Key to the genera and checklist of species of Australian temnocephalans
(Temnocephalida)
KIM B. SEWELL
Centre for Microscopy and Microanalysis (CMM), The University of Queensland, St. Lucia, Queensland, 4072, Australia; email k.sewell@uq.edu.au

Abstract
Temnocephalans are small, active ectosymbiotic flatworms that in Australia are associated with freshwater crustacean hosts, particularly crayfish of the family Parastacidae. There are 91 named Australian temnocephalan species comprised of 13 genera, viz. Didymorchis, Diceratocephala, Decadidymus, Actinodactylella, Temnomonticella, Temnohaswellia, Achenella, Temnosewellia, Notodactylus, Craspedella, Gelasinella, Heptacrapsedella and Zygoella; most with distinctive dorsal facies. Methods to collect, handle and process temnocephalans are outlined. Techniques suitable to examine the sclerotic components of the cirrus and vagina for discrimination to the level of species are reiterated briefly. All current Australia temnocephalan species and their authorities are listed. A key to discriminate the Australia genera is presented, based on a small suite of morphological characters, most related to the organs of attachment and locomotion, and visible on live specimens with a stereo dissecting microscope. The aim of this key is to provide shortcuts to taxonomic identification that will help to reduce the practice of lumping, at the family level, temnocephalans collected in ecological, biomonitoring and biodiversity studies.

Keywords
Temnocephalida, Temnocephaloidea, key, genus identification, Didymorchis, Diceratocephala, Decadidymus, Actinodactylella, Temnomonticella, Temnohaswellia, Achenella, Temnosewellia, Notodactylus, Craspedella, Gelasinella, Heptacrapsedella, Zygoella, crayfish, Parastacidae, Australia, checklist.

Introduction
Temnocephalans (Platyhelminthes, Temnocephalida) are small, active ectosymbiotic rhabdocoel turbellarians known mainly from Australia and South America where they occur on freshwater hosts, particularly crustaceans. They have a colourful early taxonomic history that was reviewed by Williams (1981). Most temnocephalan genera lack locomotory cilia, and have a posterior attachment organ, frequently referred to as a ‘sucker’, which they use in tandem with the anterior tentacles to effect a looping ‘leech-like’ locomotion which confused the issue of their origins (Williams, 1981, Haswell; 1893a; Fyfe, 1942). The true taxonomic position of the Temnocephalida has now been resolved, and concomitantly, the temnocephalan status of a number of controversial Australian genera has been confirmed (Cannon and Joffe, 2001). There is arguably an overdue need to update the search image for Australian temnocephalans beyond that of a ‘typical’ or ‘textbook’ facies of a worm with five anterior tentacles and a circular posterior attachment organ or sucker (Figure 1).

A detailed understanding of the internal anatomy of temnocephalans is essential to confirm their taxonomy. The diagram in Figure 2 shows the anatomy of the Australian temnocephalan Gelasinella powellorum and been compiled from examination of wholemounts, histological sections and live worms. Species discrimination often requires very fine details of the reproductive organs to be elucidated using a compound light microscope with cleared preparations of the sclerotic parts of the male copulatory organ or cirrus and the vagina (see, for example Figure 3). Cannon and Sewell (1991) reviewed and provided a key for Temnosewellia from Cherax spp. crayfish in Australia and Sewell et al. (2006) reviewed and provided keys to all species of Temnohaswellia and Temnosewellia from Euastacus spp. crayfish in Australia.
most related to the organs of attachment and locomotion, and visible on live specimens with a stereo dissecting microscope. The aim of this key is to provide shortcuts to taxonomic identification that will help to reduce the practice of lumping, at the family level, temnocephalans collected in ecological, biomonitoring and biodiversity studies.

Schockaert et al. (2008) stated that turbellarians are seldom, if ever, taken into account in biodiversity studies of freshwater habitats even though they are mostly present in high numbers of species and individuals. It is hoped that the key to the genera of Australian Temnocephalida presented here will help rectify this situation by allowing workers to more readily discriminate temnocephalan taxa than has been possible in the past.

Many of the images presented here were compiled from light microscope (LM) still and video footage and scanning electron microscope (SEM) images collected while I was working at the Queensland Museum (QM) as: (1) a part-time PhD student of The University of Queensland (UQ) from 1992 to 1998; and (2) a full-time researcher employed by James Cook University in 2002. Some of the video derived images are less than optimal quality, and lack a scale bar. They are, nonetheless, of sufficient resolution to elucidate the key characters.

