the latter worms were obtained from *Euastacus sulcatus* collected on 1.09.1994, by Sewell. K.B. at Spicers Gap, Main Ra. NP, Qld (28°04.0'S 152°26.3'E) and ident. by John Short, QM.

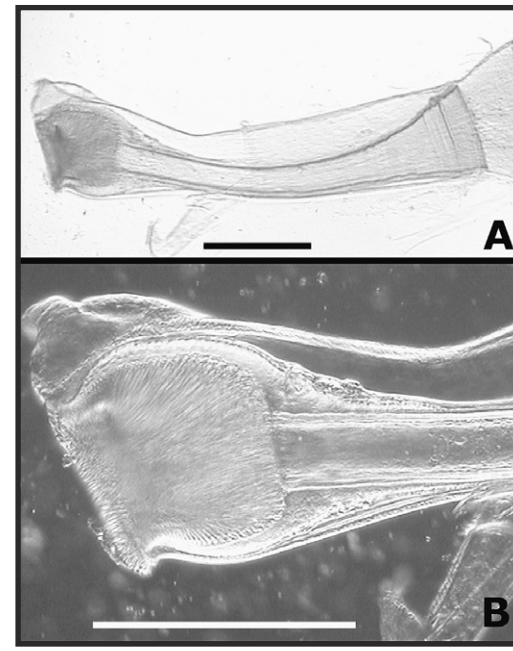


FIG. 37. *Temnosewellia cypellum* sp. nov. from *Euastacus spinifer*. A-B, Nomarski interference contrast photomicrographs of Faure's preparations. A, QMG220953, whole cirrus, scale = 250µm; B, QMG220953, introvert distal region, scale = 250µm.

Temnosewellia fasciata (Haswell, 1888)
(Fig. 39A–C)

Temnocephala fasciata Haswell, 1888: 284: pl. 20 figs 1, 2, pl. 21, figs 1–7, 9–13, pl. 22, figs 1–7, 11–18.

Temnosewellia fasciata: Damborenea & Cannon, 2001: 1116.

ETYMOLOGY. Haswell (1888) provided no derivation of the name. Clearly it is from *fascia* = band, zone, stripe (Latin). Haswell (1888) stated that the body of this species has 'several, usually three, broad, transverse dark bands, separated from one another by lighter intervals'.

MATERIAL. From *Euastacus australasiensis* (juvenile). NSW: [QMW26586], QMG220900 (CP), Govetts Leap Brook, James St crossing on Braeside Walk, Blackheath, Blue Mts NP, (33°38.5'S 150°18.4'E), 12.02.2002, K.B. Sewell & R.D. Sewell, 100% alc/Fau.

From *Euastacus clarkae*. NSW: [QMW26598], QMG220926–220927 (WM), Cockerawombeeba Ck at Rimau Rd crossing, Werrikimbe NP (31°11.4'S 152°22.2'E), 23.10.1991, L.R.G. Cannon & K.B. Sewell, HW/Form/MB/Hx; QMG220928–220929 (WM), HW/Form/Hx; QMG220930 (WM), HW/Form/Un; QMG220931–220934 (WM), HW/Form/Hx; [QMW26597], QMG220935 (CP), 7.02.2002,

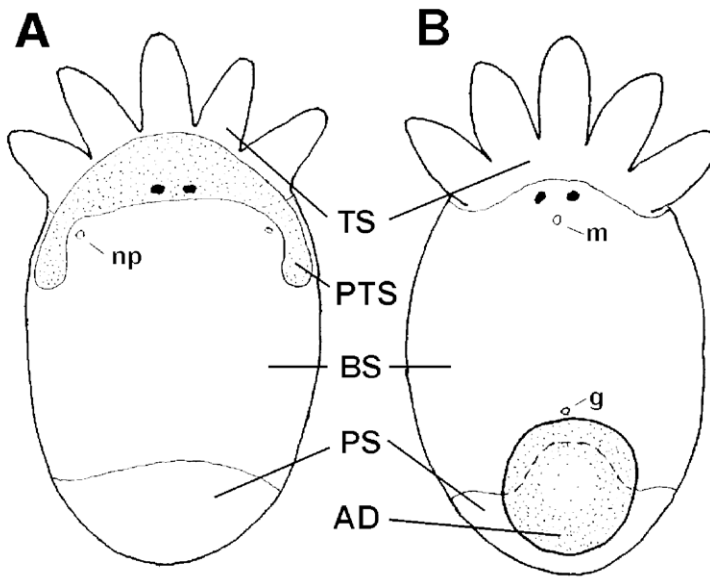


FIG 38. A. Mosaic of epidermal syncytia for *Temnosewellia cypellum* sp. nov. from *Euastacus spinifer* [QMW26654] from the Karuah R., NSW in (A) dorsal view, (B) ventral view. AD, adhesive disc syncytium; BS, body syncytium; PS, peduncular syncytium; PTS, post-tentacular syncytium; TS, tentacular syncytium; g, gonopore; m, mouth; np, nephridiopore; derived from 4 specimens: QMG220947–220950

K.B. Sewell & R.D. Sewell, 100% alc/Fau, [QMW26598], 23.10.1991, L.R.G. Cannon & K.B. Sewell, QMG220936–220939 (CP), HW/Form/Fau; QMG220940–220941 (LS[8,7]), Form/H&E.

From *Euastacus polysetosus*.NSW:[QMW26640], QMG220907–220908 (WM), Dilgry R., at Dilgry River Picnic Area, Barrington Tops NP, (31°53.6'S 151°31.3'E), 9.02.2002, K.B. Sewell & R.D. Sewell, 100% alc/Un; QMG220909–220911 (CP), 100% alc/ Fau.

From *Euastacus* sp. NSW: [QMW26581], QMG220883–220888 (WM), Cudgegong R. at junction with Mill Ck, Wollemi NP, (32°50.7'S 150°14.4'E), 11.02.2002, K.B. Sewell & R.D. Sewell, 100% alc/Un; QMG220889 (CP), 100% alc/Fau; QMG220890–220898 (CP), Fau.

From *Euastacus spinifer.* NSW: [QMW26585], QMG220869–220871 (WM), Jamieson Ck, 0.5 km above Wentworth Falls, beside Darwins Walk, Blue Mts NP, (33°43.6'S 150°22.5'E), 12.02.2002, K.B. Sewell & R.D. Sewell, 100% alc/Un; QMW26584], QMG220872–220873 (WM), 20.10.1991, L.R.G. Cannon & K.B. Sewell, HW/Form/Hx; [QMW26585], QMG220874–220876 (WM), 12.02.2002, K.B. Sewell & R.D. Sewell, 100% alc/Un; QMG219983 (CP), 100% alc/Fau; QMG220877–220882 (CP), Fau; [QMW26642], QM 220912 (WM), Problem Ck crossing on Frying Pan Rd, trib. of Telegherry R., Chichester SF, 1km E of Telegherry FP, (32°13.6'S 151°45.8'E), 10.02.2002, K.B. Sewell & R.D. Sewell, hot Bouin/Un; QM 220913–220914 (WM), 70% alc/Un; QM 220915–220917 (WM), Bouin/Un; QM 220918–220919 (CP), 100% alc/Fau; QM 220920–220925 (CP), Fau; [QMW27490], QMG221216, (CP), 9.01.2004, D. Blair & R.D. Sewell, alc/Fau; [QMW27496], QMG221215 (CP), Govetts Leap Brook, James St crossing on Braeside Walk, Blackheath, Blue Mts NP, 2.01.2004 (34°37.1'S 150°32.5'E), Blair D. & Sewell R.D., alc/ Fau; [QMW27486], QMG221217 (CP), Piles Ck trib., beside the Great North Walk, Brisbane Waters NP (33°26.2'E 151°16.4'E), 8.01.2004, D. Blair & R.D. Sewell, alc/Fau.

DESCRIPTION. Characteristics of genus; pattern of body pigment typical, as described and figured by Haswell (1893: plate X, fig. 1). Selected body measurements of specimens from *Euastacus spinifer* are: QMG220869: B(4325 × 3529), LE(3162), PH(714 × 1326, SD(1387, PD(571); QMG220870: B(4447 × 3346), LE(3223), PH(694 × 1163), SD(na), PD(632); QMG220871: B(3876 × 2672), LE(2713), PH(504 × 984), SD(1244, PD(490); QMG220872: B(2958 × 1612), LE(1958), PH(347 × 551), SD(632), PD(306); QMG220873: B(3060 × 1632), LE(2081), PH(408 × 551), SD(775), PD(326).

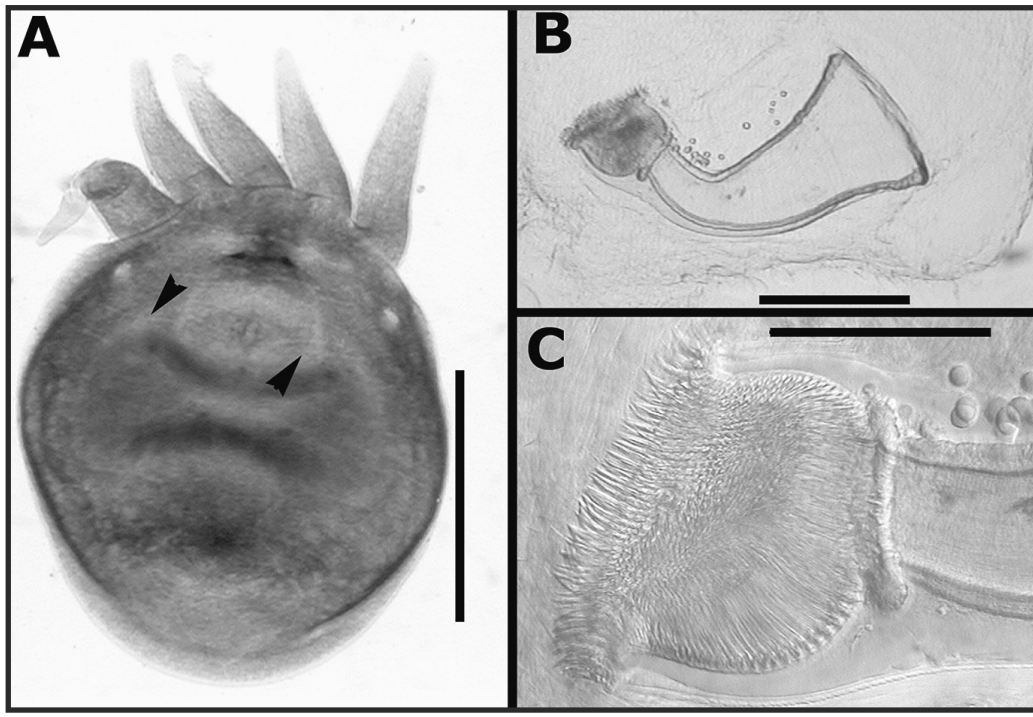


FIG. 39. *Temnosewellia fasciata* from *Euastacus australasiensis*. A, QMG220874, whole worm showing pigment pattern and non-pigmented outlines of facets (arrowheads), scale = 1mm; B–C. Nomarski interference contrast photomicrographs of Faure's preparations; B, QMG220878, whole cirrus, scale = 250µm; C, QMG220878, introvert distal region, scale = 250µm.

Reproductive System. Male. Cirrus: General form as figured by Haswell (1888: plate XXII, fig. 5; 1893: plate XIII, fig. 14). Shaft cone-shaped. Introvert essentially as figured by Haswell (1888: plate XXII, fig. 5; 1893: plate XIII, fig. 14) goblet-shaped; distal opening slightly oblique. Swelling uneven, extends proximally far past introvert base on both sides, much further on longer side. Selected cirrus measurements of specimens from *Euastacus spinifer* are: QMG220877: S(581 × 202), I(173 × 52), IS(113 × 359); QMG220878: S(532 × 262), I(161 × 60), IS(121 × 367); QMG220879: S(532 × 218), I(173 × 56), IS(141 × 323); QMG220880: S(484 × 181), I(173 × 60), IS(109 × 363); QMG220881: S(556 × 218), I(165 × 56), IS(137 × 290).

HOSTS. *Euastacus australasiensis, E. clarkae, E. polysetosus, E.* sp. nov?, *E. spinifer*.

DISTRIBUTION. Mid-eastern NSW — from the Wollemi NP; Weerikimbe NP; and the Blue Mountains NP.

REMARKS. There are no types of *Temnosewellia fasciata* lodged in any Australian museum. Nonetheless, we can confidently place these worms as *Temnosewellia fasciata* as they conform closely to the species description provided by Haswell (1888) and updated by Haswell (1893, 1924). In particular, the general form of the cirrus is close to that illustrated (without a scale bar) by Haswell (1888: plate XXII, fig. 5), and the relative dimensions of the swelling on the shorter side of the introvert conform closely to our specimens. We observed on our specimens a small aggregation of tissue that often encircles the shaft, just proximal to the introvert base, and thus resembles a collar.

We believe it likely that Haswell obtained the original specimens used to describe the species from the Blue Mountains region. Unfortunately, Haswell (1888) provided no clues as to the precise locality of these specimens, listing the host, *Astacopis serratus* as occurring in 'streams of New South Wales'. Haswell (1893) stated that he obtained *Temnosewellia fasciata* from *Astacopsis serratus* from 'various parts of the Blue Mountains, as well as from streams in the coastal districts,

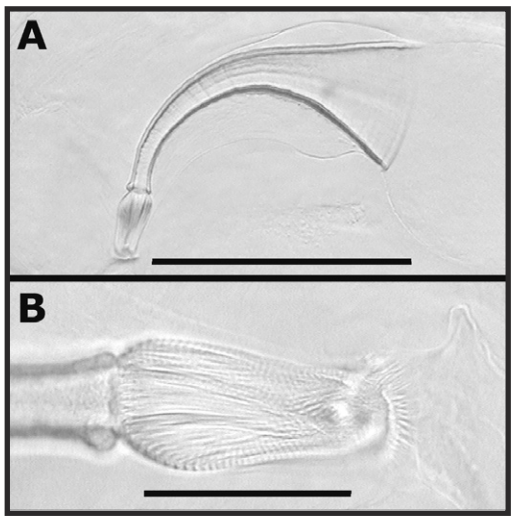


FIG. 40. *Temnosewellia fax* sp. nov. from *Euastacus* c.f. *crassus*. A-B, Nomarski interference contrast photomicrographs of Faure's preparations. A, QMG220979, whole cirrus, scale = 250µm; B, QMG220979, introvert distal region, scale = 50µm.

from the Richmond River in the north, to the Yarra in the South'. The now known distribution of different *Euastacus* species across this range, coupled with the statement by Haswell (1893) that 'the specimens of *Astacopsis serratus* from different localities differ a good deal as regards colouration and other minor points' is evidence that he sampled a considerable number of different host species.

Haswell (1888) stated that the body of this species has 'several, usually three, broad, transverse dark bands, separated from one another by lighter intervals'. We believe that he, (Haswell, 1888) was referring to the pattern of open spaces in the parenchymal pigment ventral to the dorsal network created by the unpigmented neural plexus. We have seen video footage of a large colony of *Temnosewellia fasciata* living on *Euastacus spinifer* in the laboratory and can confirm that a significant proportion of the population of worms appear to have dorsal transverse dark and light (white) bands of somewhat variable thickness and pattern. Later, Haswell (1893) suggested that the pattern of the 'darker and lighter zones' of pigment found in *Temnosewellia fasciata* did not always conform exactly to the pattern described in Haswell (1888).

The pigment pattern observed here for *Temnosewellia fasciata* conforms essentially to that described for the species by Haswell (1893), and indeed is typical of most *Temnosewellia* species with body pigment and occurring on *Euastacus* crayfish (see, for example, Fig. 28A). Haswell (1893) described accurately the body pigment of *Temnosewellia fasciata* as comprised of a fine, close network of very delicate threads of granular pigment which are darker on the dorsal surface. Haswell (1893: plate X, fig. 1) described and figured a principal layer of pigment dorsally just below the basement membrane and less dense pigment ventral to this layer throughout the parenchyma. The cirrus of the present species most closely resembles that of *Temnosewellia batiola* sp. nov., but the introvert opening is not as wide.

Some specimens (AMW28703–28711) identified as *Temnocephala* [= *Temnosewellia*] *fasciata* by W. A. Haswell in the collection of the Australian Museum, Sydney were from *Astacopsis serratus* [= *Euastacus* spp.] collected at Leura, Blue Mountains, NSW. These specimens we consider to represent the variety of *Temnosewellia fasciata* described briefly and figured (Haswell (1893: plate XIII, fig 14), and which we have named *Temnosewellia possibilitas* sp. nov. in the present study.

Temnosewellia fax sp. nov.
(Fig. 40A–B)

ETYMOLOGY. From *fax* = torch, flame (Latin); a reference to the shape of the cirrus introvert.

MATERIAL. HOLOTYPE: From *Euastacus armatus* [QMW26582], QMG220969 (WM), Buffalo R., Shultz Track, 36km S of Buffalo, VIC (36°59.5'S 146°48.0'E), 10.03.2002, G.N. Edney, 100% Alc/Un. PARATYPES: QMG220970–220973 (WM), 100% alc/Un. OTHER MATERIAL FROM TYPE LOCALITY: QMG220974–220981 (CP), 100% alc/Fau; from *Euastacus* cf. *crassus* [QMW26596], QMG220899 (CP), 10.03.2002, G.N. Edney, 100% Alc/Un. OTHER MATERIAL. From *Euastacus hirsutus*. NSW: [unreg. host], QMG220181 (WM), Belmore Falls, in stream above falls (34°38.5'S 150°33.3'E), 9.03.1939, unknown fixative/Hx.

From *Euastacus yanga*. NSW: [QMW26626], QMG221008 (WM), Burrawang Ck at road crossing, 3km NW Belmore Falls, Morton NP, NSW (34°37.1'S 150°32.5'E), 13.02.2002, K.B. Sewell & R.D. Sewell, 70% alc/Un; QMG221009 (CP), 70% alc/Fau.

DESCRIPTION. Characteristics of genus; pattern of body pigment typical. Selected body measurements of type specimens from *Euastacus armatus* are: QMG220969 (H): B(3448 × 2326), LE(2224), PH(530

× 632), SD(854), PD(366); QMG220970 (P): B(4508 × 3244), LE(2897), PH(694 × 1000), SD(1000), PD(592); QMG220971 (P): B(3917 × 3713), LE(2958), PH(775 × 1020), SD(1326), PD(612); QMG220972 (P): B(3937 × 3366), LE(2897), PH(734 × 979), SD(1224), PD(632); QMG220973 (P): B(4824 × 2978), LE(2754), PH(755 × 867), SD(898), PD(510).

Reproductive System. Male. Cirrus: Shaft cone-shaped. Introvert cylinder to scoop-shaped; distal opening oblique. Swelling slightly uneven(?), extends proximally somewhat past introvert base on longer side, less on shorter side. Selected cirrus measurements of specimens from *Euastacus armatus* from type locality are: QMG220976: S(354 × 124), I(77 × 20), IS(19 × na); QMG220977: S(380 × 100), I(75 × 20), IS(26 × 19(?)); QMG220978: S(358 × 136), I(71 × 20), IS(27 × na); QMG220979: S(366 × 122), I(65 × 20), IS(22 × 17(?)); QMG220980: S(373 × 132), I(75 × 20), IS(23 × na).

HOSTS. *Euastacus armatus*, *E.* cf. *crassus*; *E. hirsutus*, *E. yanga*.

DISTRIBUTION. Mid-eastern NSW — from the Belmore Falls region, W of Kaima. Southern VIC — from the southern Gippsland region, near Buffalo.

REMARKS. The cirrus of this species was invariably strongly curved in the specimens examined here and may be a useful character. However, we prefer not to put too much emphasis on cirrus curvature in distinguishing between species. The introvert in most cases appears collapsed and folded which leads to the flame-like appearance. The cirrus is somewhat similar to that of *Temnosewellia comythus* sp. nov., though smaller overall with an introvert smaller relative to shaft length.

We include tentatively here specimens from *Euastacus yanga* collected from Burrawang Ck, a tributary of Barrengarry Ck, and upstream of Belmore Falls, NSW despite the large geographical distance between this location and those in VIC.

Temnosewellia flammula sp. nov.
(Fig. 41A–B)

ETYMOLOGY. From *flamma* = fire (Latin, diminutive); a reference to the tiny flame-like introvert on the fluted end of the cirrus shaft.

MATERIAL. HOLOTYPE: QMG220860 (WM), from *Euastacus neohirsutus* [QMW26650], Middle Ck trib., beside road 6 km upstream from Corritts Water, NSW (30°21.4'S 152°29.1'E), 6.02.2002, K.B. Sewell & R.D. Sewell, 70% alc/Un. OTHER MATERIAL FROM TYPE LOCALITY: [QMW26651], QMG220862 (WM) [juvenile], 15.02.1992, K.B. Sewell & S.G. Sewell, HW/Form/Hx; [QMW26650], QMG220864 (CP), 6.Feb.2002, K.B. Sewell & R.D. Sewell, 100% alc/Fau.

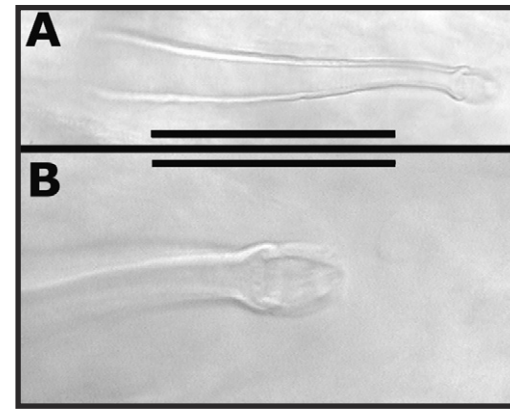


FIG. 41. *Temnosewellia flammula* sp. nov. from *Euastacus neohirsutus*. A–C. Nomarski interference contrast photomicrographs of Faure's preparations. A, QMG220864. Whole cirrus. Scale = 100µm. B, QMG220864. Introvert distal region. Scale = 50µm.

DESCRIPTION. Characteristics of genus; pattern of body pigment typical. Selected body measurements of holotype from *Euastacus neohirsutus* are: QMG220860 (H): B(1764 × 1171), LE(1244), PH(346 × 520, SD(537), PD(272).

Reproductive System. Male. Cirrus: Shaft cone-shaped. Introvert tiny, scoop-shaped; distal opening oblique. Swelling not observed. Selected cirrus measurements of specimens from *Euastacus neohirsutus* are: QMG220860 (H) [WM]: S(242 × 48), I(17(?) × 12), IS(na × na); QMG220864: S(148 × 26), I(18(?) × 12), IS(121 × 367).

HOST. *Euastacus neohirsutus*.

DISTRIBUTION. North-eastern NSW — from Middle Ck, W of Dorrigo.

REMARKS. The tiny cirrus and introvert discriminates this species despite only a few specimens being available. It is similar to that of *Temnosewellia minima* sp. nov., but the introvert is relatively smaller and more flame-like. Measurements of the length of the cirrus introvert are tentative and must be confirmed from additional specimens. Body pigment was well developed in the single, small juvenile specimen examined.

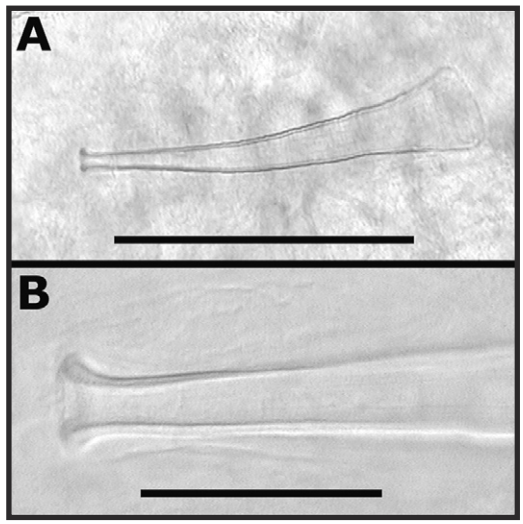


FIG. 42. *Temnosewellia gingrina* sp. nov. from *Euastacus suttoni*. A, B. Nomarski interference contrast photomicrographs of Faure's preparations. A, QMG220739. Whole cirrus. Scale = 250µm. B, QMG220739. Introvert distal region. Scale = 50µm.

Temnosewellia gingrina sp
(Fig. 42A–B)

ETYMOLOGY. From *gingrina* = small flute (Latin, feminine); a reference to the small, narrow cirrus with a fluted end.

MATERIAL. HOLOTYPE: QMG220729 (WM), from *Euastacus suttoni* [QMW26663], Washpool Ck, nr Thunderbolts Hideout, N of Tenterfield (28°58.4'S 152°04.4'E), 4.02.2002, K.B. Sewell & R.D. Sewell, hot Bouin/Un.PARATYPES: QMG220730–220733 (WM), hot Bouin/Un. OTHER MATERIAL FROM TYPE LOCALITY: [QMW26661], QMG220734–220738 (CP), 19.12.2001, K.B., S.G., R.D. & M.R. Sewell, 100% alc/Fau; QMG220739–220744 (CP), Fau. OTHER MATERIAL. From *Euastacus dangadi.* NSW: [QMW26604], QMG220745–220747 (WM), Eungai Ck trib., at Cedar Crossing, Ngaamba NR., Ingalba SF (30°53.9'S 152°47.3'E), 24.03.2002, K.B. Sewell, 100% alc/Un; [QMW26605], QMG220748 (CP), 6.02.2002, K.B. Sewell & R.D. Sewell, 100% alc/Fau; [QMW26604], QMG220749–220750 (CP), 24.03.2002, K.B. Sewell, 100% alc/Fau.

From *Euastacus gumar.* NSW: [QMW26622], QMG220751 (WM), Culmaron Ck, Richmond Ra. NP (28°50.5'S 152°44.1'E), 4.03.2002, K.B. Sewell, S.G. Sewell & J.A. Coughran, 100% alc/Bouin/Un; QMG220752 (WM), 100% alc/Un; QMG220753–220754 (CP), 100% alc/Fau; QMG220755 (CP), Fau.

From *Euastacus sulcatus*. NSW: [QMW26655], QMG220543 (WM), Bundoozle Flora Reserve, Richmond Ra. NP, NSW (28°36.4'S 152°42.1'E), 4.03.2002, K.B. Sewell, S.G. Sewell & J.A. Coughran, 100% alc/Bouin/Un; QMG220544 (WM), 100% alc/Un; QMG220545 (WM), 100% alc/Bouin/Un; QMG220546–220547 (CP), 100% alc/Fau.; QMG220548–220551 (CP), Fau; QMG220552–220553 (CP), 100% alc/Bouin/Fau.

From *Euastacus suttoni*. Qld: [QMW26660], QMG220756 (WM) beside rd to The Pyramids, Girraween NP (28°49.1S 151°58.8'E), 18.04.1990, S. Cook, Carn/Hx; QMG220757 (WM), HW/Form-Acetic/Hx; QMG220758 (WM), Form-Acetic/MB/Hx; QMG220759 (WM), Form-Acetic/Hx; ; QMG220760 (WM), HW/Form-Acetic/Hx; QMG220761 (WM) Form-Acetic/Hx; QMG220762–220763 (WM) HW/Form-Acetic/Hx; QMG220764 (WM), Carn/MB/Hx; QMG220765 (WM) hot Form-Acetic/Hx; QMG220766–220770 (CP), HW/70% alc/Fau; QMG220771–220772 (LS[5,3]), Bouin/H&E; QMG220773–220775 (LS[1,4,12]), HW/Form-Acetic/H&E; QMG220776 (LS[12]), Bouin/H&E; QMG220777–220778 (LS[5,7]), Form-Acetic/H&E; QMG220779–220780 (LS[5,8]), Carn/H&E; QMG220781–220782 (LS[6,4]), Form-Acetic/H&E; QMG220783–220784 (LS[3,5]), Bouin/H&E; QMG220785 (LS[6]), Carn/H&E.

NSW: [QMW6463], QMG220786–220789 (WM), Poverty Point, 24.1km SE Tenterfield (29°08'S 152°20'E), Dec. 1973, A. Martin, 70% alc(?)/Hx; [QMW6465], QMG220790 (WM) Poverty Point, nr Tenterfield (29°08'S 152°20'E), J. Toop, 70% alc(?)/Hx; QMG220791–220793 (CP), Poverty Point, 24.1km SE Tenterfield (29°08'S 152°20'E), Dec. 1973, A. Martin, 70% alc(?)/Fau; QMG220794–220797 (LS[7,18,12,15]), 70% alc(?)/H&E; [QMW6468], QMG220798–220799 (WM), Gibralter Ra. NP (29°35'S 152°13'E), 19.12.1972, S.R. Monteith, 70% alc(?)/Hx; [QMW26662],QMG220800–220802 (WM), Glen Innes, Dec. 1976, I. Kneipp, 70% alc/Hx; QMG220803–220804 (CP), 70% alc/Fau; QMG220805–220806 (LS[3,2]), 70% alc/H&E.

From *Euastacus valentulus*. NSW: [QMW6459], QMG220807 (WM), Rocky Ck rainforest, Whian Whian SF (28°40'S 153°18'E), Jul. 1974, G.B. Monteith & S.R. Monteith., 70% alc/MB/Hx; QMG220808–220810 (WM), 70% alc/Hx; QMG220811–220812 (WM), 70% alc/Un; QMG220813–220814 (WM), 70% alc/MB/Hx; QMG220815–220820 (CP), 70% alc/Fau; QMG220821–220823 (LS[1,6,26]), 70% alc/H&E.

DESCRIPTION. Characteristics of genus; pattern of body pigment typical. Selected body measurements of type specimens from *Euastacus suttoni* are: QMG220729 (H): B(5100 × 2570), LE(3448), PH(694 × 918), SD(1306), PD(510); QMG220730 (P): B(2490 × 2142), LE(3080), PH(592 × 836), SD(1081), PD(469); QMG220731 (P): B(2250 × 1285), LE(1714), PH(367 × 449), SD(612),

PD(306); QMG220732 (P): B(4753 × 2489, LE(3427), PH(673 × 775), SD(1244), PD(510); QMG220733 (P): B(7099 × 3203), LE(5161), PH(979 × 1285), SD(1469), PD(694).

Reproductive System. Male. Cirrus: Shaft cone-shaped. Introvert lacks spined region, but has some low cusp-like protuberences on distal rim of cirrus shaft; distal opening absent (corresponds with introvert base). Swelling absent(?). Selected cirrus measurements of specimens from *Euastacus suttoni* from type locality are: QMG220734 S(270 × 67), I(na × 17); QMG220735 S(335 × 91), I(na × 18); QMG220737 S(360 × 112), I(na × 19); QMG220739 S(319 × 67), I(na × 18); QMG220740 S(348 × 65), I(na × 18).

HOSTS. *Euastacus dangadi, E. gumar, E. suttoni, E. sulcatus, E. valentulus*.

DISTRIBUTION. South-eastern Qld — from Girraween NP, near Eukey.

North-eastern NSW — from Richmond Ra. NP at Culmaron Ck and at Bundoozle FR; from the Tenterfield area at Washpool Ck and at Poverty Point; from Ngaamba NR, Ingalba SF at Cedar Crossing; and from Whian Whian SF at Rocky Ck rainforest.

REMARKS. The introvert lacks spines and appears reduced to no more than a fluted flange with low cusp-like protuberances. Neither an unspined distal region nor an introvert swelling was observed. Presumably the distal end of the shaft serves as the intromittent organ. The cirrus is most similar to that of *Temnosewellia aspinosa* sp. nov., but the proximal diameter is much greater in that species.

Temnosewellia gracilis sp. nov.
(Fig. 43A–B)

ETYMOLOGY. From *gracilis* = slender (Latin); a reference to the appearance of the cirrus.

MATERIAL.HOLOTYPE. QMG220982 (WM), from *Euastacus guwinus*? (cf. *dharawalus*) [QMW26624] Tianjarra Ck, above Tianjarra Falls, Morton NP, NSW (35°06.7'S 150°19.8'E), 18.10.1991, L.R.G. Cannon & K.B. Sewell, HW/Form/Hx. PARATYPES: [QMW26623], QMG220983–220984 (WM), 18.02.2002, K.B. Sewell & R.D. Sewell, hot Bouin/Un. OTHER MATERIAL FROM TYPE LOCALITY: QMG220985–220987 (WM), [QMW26623], 18.02.2002, K.B. Sewell & R.D. Sewell, hot Bouin/Un; QMG220988–220989 (CP), 100% alc/Fau; QMG220990–220992 (CP), Fau; [QMW26624], QMG220993 (LS[6]), 18.10.1991, L.R.G. Cannon & K.B. Sewell, Form/H&E.

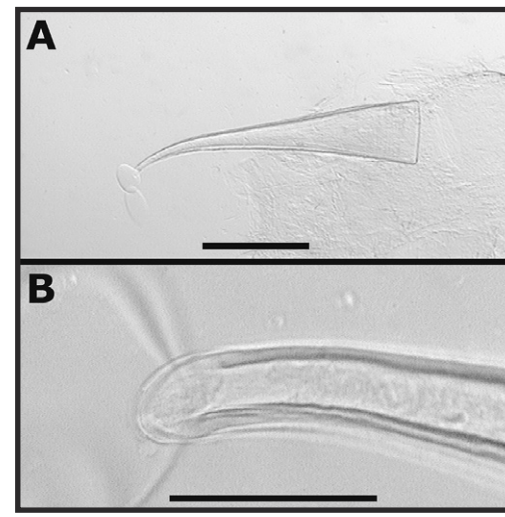


FIG. 43. *Temnosewellia gracilis* sp. nov. from *Euastacus guwinus* (cf. *dharawalus*). A-B, Nomarski interference contrast photomicrographs of Faure's preparations. A, QMG220991, whole cirrus, scale = 250µm; B, QMG220991, introvert distal region, scale = 50µm.

DESCRIPTION. Characteristics of genus; pattern of body pigment typical. Selected body measurements of type specimens from *Euastacus guwinus*? (c.f. *dharawalus*) are: QMG220982 (H): B(3529 × 1979), LE(2366), PH(390 × 667), SD(846), PD(350); QMG220983 (P): B(5304 × 3019), LE(3774), PH(626 × 935), SD(1138), PD(447); QMG220984 (P): B(4039 × 2693), LE(2876), PH(455 × 813), SD(1016), PD(528).

Reproductive System. Male. Cirrus: Shaft cone-shaped. Introvert tiny, scoop-shaped; distal opening oblique. Swelling uneven, extends proximally slightly past introvert base on longer side, shorter side not observed. Selected cirrus measurements of specimens from *Euastacus guwinus*? (cf. *dharawalus*) from type locality are: QMG220990: S(620 × 136), I(22 × 18), IS(na × na); QMG220991: S(681 × 144), I(26 × 18), IS(na × na); QMG220992: S(671 × 173), I(26 × 14), IS(na × na).

HOST. *Euastacus guwinus*? (cf. *dharawalus*).

DISTRIBUTION. Mid-eastern NSW — from W of Nowra, Morton NP, at Tianjarra Falls.

REMARKS. The cirrus of this species is large, but the introvert is extremely small and fine details are difficult to resolve. It perhaps resembles that of *Temnosewellia acicularis* sp. nov., but has a relatively wider proximal diameter and the

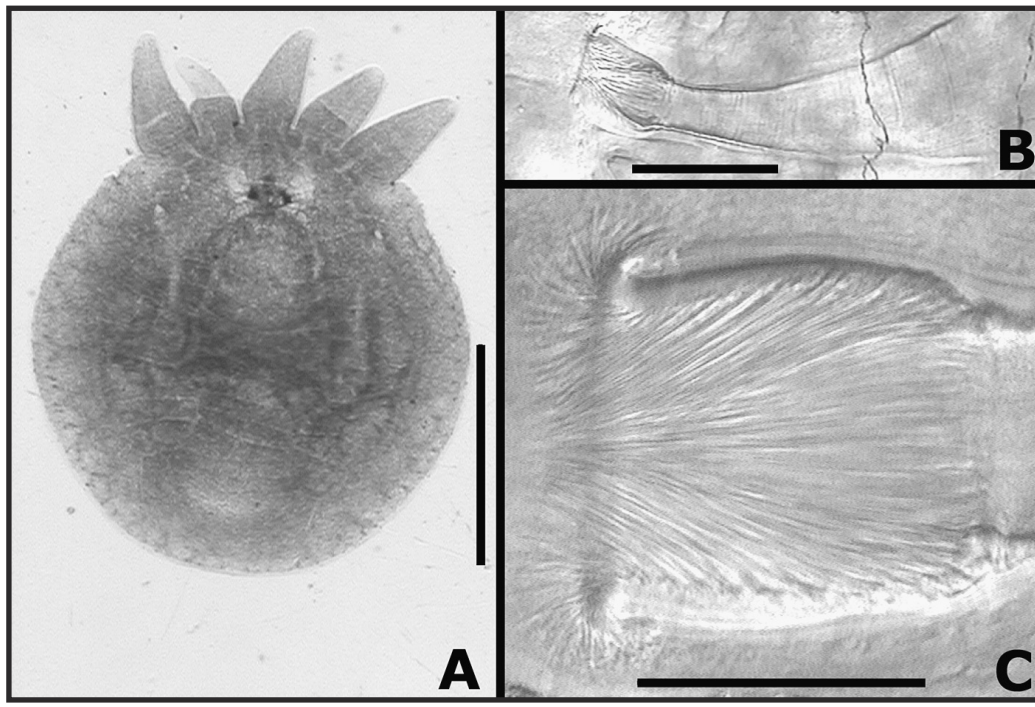


FIG. 44. *Temnosewellia keras* sp. nov. from *Euastacus yarraensis.* A, QMG221117, whole worm (Holotype) showing pigment pattern, scale = 1mm; B–C, Nomarski interference contrast photomicrographs of Faure's preparations; B, QMG221124, whole cirrus, scale = 100µm; C, QMG221130*,* introvert distal region, scale = 50µm.

introvert is much smaller. The introvert swelling on the longer side of the introvert is clearly wider than that on the shorter side, but its extent otherwise could not be determined. Very fine spines are present.

Temnosewellia keras sp.nov.
(Fig. 44A–C)

ETYMOLOGY. From *keras* = horn (Greek, noun); a reference to the shape of the cirrus.

MATERIAL. HOLOTYPE: QMG221117 (WM), from *Euastacus yarraensis* [QMW26593], SF nr Cockatoo beside road in picnic area (37°56.6'S 145°29.6'E), 21.03.2002, K.B. Sewell, S.H. Lawler & G.N. Edney, 100% alc/Un. PARATYPES: QMG221118–221121 (WM), 100% alc/Un. OTHER MATERIAL FROM TYPE LOCALITY: QMG221122–221126 (CP), 100% alc/Fau. OTHER MATERIAL. From *Euastacus kershawi*. VIC: [QMW26630], QMG221134 (CP), Labertouche Ck (Tarago R. trib.), on Old Telegraph Rd, W of Jindivick, VIC (38°03.2'S 145°50.1'E), 21.03.2002, K.B. Sewell, S.H. Lawler & G.N. Edney, 100% alc/Un.

From *Euastacus yarraensis*. VIC: [QMW26673], QMG221127 (WM), Labertouche Ck (Tarago R. trib.), on Old Telegraph Rd, W of Jindivick, VIC (38°03.2'S 145°50.1'E), 8.10.1991, L.R.G. Cannon & K.B. Sewell, HW/Form/Hx; QMG221128 (WM), HW/Form/Un; QMG221129–221130 (CP), HW/Form/Fau; QMG221131–221133 (LS [7,3,7]), HW/Form/H&E; [unreg. host, ident. Dr Susan Lawler, Latrobe University, VIC], QMG221213 (CP), Otways Love Ck, at picnic ground, Kawarren, Otways (38°28.8'E 143°35.0'E), 1.01.2004, D. Blair, R.D. Sewell, S.H. Lawler & G.N. Edney, alc/Fau. [NMVJ 6156] NMVF 93852–93856 (WM), Bunyip River, top of road from Princes HigHwy (37°55'S 145°43'E) 18.02.1977, P.S. Lake, 70% alc(?)/Hx; NMVF 93857–93858 (WM), 70% alc(?)/Un, NMVF 93859–93860 (CP), 70%alc(?)/Fau; NMVF 93863 (LS[7]), 70% alc(?)/H&E.

From *Astacopsis serratus* [= *Euastacus* spp]. VIC: [unreg. host], NMVF 93864–93866 (WM), Headwaters of Lederberger R., Blackwood (37°35'S 144°24'E), 15.10.1956, unknown fixation/carmine(?); NMVF 93867–93869 (CP), unknown fixation/Fau; NMVF 93897–93901 (WM), unknown fixation/Hx(?);NMVF 93902 (LS[8]), unknown fixation/H&E.

From *Hyridella (Hyridella) depressa* (Lamarck, 1819)) (Mollusca; Bivalvia; Unionoidea: Hyriidae)

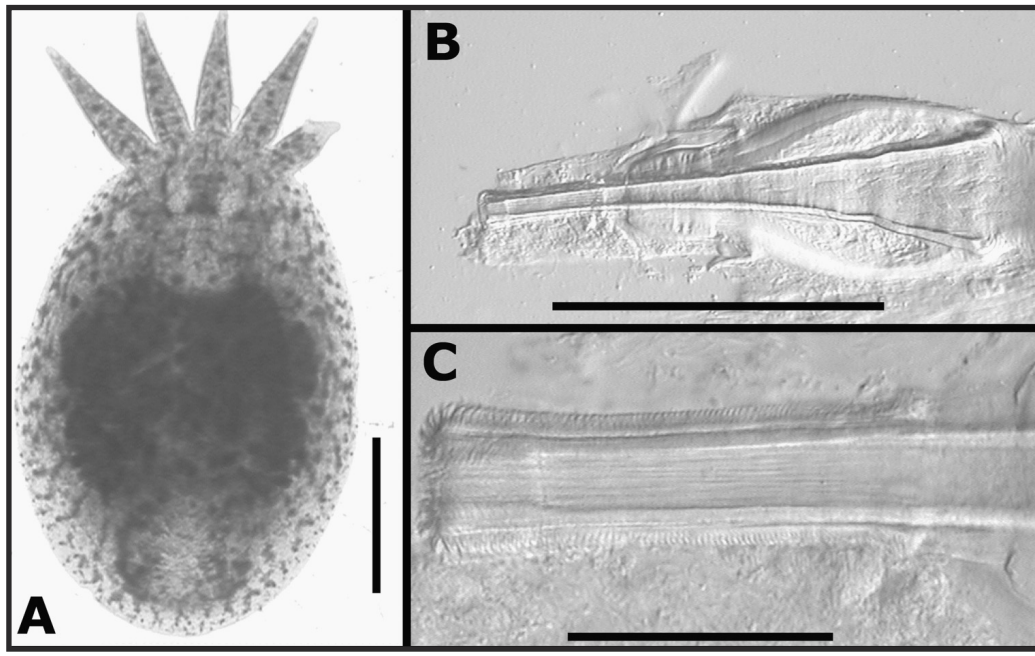


FIG. 45. *Temnosewellia maculata* sp. nov. from *Euastacus bispinosus.* A, QMG221150, whole worm (Holotype) showing punctate pigment pattern, scale = 1mm; B–C, Nomarski interference contrast photomicrographs of Faure's preparations; B, QMG221155*,* whole cirrus, scale = 250µm; C, QMG221155*,* everted introvert distal region, scale = 50µm.

[probably a spurious record; see Remarks]. VIC: [unreg. host], NMVF 93870–93871 (WM), Forrest (38°31'S 143°43'E), 1948, A. Wilhelms, unknown fixation/carmine(?); NMVF 93872–938714 (CP), unknown fixation/Fau; NMVF 93876–93884 (LS[3,4,3,3,1,1,1,1,1), unknown fixation/H&E(?).

DESCRIPTION. Characteristics of genus; pattern of body pigment typical, sometimes punctate. Selected body measurements of type specimens from *Euastacus yarraensis* are: QMG221117 (H): B(2550 × 2020), LE(1693), PH(480 × 537), SD(821), PD(366); QMG221118 (P): B(3264 × 1918), LE(1979), PH(520 × 553,) SD(829), PD(358); QMG221119 (P): B(3060 × 1734), LE(2122), PH(447 × 528), SD(691), PD(386); QMG221120 (P): B(2713 X1693), LE(1918), PH(431 × 626), SD(854), PD(358); QMG221121 (P): B(3182 × 1897), LE(2122), PH(488 × 650), SD(870), PD(423).

ReproductiveSystem. Male. Cirrus: Shaft cone-shaped. Introvert cylinder to cone-shaped; distal opening not oblique. Swelling near even, tapers rapidly just distal to introvert base and [apparently] does not extend proximally past introvert base. Selected cirrus measurements of specimens from *Euastacus yarraensis* from type locality are: QMG221123: S(167 × 71), I(63 × 41), IS(na × na); QMG221124: S(226 × 106), I(63 × 37), IS(na × na); QMG221125: S(217 × 102), I(63 × 42), IS(na × na); QMG221126: S(183 × 81), I(63 × 44), IS(na × na).

HOSTS. *Astacopsis serratus* [= *Euastacus* spp.], *Euastacus kershawi*, *E. yarraensis*.

DISTRIBUTION. From the region of Melbourne, VIC.

REMARKS. This is one of several species with a simple cone-shaped introvert with a transverse distal opening. It most closely resembles *Temnosewellia coughrani* sp. nov., but is smaller and the latter has an oblique opening to the introvert and the introvert swelling is not apparent, whereas in *T. keras* sp. nov., it is even. The record from the freshwater, unionid bivalve, *Hyridella (Hyridella) depressa,* is probably spurious and has very likely resulted from placement of this mollusc and a crayfish together in the same container when collected in the field.

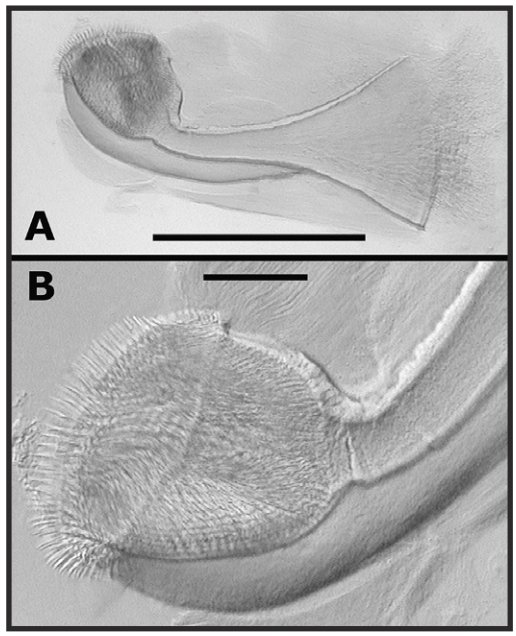


FIG. 46. *Temnosewellia magna* sp. nov. from 'Lobster' [= *Euastacus armatus*?]. A, B. Nomarski interference contrast photomicrographs of Faure's preparations. A, NMVF93818, whole cirrus, scale = 500μm; B, NMVF93818, introvert distal region, scale = 100μm.

Temnosewellia maculata sp. nov.
(Fig. 45A–C)

ETYMOLOGY. From *maculosus* = dappled or spotted (Latin); a reference to the dappled or spotted body pigment.

MATERIAL. HOLOTYPE: QMG221150 (WM), from *Euastacus bispinosus* [QMW26591], Jimmys Ck, at picnic ground 6.5km WNW Mafeking, VIC (37°23'S 142°34'E), 5.10.1991, L.R.G. Cannon & K.B. Sewell, HW/Form/Hx. PARATYPES: QMG221151 (WM), HW/Form/Hx; QMG221152–221153 (WM), HW/Form/MB/Hx; QMG221154 (WM), HW/Form/Un. OTHER MATERIAL FROM TYPE LOCALITY: QMG221155 (CP), Form/Fau; QMG221156–221159 (CP), HW/Form/Fau; QMG221160–221161 (LS[7,7]), Form/H&E. OTHER MATERIAL. From *Euastacus bispinosus*.VIC: [unreg. host], QMG221218 (CP), Rose Ck, just downstream of Burrang Falls, Grampians NP, (37°09.0'E 142°22.7'E), 31.12.2003, D. Blair, R.D. Sewell, S.H. Lawler & G.N. Edney, alc/Fau. SA: [AMP 25029], AMW28701–28702 (WM), Mt Gambier, Ewens Ponds (37°50'S, 140°47'E), 6.09.1975, N. Coleman, unknown fixative/Hx.

DESCRIPTION. Characteristics of genus; pattern of body pigment punctate. Selected body measurements of type specimens from *Euastacus bispinosus* are: QMG221150 (H): B(4141 × 2285), LE(2795), PH(447 × 618), SD(976), PD(398); QMG221151 (P): B(4855 × 2448), LE(3295), PH(593 × 691), SD(1041), PD(488); QMG221152 (P): B(3142 × 1673), LE(2020), PH(366 × 528), SD(724), PD(301); QMG221153 (P): B(1754 × 480), LE(1510), PH(207 × 407), SD(236), PD(504); QMG221154 (P): B(4488 × 2550), LE(3060), PH(569 × 789), SD(829), PD(455).

Reproductive System. Male. Cirrus: Shaft cone-shaped. Introvert cylinder shaped; distal opening slightly oblique. Swelling near equal(?), extending proximally slightly past introvert base on both sides, about equal on both sides. Selected cirrus measurements of specimens from *Euastacus bispinosus* from type locality are: QMG221155: S(295 × 93), I(98 × 18), IS(na × na); QMG221156: S(354 × 79), I(96 × 16), IS(na × na); QMG221157: S(370 × 65), I(96 × 15), IS(na × na).

HOST. *Euastacus bispinosus*.

DISTRIBUTION. South western VIC from The Grampians NP, at Jimmys Ck, near Mafeking. South eastern SA — from the Mt Gambier region, at Ewens ponds.

REMARKS. This is the most strongly pigmented species examined here. The pigment is punctate, even in small specimens (Fig. 45A). Moreover, in larger specimens of this species, punctate pigment occurs in the dorsal region of the sucker disc and occasionally in the ventral region. The introvert is distinctive among the group with punctate pigment, being long and narrow and armed with relatively uniform small spines. *Temnosewellia minima* sp. nov. also has a cylindrical introvert, but the whole cirrus is half the size and the introvert much smaller than in the present species.

Temnosewellia magna sp. nov.
(Fig. 46A–B)

ETYMOLOGY. From *magnus* = large (Latin); a reference to the large size of the goblet shaped introvert.

MATERIAL. HOLOTYPE. NMVF 93811 (WM), from 'Lobster' [= *Euastacus armatus*?], [unreg. host], Wangaratta, King River (36°21'S 146°19'E), 10.09.1918, C.F. Cole, unknown fixation/carmine(?). PARATYPES. NMVF 93812 (WM), unknown fixation, carmine(?); NMVF 93813 (WM), unknown fixation/Hx. OTHER SPECIMENS FROM TYPE LOCALITY: NMVF 93814–93820 (CP), unknown fixation/Fau; NMVF 93821–93822 (LS[6, 5]), unknown fixation/

unknown stain [H&E(?)], NMVF 93823 (LS [8]), unknown fixation/Hx.

DESCRIPTION. Characteristics of genus; pattern of body pigment typical. Selected body measurements of specimens from 'Lobster' from type locality are: NMVF 93811 (H): B(8017 × 3346), LE(5365), PH(1061 × 1346, SD(1836), PD(877); NMVF 93812 (P): B(8792 × 3815), LE(571), PH(1081 × 1550, SD(1428), PD(775); NMVF 93813 (P): B(3570 × 2550), LE(2897), PH(714 × 898, SD(1285), PD(490).

Reproductive System. Male. Cirrus: Shaft cone to funnel-shaped. Introvert goblet-shaped; distal opening oblique. Swelling near even, extends proximally well past the introvert base, slightly farther on longer side. Selected cirrus measurements of specimens from 'Lobster' from type locality are: NMVF 93814: S(754 × 496), I(323 × 133), IS(399 × 306); NMVF 93815: S(782 × 556), I(331 × 149), IS(399 × 286); NMVF 93816: S(774 × 468), I(302 × 133), IS(472 × 294); NMVF 93818: S(655 × 403), I(302 × 85), IS(383 × 266).

HOST. *Euastacus armatus*?

DISTRIBUTION. King River at Wangaratta, Victoria

REMARKS. This worm reaches an extremely large size, with some specimens almost 9mm body length. Based on the approximate ranges of *Euastacus* species presented by Morgan (1986) the host is most likely to be *E. armatus*. The introvert swelling is particularly prominent on the longer side of the introvert. The very large size of the cirrus and its goblet shape make it most similar to *Temnosewellia maxima* sp. nov., *T. batiola* sp. nov. and *T. fasciata,* however, the introvert swelling is uneven in the last two species. *Temnosewellia magna* sp. nov. differs from *T. maxima* sp. nov.as the shaft flares more proximally in the former.

Temnosewellia maxima sp. nov.
(Fig. 47A–B)

ETYMOLOGY. From *maximus* = greatest (Latin); a reference to the great size of the cirrus.

MATERIAL. HOLOTYPE: QMG220608 (WM), from *Euastacus sulcatus* [unreg. host, ident. Ron Monroe, Curator of Crustacea, QM], Nagarigoon Falls, Lamington NP, Qld (28°13.3'S 153°12.0'E), 31.03.1976, R. Monroe, 70% alc(?)/Hx. PARATYPES: QMG220609 (WM), 70% alc(?)/Hx; QMG220610–220611 (WM), 70% alc(?)/Hx. OTHER MATERIAL FROM TYPE LOCALITY: QMG220612–220614 (CP), 70% alc(?)/Fau; QMG220615–220617 (LS[14,13,8]), 70% alc(?)/H&E. OTHER MATERIAL. From *Euastacus sulcatus.* Qld: [unreg. host, ident. collector as 'Blue Land Crayfish'], QMG220618–220619 (WM), Lamington NP (28°19'S 153°05'E), 3.02.1984, W. Higgins, 70% alc/Hx; QMG220620–220621 (LS[14,17]), 70% alc/H&E; [unreg. host, ident. Dr John Short, QM], QMG220622 (WM), Mt Huntley, at spring beside walking track nr summit, Main Ra. NP (28°08.8'S 152°26.6'E), 30.01.1993, G.B. Monteith, HW/Bouin/Hx; QMG220623 (WM) HW/Bouin/MB/Hx; QMG220624–220627 (WM), 70% alc/Un; QMG220628–220629 (LS[25,25]) HW/Bouin/H&E.

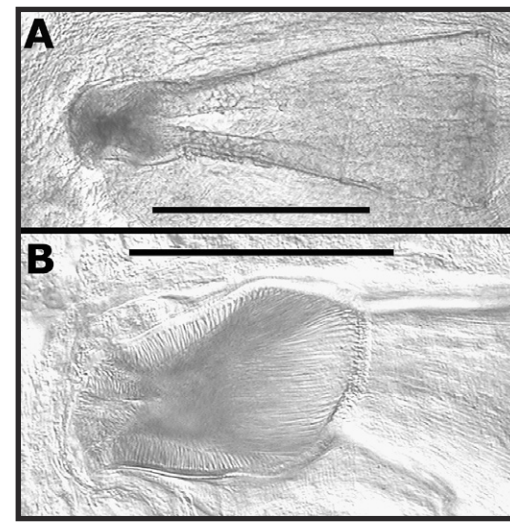


FIG. 47. *Temnosewellia maxima* sp. nov. from *Euastacus sulcatus*. A-B, Nomarski interference contrast photomicrographs of Faure's preparations. A, QMG220614, whole cirrus, scale = 500µm; B, QMG220612, introvert distal region, scale = 250µm.

DESCRIPTION. Characteristics of genus; pattern of body pigment typical. Selected body measurements of type specimens from *Euastacus sulcatus* are: QMG220608 (H): B(6793 × 4080), LE(5406), PH(918 × 1632), SD(1734), PD(1020); QMG220609 (P): B(5977 × 4162), LE(4080), PH(1122 × 1428), SD(na), PD(857); QMG220610 (P): B(4141 × 2632), LE(3121), PH(673 × 836), SD(1020), PD(490); QMG220611 (P): B(6467 × 3876), LE(4570), PH(1020 × 1571), SD(1673), PD(714).

Reproductive System. Male. Cirrus: Shaft cone-shaped. Introvert scoop to goblet-shaped; distal opening oblique, often folded into irregular shape. Swelling even, extends proximally well past introvert base equally distance on each side.

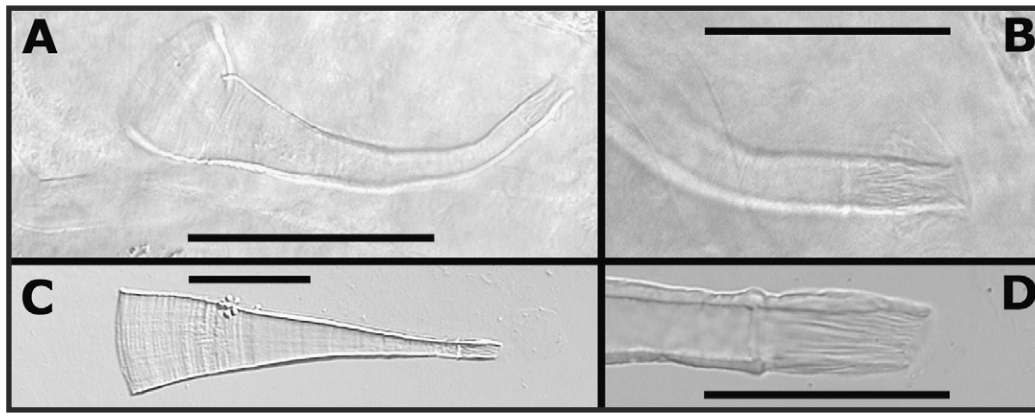


FIG. 48. *Temnosewellia minima* sp. nov. from *Euastacus sulcatus*. A–D, Nomarski interference contrast photomicrographs of Faure's preparations. A, QMG220585, whole cirrus, scale = 100µm; B, QMG220585, introvert distal region, scale = 50µm; C, QMG220594, whole cirrus, scale = 100µm; D, QMG220594, introvert distal region, scale = 50µm.

Selected cirrus measurements of specimens from *Euastacus sulcatus* from type locality are: QMG220612: S(314 × 323), I(258 × 121), IS(210 × na); QMG220613 [juvenile]: S(101 × 173), I(246 × 133), IS(101 × 101); QMG220614: S(746 × 411), I(242 × 137), IS(343 × 343).

HOST. *Euastacus sulcatus*.

DISTRIBUTION. South-eastern Qld — from the Lamington NP region, and at Mt Huntley.

REMARKS. This species was the largest examined in the present study, with one specimen from Lamington NP (QMG220618) being over 10mm in body length. The body pigment of these worms, while typical, is fine and thus appears shadowy. The cirrus is extremely large and may be distinguished from the most similar species *Temnosewellia magna* sp. nov. by the proximal diameter of the shaft, which is relatively much greater in the latter species.

Temnosewellia minima sp. nov.
(Fig. 48A–D)

Temnocephala sp. 3. Joffe & Cannon (1998: 3)

ETYMOLOGY. From *minimus* = least (Latin); a reference to the tiny size of the cirrus.

MATERIAL. HOLOTYPE: QMG220581 (WM), from *Euastacus sulcatus*, [QMW26657], upper Tallebudgera Ck, at '1000m mark on main track' (28°14.0'S 153°18.5'E), 22.04.2002, D.J. & L.V. Cook, L.RG. Cannon, K.B. & S.G. Sewell, 100% alc/Un. PARATYPES: QMG220582–220584 (WM), 100% alc/Un. OTHER MATERIAL FROM TYPE LOCALITY: QMG220585–220587 (CP), 100% alc/Fau. OTHER MATERIAL. From *Euastacus sulcatus*. Qld: [QMW18000 & 26656], QMG220588 (WM) Mosses Well, Spicers Gap, Main Ra. NP (28°04.0'S 152°26.3'E), 25.11.1991, K.B. Sewell & C. Lee, HW/Form/Hx; QMG220589 (WM), Form/Hx; QMG220590–220591 (WM), HW/Form/Hx; QMG220592 (WM) Glacial Acetic Acid/Hx; QMG220593 (WM), Form/Hx; [unreg. host, ident. Dr John Short, QM], QMG220594–220599 (CP), 1.09.1994, K.B. Sewell, Fau; [QMW18000 & 26656], QMG220600–220601 (LS[1,1,]), 1.09.1994, K.B. Sewell & C. Lee, Bouin/H&E; QMG220602 (LS[2]), HW/Form/H&E. [unreg. host, ident. Dr John Short, QM], QMG220603 (WM), Mt Huntley, at spring beside walking track nr summit, Main Ra. NP (28°08.8'S 152°26.6'E), 30.01.1993, G.B. Monteith, 70% alc/Un; QMG220604–220607 (CP), 70% alc/Fau.

DESCRIPTION. Characteristics of genus; pattern of body pigment typical. Selected body measurements of type specimens from *Euastacus sulcatus* are: QMG220581 (H): B(2305 × 1163), LE(1632), PH(480 × 382), SD(602), PD(293); QMG220582 (P): B(2244 × 1081), LE(1571), PH(447 × 366), SD(545), PD(260); QMG220583 (P): B(1877 × 816), LE(1367), PH(366 × 309), SD(488), PD(215); QMG220584 (P): B(2162 × 1061), LE(1571), PH(439 × 350), SD(528), PD(268).

Reproductive System. Male. Cirrus: Shaft cone-shaped. Introvert cylinder to scoop-shaped; distal opening not obviously oblique. Swelling not observed. Selected cirrus measurements of specimens from *Euastacus sulcatus* from type locality are: QMG220585: S(179 × 59), I(24 ×

12), IS(na × na); QMG220586: S(154 × 41), I(25 × 10), IS(na × na); QMG220587: S(159 × 55), I(26 × 9), IS(na × na).

HOST. *Euastacus sulcatus*.

DISTRIBUTION. South-eastern Qld — from the the Macpherson Ra. region, near Mt Cougal; and from the Main Ra. NP, at Spicers Gap and Mt Huntley.

REMARKS. No large specimens were available from the type locality. Larger specimens were however available from the Spicers Gap locality and these displayed the typical, closely woven network of dorsal body pigment. The cirrus of this species is small and the introvert is tiny. The small size of the cirrus and cylindical nature of the introvert make *Temnosewellia minima* sp. nov. most similar to *T. flammula* sp. nov., but in *T. minima* sp. nov. the introvert is less flame-like. No introvert swelling was observed in *T. minima* sp. nov. but it is likely to be very narrow.

Temnosewellia muscalingulata sp. nov.
(Fig. 49A–D)

ETYMOLOGY. From *musca* = fly (Latin) and *lingua* = tongue (Latin, feminine, diminutive); a reference to the shape of the introvert being reminiscent of the proboscis of a fly.

MATERIAL. HOLOTYPE. QMG221034 (WM) from *Euastacus rieki* [QMW26644], Wragges Ck on Kosciusko Rd 5km NE Perisher Valley, Kosciusko NP, NSW (36°22.9'S 148°27.4'E), 18.03.2002, K.B. Sewell, 100% alc/Un. PARATYPES: QMG221035–221036 (WM), 100% alc/Un; [QMW26645] QMG221037–221038 (WM), 14.10.1991, L.R.G. Cannon & K.B. Sewell, HW/Form/Un. OTHERMATERIAL FROM TYPE LOCALITY: [QMW26645], QMG221039 (WM), 14.10.1991, L.R.G. Cannon & K.B. Sewell HW/Form/Un;], QMG221040–221042 (WM), HW/Form/Hx; [QMW26644], QMG221043–221046 (CP), 18.03.2002, K.B. Sewell, 100% alc/Fau; [QMW26645], QMG221047–221049 (CP), 14/10/1991, L.R.G. Cannon & K.B. Sewell, HW/Form/Fau; QMG221050–221051 (LS[5,6]), 14.10.1991, L.R.G. Cannon & K.B. Sewell, Form/H&E. OTHER MATERIAL. From *Euastacus armatus*. VIC: [unreg. host, ident. Dr Susan Lawler, Latrobe University, VIC], QMG221162 (CP), Yackandandah Ck (36°14'S 146°57'S), 20.11.2001, S.H. Lawler & G.N. Edney, Fau.

From *Euastacus crassus*. VIC: [QMW26601], QMG221052–221060 (WM), Buchan R. in Native Dog Flat camping ground, Alpine NP (36°53.9'S 148°05.3'E), 19.03.2002, K.B. Sewell, S.H. Lawler & G.N. Edney, 100% alc/Un; QMG221061–221066 (CP), 100% alc/Fau.

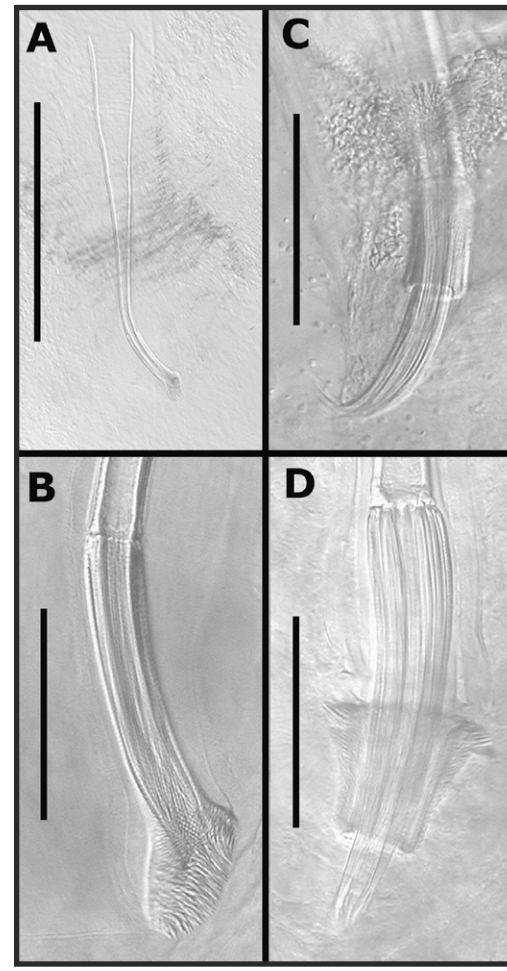


FIG. 49. *Temnosewellia muscalingulata* sp. nov. from *Euastacus rieki*. A–D, Nomarski interference contrast photomicrographs of Faure's preparations. A, QMG221045, whole cirrus, scale = 500µm; B, QMG221045, introvert distal region, scale = 50µm; C, QMG221162, everted introvert distal region, scale = 50µm; D, QMG221048, everted introvert distal region, scale = 50µm.

From *Euastacus neodiversus*. VIC: [QMW26635], QMG221067–221071 (WM), Tarra R., 50 m above Tarra Falls, Tarra Valley NP (38°29'S 146°36'E), 10.10.1991, L.R.G. Cannon & K.B. Sewell, HW/Form/MB/Hx; QMG221072–221077 (CP), HW/Form/Fau; QMG221078 (LS[4]), Form/H&E; QMG221079 (LS[5]), Bouin/H&E.

From *Euastacus woiwuru*. VIC: [QMW26669], QMG221080, 221082–221083 (WM), Dobsons Ck at crossing Alpine Rd nr junction with Mountain Hwy, Ferntree Gully SF, Dandenongs (37°52.3'S 145°20.0'E),

22.03.2002, K.B. Sewell, 100% alc/Un; [QMW26670], QMG221084–221086 (WM), 22.03.2002, L.R.G. Cannon & K.B. Sewell HW/Form/Hx; QMG221087–221091 (CP), 100% alc/Fau; QMG221092–221093 (LS[5,5]), Form/H&E. [NMVJ 4529], NMVF 93824 (WM) Creek between Mt Evelyn and Wandin North (37°47'S 145°23'E), Sep. 1963, J.R. Kane, unknown fixative/Hx; [unreg. host], NMVF 93825 (WM), Neerim, (37°58'S 145°57'E), 10.04.1906, S.W. Fulton, unknown fixative/carmine(?); NMVF 93826 (CP), unknown fixative/Fau.

From 'fresh water cray' VIC: [unreg. host], NMVF 93827–93833 (CP), Fern tree Gully (37°53'S 145°18'E), 18.02.1872, unknown fixation/Fau; NMVF 93834–93837 (LS[5,4,5,4]), unknown fixative/unknown stain[H&E(?)]; NMV 93892–93894 (WM), unknown fixation/Hx; NMV 93895–93896 (LS[5,5]), unknown fixation/Hx.

DESCRIPTION. Characteristics of genus; pattern of body pigment typical. Selected body measurements of type specimens from *Euastacus rieki* are: QMG221034 (H): B(4039 × 2917), LE(2652), PH(512 × 756), SD(1179), PD(610); QMG221035 (P): B(3835 × 2836), LE(2795), PH(545 × 805), SD(1220), PD(561); QMG221036 (P): B(3917 × 3101), LE(2693), PH(593 × 862), SD(1187), PD(545); QMG221037 (P): B(3509 × 1979), LE(2265), PH(366 × 618), SD(602), PD(341); QMG221038 (P): B(3774 × 1958), LE(2530), PH(407 × 626), SD(846), PD(390).

Reproductive System. Male. Cirrus: Shaft cone-shaped. Introvert cylinder-shaped except for flared distal region; distal opening oblique. Spines in flared distal region of introvert clearly larger than those in proximal cylinder-shaped region. Very long, thin spines (about 140 long) attached on, or just distal to, introvert base and project distally. Swelling uneven, very narrow(?). Selected cirrus measurements of specimens from *Euastacus rieki* from type locality are: QMG221045: S(677 × 102), I(187 × 26), IS(na × na); QMG221046: S(448 × 77), I(165 × 27), IS(na × na); QMG221049: S(359 × 38), I(177 × 25), IS(na × na).

HOSTS. *Euastacus armatus*, *E. crassus*, *E. neodiversus, E. rieki, E. woiwuru*.

DISTRIBUTION. Southern NSW — from the Kosciusko NP region. Northern VIC — from the Alpine NP. Southern VIC — from the Tarra Valley NP region; and the Melbourne region.

REMARKS. A widespread worm with a large, very slender cirrus and a unique introvert that clearly distinguishes this species from all others in the genus. The extremely long spines attached near the introvert base can only be clearly seen when the introvert is at least partially everted.

Temnosewellia possibilitas sp.nov.
(Fig. 50A–D)

ETYMOLOGY. From *possibilitas* = possibility (Latin); for the possibility of this species being the 'variety' of *Temnosewellia fasciata* described by Haswell (1893).

MATERIAL. HOLOTYPE. [unreg. host], AMW28703 (WM), from *Astacopsis serratus* [= *Euastacus* spp.], Leura, Blue Mountains (33°43'S 150°19'E), unknown date/collector/fixative [specimens ident. W.A. Haswell.]; unknown fixative/Un. PARATYPE: AMW28704 (WM), unknown fixative/Un. OTHER MATERIAL FROM THE TYPE LOCALITY: AMW28705–28707 (WM), unknown fixative/Un; AMW28708–28711 (CP), unknown fixative/Fau. OTHER MATERIAL. From *Euastacus bispinosus.* VIC: [NMVJ 875], NMV F 93885– F 93886 (WM), Glenelg R., VIC (37°17'S 141°16'E), 1941, E.M. Clarke, unknown fixative/Hx; NMV F 93887–93890 (CP), unknown fixative/Fau; NMV F 93891 (LS[6]), unknown fixative/H&E.

DESCRIPTION. Characteristics of genus; pattern of body pigment typical. Selected body measurements of type specimens from *Astacopsis serratus* [*Euastacus* spp.] are: AMW28703 (H): B(4468 × 2122), LE(3162), PH(663 × 816), SD(1073), PD(569); AMW28704 (P): B(2407 × 1326), LE(1918), PH(431 × 537), SD(748), PD(374).

Reproductive System. Male. Cirrus: In general form as figured by Haswell (1893: plate XIII, fig. 14). Shaft cone-shaped. Introvert scoop-shaped with distal region more rapidly tapering as figured by Haswell (1893: plate XIII, fig. 14); distal opening slightly oblique. Swelling near even, extends proximally slightly past introvert, about equally on both sides. Selected cirrus measurements of specimens from *Astacopsis serratus* [= *Euastacus* spp.] are: AMW28708: S(641 × 242), I(154 × 47), IS(12 × 12); AMW28709: S(581 × 246), I(159 × 53), IS(12 × 18); AMW28710: S(609 × 218), I(154 × 47), IS(na × na); AMW28711: S(641 × 226), I(157 × 49), IS(na × na).

HOSTS. *Astacopsis serratus* [= *Euastacus* spp.], *Euastacus bispinosus*.

DISTRIBUTION. Mid eastern NSW — from the Blue Mountains NP region. South-western VIC — from the Glenelg R.

REMARKS. Haswell (1893) described and figured the cirrus of a worm he regarded as a variety of *Temnosewellia fasciata*. We believe it

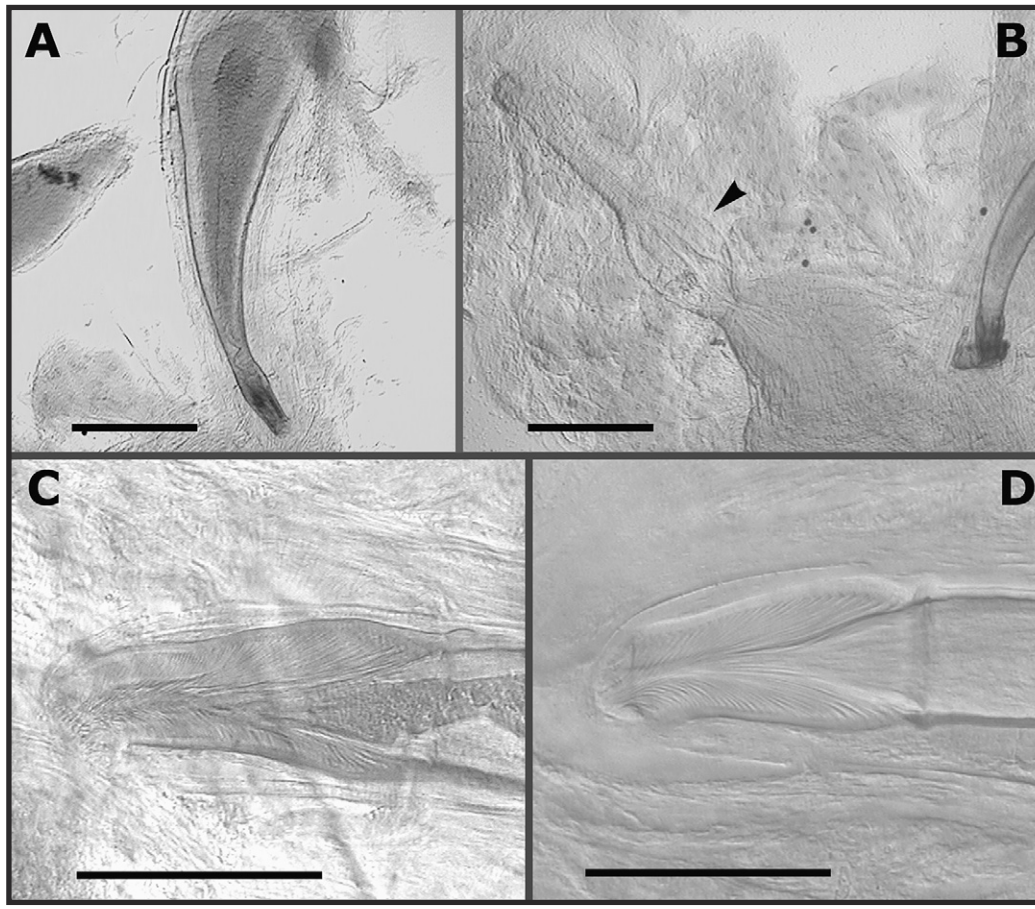


FIG. 50. *Temnosewellia possibilitas* sp. nov. A–D, Nomarski interference contrast photomicrographs of Faure's preparations. A, AMW29708 from *Astacopsis serratus* [= *Euastacus* sp.] whole cirrus, scale = 250µm. B, AMW28710, from *Astacopsis serratus* [= *Euastacus* sp.], partly everted introvert and weakly sclerotised, compartmentalised vagina (arrowhead), scale = 250µm; C, AMW28709, from *Astacopsis serratus* [= *Euastacus* sp.], cirrus introvert, scale = 100µm; D, NMVF93888 from *Euastacus bispinosus*, cirrus introvert, scale = 100µm.

probable that the present species and Haswell's 'variety' are one and the same. Haswell (1893) described the variety as occuring 'together with' *Temnosewellia fasciata* and 'closely resembling the young of that species'. We did not find the two species together but we did find *T. fasciata* on *Euastacis australasiensis* collected just above Wentworth Falls, which is within five km of Leura from where the present species was collected. According to Morgan (1997) this region of the Blue Mountains is inhabited by only two *Euastacus* species, *E. australasiensis* and *E. spinifer*. Haswell (1893) identified as *T. fasciata* the specimens examined here that were collected from *Astacopsis serratus* [= *Euastacus* spp.] from Leura, Blue Mountains. The cirrus of these specimens was revealed by Faure's medium to be similar to that of the form figured by Haswell (1893: plate XIII fig. 14). In particular, the introvert has a distinctive narrowed distal region. Haswell (1893) described the cirrus as closely resembing that of *Temnohaswellia novaezealandiae* in possessing 'a small introvert with exceedingly fine spines'.

Haswell (1893) described the vagina as having 'a zone or circlet of what appeared to be rudimentary chitinous teeth'. We did not observe anything resembling teeth in the distal vagina

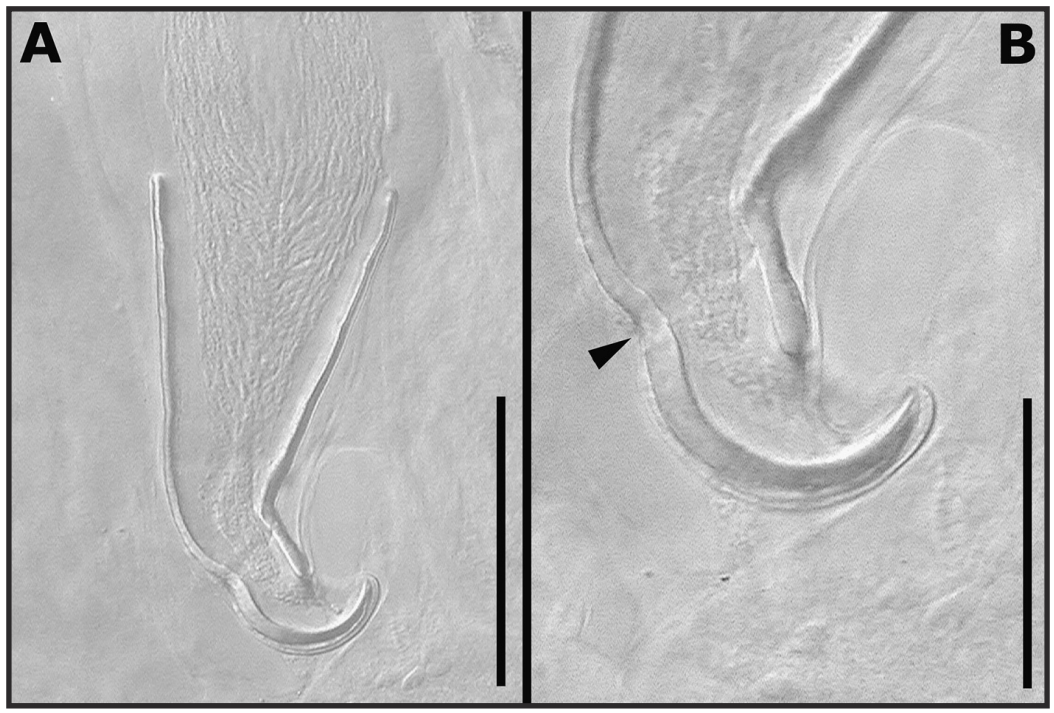


FIG. 51. *Temnosewellia unguiculus* sp. nov. from *Euastacus claytoni*. A-B, Nomarski interference contrast photomicrographs of Faure's preparations. A, QMG221024, whole cirrus, scale = 100µm; B, QMG221024, introvert showing the introvert base (arrowhead), scale = 50µm.

of *Temnosewellia possibilitas* sp. nov. The vagina of this species is however more tightly compartmentalised than typical of other species examined here (Fig. 50B).

This species has a cirrus most similar to those of *Temnosewellia fax* sp. nov. and *T. comythus* sp. nov., but larger and the introvert swelling is even (not uneven) and extends only a short distance proximally, not a medium to long distance as in those two species.

We tentatively include in this species specimens collected from *Euastacus bispinosus* from the Glenelg R. VIC noting that the introvert is slightly shorter in these specimens. We recognise that their locations are far apart.

Temnosewellia unguiculus sp. nov.
(Fig. 51A, B)

ETYMOLOGY. From *unguiculus* = small claw, talon or fingernail (Latin, masculine, diminutive); a reference to the small size of the cirrus and the resemblance of the introvert to a hooked claw.

MATERIAL. HOLOTYPE. QMG221011 (WM), from *Euastacus claytoni* [QMW26599], Lowden Ck, in Lowden FP picnic area, Tallaganda SF, NSW (35°30.8'S 149°36.2'E), 17.10.1991, L.R.G. Cannon & K.B. Sewell, HW/Form/Hx. PARATYPES: QMG221012 (WM), HW/Form/Hx; QMG221013–221014 (WM) HW/Form/Un; [QMW26600], QMG221015 (WM), 16.02.2002, K.B. Sewell & R.D. Sewell, hot Bouin/Un. OTHER MATERIAL FROM TYPE LOCALITY: [QMW26599], QMG221016–221018 (WM), L.R.G. Cannon & K.B. Sewell, HW/Form/Un; [QMW26600], QMG221019–221022 (WM), 16.02.2002, K.B. Sewell & R.D. Sewell, hot Bouin/Un; QMG221023 (CP) 70% alc/Fau; [QMW26599], QMG221024–221026 (CP), L.R.G. Cannon & K.B. Sewell, HW/Form/Fau; [QMW26600], QMG221027–221031 (CP), 16.02.2002, K.B. Sewell & R.D. Sewell, 70% alc/Fau; [QMW26599], QMG221032–221033 (LS[7,6]), L.R.G. Cannon & K.B. Sewell, HW/Form/H&E.

DESCRIPTION. Characteristics of genus; pattern of body pigment typical. Selected body measurements of type specimens from *Euastacus claytoni* are: QMG221011 (H): B(4019 × 2183), LE(2693), PH(439 × 756), SD(886), PD(390); QMG221012 (P): B(4304 × 2346), LE(2978), PH(480 × 752), SD(967), PD(496); QMG221013

(P): B(4060 × 2203), LE(2815), PH(512 × 691), SD(951), PD(447); QMG221014 (P): B(4794 × 2468), LE(3203), PH(528 × 748), SD(935), PD(463); QMG221015 (P): B(4753 × 2611), LE(3284), PH(691 × 748), SD(940), PD(472).

Reproductive System. Male. Cirrus: Shaft cone-shaped, with strongly curved distal region. Introvert lacks spined region(?), scoop-shaped, introvert longer side strongly curved; distal opening very oblique. Swelling uneven, not extending past introvert base on either side(?). Selected cirrus measurements of specimens from *Euastacus claytoni* from type locality are: QMG221024: S(148 × 85), I(77 × 30), IS(na × na); QMG221025: S(148 × 71), I(77 × 30), IS(na × na); QMG221026: S(183 × 116), I(77 × 35), IS(na × na); QMG221027 S(173 × 116), I(83 × 33), IS(na × na); QMG221029 S(195 × 132), I(78 × 33), IS(na × na).

HOST. *Euastacus claytoni*.

DISTRIBUTION. South-eastern NSW — from Lowden Ck, Tallaganda SF.

REMARKS. The morphology of the cirrus is unique and serves to distinguish this species. The cirrus is small but has an extremely distinctive introvert shape resulting from a long and strongly curved longer side. The fine details of the introvert are difficult to resolve. The introvert swelling was difficult to distinguish. Spines were not observed, but longitudinal rows of striae reminiscent of spines are present.

Temnosewellia sp.

MATERIAL. From *Euastacus neohirsutus*. NSW: [QMW26651], QMG220861 (Middle Ck trib., beside road 6km upstream from Corritts Water, NSW (30°21.4'S 152°29.1'E), 15.02.1992, K.B. Sewell & S.G. Sewell, HW/Form/Hx; QMG220866 (CP) [juvenile], HW/Form/Fau; QMG220867–220868 (LS[1,2]), Form/H&E.

DESCRIPTION. Characteristics of genus; pattern of body pigment typical.

REMARKS. This species occurred with *Temnosewellia flammula* sp. nov. but has a clearly different and larger cirrus introvert (although only immature worms were available for study). All the specimens examined had well developed body pigment. In the absence of mature specimens we are reluctant to describe this species formally.

DISCUSSION

The assertion more than 10 years ago by Cannon (1991) that the Australasian region is the centre of diversity of the Temnocephalida is supported here by the addition of 10 new species of *Temnohaswellia* and 31 new species of *Temnosewellia* all from hosts in the crayfish genus *Euastacus* collected from eastern Australia. Furthermore, the prediction by Cannon & Sewell (1994) that the large, brown-pigmented worms with 5 tentacles that inhabit the surface of most *Euastacus* spp. belonged to many species, is confirmed. These species, not all of which are equally pigmented, were recorded from the complete extent of the range of *Euastacus*, from the base of Cape York (NE Qld) to the Grampians NP in Vic.

We were able to confirm the validity of *Temnohaswellia comes* (Haswell, 1893) and the poorly described *Temnoshaswellia simulator* (Haswell, 1924) which previously were the only known members of the genus described as occurring on *Euastacus* species. The validity of *Temnosewellia fasciata* (Haswell, 1888), the first temnocephalan species recorded from *Euastacus*, was confirmed, and we consider that *T. possibilitas* is very likely the 'variety' of *T. fasciata* reported by Haswell (1893).

The present study and recent taxonomic studies by Cannon (1993), Cannon & Sewell (1995, 2001), Sewell & Cannon (1998a) together provide strong evidence that eastern Australia is in fact the centre of diversity for the worms, although it must be remembered that the temnocephalan fauna of New Guinea has been little studied.

Molecular studies associated with the present study will allow in-depth analyses of species and biogeography. Neverthless, some interesting related factors have emerged that warrant discussion here. Many *Temnohaswellia* species are found on numerous species of hosts, and the distribution of a host is a more reliable clue than its species identity in helping to identify worms, i.e for most Australian *Temnohaswellia* species, geography is more significant than host. Several species of *Temnohaswellia*, most notably *T. comes*, have extensive geographical ranges as well as very low host specificity. The single New Zealand species, *Temnohaswellia novaezealandiae*, is restricted to the two available New Zealand crayfish hosts, but on these has a wide geographical distribution. In contrast, for most Australian *Temnosewellia* spp., the geographical location, the

distribution and identity of the *Euastacus* crayfish host(s) are all useful taxonomic guides.

Temnosewellia species are certainly not limited to hosts of the genus *Euastacus*, or even to parastacid crayfish hosts. Indeed, species of *Temnosewellia* have been reported in Australia from *Cherax* and *Engaeus* crayfish, as well as the burrowing isopod, *Phreatoicopsis terricola,* and from freshwater crabs (*Holthusiana*) and freshwater shrimp (*Macrobrachium*, *Caridina* and *Paratya*) (Cannon, 1993; Cannon & Sewell, 2001; Haswell, 1893; Williams, 1980). Moreover, the genus extends beyond Australia: *Temosewellia semperi* is a symbiont of freshwater crabs in the region from Indonesia to India, and *T. rouxi* is recorded from *Cherax* crayfish from the Aru Isands, just to the north of Australia, as well as from cultured crayfish in Australia (Cannon, 1991; Merton, 1914; Weber, 1889). Translocation of cultured Australian *Cherax* crayfish, particularly the marron, *C. tenuimanus*, has resulted in the spread of *Temnosewellia* species globally. In particular, *T. minor* has been reported from as far afield as South Africa, Japan and Europe (Mitchell & Kok 1988; Avenant-Oldewage, 1993; Oki et al*.,* 1995; Xylander, 1997; Cannon & Sewell, 2001).

At several localities different *Temnohaswellia* species were observed to co-occur on the same individual host specimen. Similarly, different *Temnosewellia* species were observed to co-occur on the same individual host specimen. Also co-occurrence of the same host species by different genera of temnocephalans at a single locality has been widely reported for over 100 years (see for example, Haswell 1888, 1893). This raises questions about niche separation and competition, and signals the need for careful and detailed examination to confirm the identification of temnocephalan species.

We know too that host specifity is variable. While co-occurrences of different host genera are sometimes found with probable sharing of worms (e.g. *Temnosewellia cestus*), much remains to be learned of the ecology of these worms.

The absence of body pigment from most species of *Temnohaswellia*, the number of tentacles and the small size of the worms makes the genus readily identifiable in the field or laboratory. In contrast, pigment is usual in *Temnosewellia*, those temnocephalans with 5 tentacles, raising questions as to its function. However, the far north Queensland worms all lack body pigment. The group of non–pigmented 'white' worms i.e. *Temnosewellia alba, T. arga, T. argilla*, *T. albata*, *T. aspra, T. argeta* and *T. aphyodes* all have a similar cirrus and introvert morphology but show, in the order listed, a general decrease in overall size of the cirrus. In most other *Temnosewellia* species, some differences in body pigments were recorded, but age-related variation in pigment density was frequently observed within species and this suggests that the character should be used with caution.

The vagina of *Temnohaswellia*, unlike that of most other genera of temnocephalans, has sclerotised teeth whose arrangement has proven the most valuable character to discriminate species in the present study. Thus, our species descriptions for members of this genus rely more heavily on descriptions of the sclerotised components of the vagina than in our previous publications (e.g. Cannon & Sewell, 1995, 2001; Sewell & Cannon, 1998a). As a consequence, the species descriptions in the present paper are more succinct than those previously published.

Faure's medium revealed the gross morphology of the sclerotised components of the vagina more easily than techniques used previously, while also revealing the morphology of the cirrus. The function of the sclerotised unspined region that collars the distal introvert (i.e. the 'unspined distal region') of most Australian species of *Temnohaswellia* remains unknown. The sclerotisation may protect the smaller spines of the introvert distal region from the large teeth in the outer region of the distal vagina during copulation (or self-impregnation if it occurs). Similarly, the structure and function of the 'introvert swelling' is not yet known. Sewell (1998) postulated that for the Craspedellinae the introvert swelling assists to maintain the rigidity of the introvert during mating and serves to elastically return the introvert to the inverted state and allows the spines to be withdrawn safely after mating. A study that includes the use of transmission electron microscopy would most likely be required to elucidate the structure and function of the introvert swelling. Furthermore, until studies are conducted on growth we shall not know if the vaginal teeth (number, distribution and size) change with age.

The species descriptions provided here are based primarily on differences in the sclerotised reproductive structures. In *Temnohaswellia* there is wide variation in the vagina and often presence of vaginal teeth. The distal vagina of *Temnosewellia*, however, lacks teeth. Indeed, the

distal vagina of *Temnosewellia* species is typical of most temnocephalans in that it has only a slightly ruffled appearance. It is the great variation in cirrus morphology which is particulary useful in discriminating *Temnosewellia* spp.

Our field collecting in Australia was largely limited to the type localities of many of the *Euastacus* hosts. We are therefore confident that further examination of *Euastacus* hosts from across their distributions will reveal a greater diversity of both *Temnohaswellia* and *Temnosewellia.*

Much remains to be learned of the reproduction in these worms including the role of spermatophores mentioned by Haswell (1924) and the mode of production of the egg capsules which are of two forms: (1) those that stand on end on a peduncle and (2) those cemented flat to the host caparace with an upper sclerotised 'wisp'. Because more than one species in one genus, as well as species in different genera, can inhabit the one host it has usually not been possible to reliably determine which egg capsules belong to which temnocephalans. Perhaps now this aspect of temnocephalans can reveal further clues as to their diversity.

We have included the pattern of the epidermal mosaic in the genus taxonomic descriptions. Williams (1975) first reported that temnocephalans have a pattern of syncytial plates and Sewell & Cannon (1995) suggested that the pattern of the mosaic may have value as a taxonomic character. The pattern of the mosaic has subsequently been established to be most valuable as a taxonomic character at the level of higher taxa e.g. order and family. Joffe & Cannon (1998) mapped the mosaics of various families of temnocephalans, and later, they (Cannon & Joffe, 2001) established that an epidermis made of multiple syncytial plates is a synapomorphy for the Temnocephalida. Damborenea & Cannon (2001) examined *Temnocephala* from South America and reported the post-tentacular syncytia are paired dorsal plates which each enclose an excretory pore, a character they used to help define the genus. Within genera the pattern of the mosaic has been shown not always to be useful to distinguish species, due to lack of consistent variation in adults worms (Joffe & Cannon, 1998; Sewell 1995). Some ontogenic and occasional within species variation has been observed for some species (Joffe & Cannon, 1998).

In the present study, we examined in detail the mosaic for only two species, *Temnohaswellia comes* and *Temnosewellia cypellum* from *Euastacus spinifer*, primarily to demonstrate the patterns described by Joffe & Cannon (1998), for three putative species from *Euastacus sulcatus* (of which two are now identified as *Temnohaswellia comes* and *Temnosewellia minima*). Examination of the pattern of the mosaic of other species of *Temnohaswellia* and *Temnosewellia* from *Euastacus* hosts may reveal consistent differences in the pattern between species. There is some evidence for this. Joffe & Cannon (1998) reported that for *Temnohaswellia comes* from *Euastacus sulcatus* collected at Spicers Gap, the nephridiopores lie within the post-tentacular syncytium, whereas in another species, *Temnohaswellia* sp., collected from the same host and locality, the nephridiopores open between the post-tentacular syncytium and the body syncytium and occasionally were nearly fully separated from the body syncytium. We were unable to confirm the identity of the specimens of *Temnohaswellia* sp. examined by Joffe & Cannon (1998) but it is very likely that the species was *T. simulator* given that this species was found to co-inhabit the crayfish host at this locality in the present study.

We hope that the present work will provide improved ease with which species of *Temnohaswellia* and *Temnosewellia* may now be identified and will lead to increased scientific interest in these fascinating worms, particularly with regards to the nature of their association with their *Euastacus* hosts.

ACKNOWLEDGEMENTS

The support of the Queensland Museum (QM) and James Cook University (JCU) is gratefully acknowledged. Special thanks are due to Dr Rob Adlard (QM) who cheerfully made available laboratory space and equipment for KBS. We thank the Australian Research Council for a grant (DP0209237) which funded the study in 2002–3 and the Australian Biological Resources Study for a grant (87/5909) that funded many of the initial collections of crayfish and worms conducted prior to 2002.

We are grateful to museum staff of the state museums of New South Wales and Victoria who assisted greatly in appraising collections and records of crayfish to assist in locating suitable collection sites. Dr Penney Berents of the Australian Museum, Sydney (AM), located and organised the loan of type material of *Temnohaswellia comes*. Kate Attwood (AM) and Chris Rowley from Museum Victoria (NMV) assisted with registration of specimens.

We thank the numerous officers of National Parks, Forestry and Fisheries in Queensland, New South Wales, Australian Capital Territory and Victoria, who provided collection permits and occasionally field assistance in locating crayfish habitats. We also are indebted to Queensland Native Title Claimants for their willing permission to allow collections within their traditional country. We are particularly indebted to The Jinibara People (Queensland Native Title Claimants (QC98/045) and the Gubbi Gubbi Land and Cultural Association for their willing permission to allow collections within their traditional country.

We particularly thank Mr Doug Cook (QM) and Dr L. Cook who provided ready access to their wonderful rainforest property for collection of crayfish. Dr Geoff Monteith (QM) provided many crayfish and worms specimens and immeasurably valuable advice related to accessing difficult field sites. Mr Lewis Roberts capably guided our collection party up Mt Finnigan. Dr Mark Ponniah kindly provided specimens of worms from *Euastacus hystricosus*. Dr Rob Adlard (QM), Dr Mal Bryant (QM), Mr Geoffrey Edney, Dr Dinah Hansman, Dr Susan Lawler (Latrobe University), Mr Ryan Sewell and Mrs Susan Sewell all provided considerable and valuable assistance in the field at various times.

Peter Davie and John Short (QM) cheerfully provided expert identification of crayfish. Most of the stained specimens of worms from the QM collections mentioned here that are either stained wholemounts or serial sections, were prepared expertly by Mrs Zeinab Khalil and Mrs Christine Lee. Many of the NMV specimens mentioned here were expertly either wholemounted, sectioned or mounted in Faure's medium by Dr Boris Joffe, then of the Zoological Institute, St Petersburg, Russia.

Crayfish were collected under the following permits: Queensland Parks and Wildlife Service – Scientific Purposes Permit and Permit to Take, Use Keep or interfere with cultural of natural resources: F1/000485/02/SAA; State of Qld Department of Primary Industries Forestry – Sales Permit: 20010302; Queensland Environment Protection Agency – State Forests, Timber Reserves and other State lands: 1715 and TWB/07/2002; Queensland Environment Protection Agency (Eco-access) Take, Use Keep or Interfere with Cultural or Natural Resources Permit: WITK00468802; Queensland Parks and Wildlife Service – Permit to Collect Biological or Geological Material from Queensland State Forest, Timber Reserves and other state Lands: SF 1715; NSW Fisheries – Scientific Research Permits TO1/007 and PO1/0009; P03/0099; NSW State Forests – Special Purposes Permit: 05539, 05670 and 15257; NSW National Parks and Wildlife Service – Scientific Research License: B2348 and S10998; Environment ACT, Environmental Protection – Letter of approval to collect in Namadgi NP; VIC Department of Sustainability and Environment Research Permit #10002702.

Finally, we thank sincerely two peer reviewers of this manuscript for their thoughtful and thorough perusal.

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