Classification

Early workers were unable to determine the true rhabdocoel affinities of the taxon. Temnocephalans from Chile were originally classified as leeches by Monquin-Tandon (1986) and temnocephalans from the Philippines were classified as monogeneans by Semper (1872). In Australia, temnocephalans were initially misidentified as aberrant monogenean trematodes by Haswell (1888), before he, (Haswell, 1893a) recognised their rhabdocoel affinities. The taxonomic status of the Temnocephalida remained, however, controversial for more 150 years. Ehlers (1985) recognised that temnocephalans were undoubtedly related to rhabdocoel turbellarians, but could not provide a clear apomorphy to separate them.

It now well accepted that temnocephalans belong to the Rhabdocoela and are characterised by the presence of an epidermis made of multiple syncytial plates i.e. a syncytial mosaic (Figure 4; Joffe, 1982; Cannon and Joffe, 2001; Joffe et al.1995a,b; Joffe and Cannon 1998; Damborenea and Cannon, 2001; Amato et al. 2007, 2010). This uniquely temnocephalan character allowed confirmation of the status of the taxonomically controversial, and apparently early derived Australasian worms, Didmorchis and Diceratocephala, which both move by ciliary gliding, in place of the typical looping locomotion used by most temnocephalan species (Williams, 1981; Joffe et al. 1995a,b; Cannon and Joffe, 2001; Damborenea and Cannon, 2001).
Composition of the Australian Temnocephalida fauna

According to the online database available at http://turbellaria.umaine.edu/ the Temnocephalida contains around 23 genera and 122 species worldwide (Tyler et al. 2006-2012). Australasia contains only temnocephalans from the 'southern group' or Temnocephaloidea, and these have radiated strongly with their parastacid hosts, particularly in Australia which is recognised as the global centre of temnocephalan diversity (Cannon, 1991; Cannon and Joffé, 2001; Sewell et al., 2006). Temnocephalida from the 'northern group' or Scutarielloidea are not found in Australia. The global biogeography of temnocephalans was analysed by Cannon and Joffé (2001). The type hosts and localities of Australia temnocephalan species are available online from Tyler et al. (2006-2012) with many of the type localities linked to satellite images.

Australia has a total of 91 named temnocephalan species comprised of 13 genera, viz. Didymorchis, Diceratocephala, Decadidymus, Actinodactylella, Temnomonticellia, Temnohaswellia, Achenella, Temnosewellia, Notodactylus, Craspedella, Gelasinella, Heptacrasedella and Zygopella (Tables 1 and 2). Other regions of the world where temnocephalans are found, have considerably fewer genera (Schockaert et al., 2008). In South America, there are only two genera (Temnocephala and Didymorchis), although there is a greater diversity of host taxa e.g. crustaceans, molluscs, insects and chelonians (Damborenea and Cannon, 2001; Schockaert et al., 2008; Damborenea and Brusca, 2009). All the temnocephalans in Australia assigned previously to the genus Temnocephala, were transferred to Temnosewellia by Damborenea and Cannon (2001). Temnosewellia currently has the largest number of Australian species i.e. 52 (Table 1). Six of the 13 Australian genera are currently monotypic, but it can be predicted confidently that the number of species in all genera will increase with closer examination of Australian hosts (Table 1).

Table 1. Summary of the taxonomy of Australian Temnocephalida and the number of species from Table 1.

| Family              | Subfamily       | Genera                      | Number of species |
|---------------------|-----------------|-----------------------------|-------------------|
| Didymorchiidae      | -               | Didymorchis                 | 2                 |
| Actinodactylellida  | -               | Actinodactylia              | 1                 |
| Diceratocephalida   | -               | Diceratocephis              | 1                 |
| Diceratocephalida   | -               | Decadidymus                 | 1                 |
| Temnocephalida      | -               | Temnomonticellia            | 5                 |
| Temnocephalida      | -               | Temnosewellia               | 52                |
| Temnocephalida      | -               | Temnohaswellia              | 12                |
| Temnocephalida      | Craspedellinae  | Craspedella                 | 9                 |
| Temnocephalida      | Craspedellinae  | Gelasinella                 | 1                 |
| Temnocephalida      | Craspedellinae  | Heptacrasedella             | 1                 |
| Temnocephalida      | Craspedellinae  | Zygopella                   | 3                 |

Collection and preservation

Temnocephalan worms have soft bodies and are easily damaged if handled roughly or temperature-shocked. Worms are best left attached to their crustacean hosts during transit to the processing locality. Hosts and worms should be maintained at a suitable temperature in good quality water, preferably from the habitat in which they were collected. Hosts should be transported only with sufficient water to cover them, and the number of hosts adjusted per container according to the size, aggression and moulting status (= softness). Hosts should be segregated appropriately to ensure that temnocephalans, which are highly mobile, cannot transfer between them.

Temnocephalans are generally more sensitive to temperature changes than their hosts, and will die or rapidly break down if temperature shocked. The internal structures of temnocephalans, deteriorate very rapidly after death. To ensure the health of hosts and worms, the temperature of water in containers should be adjusted until close to the temperature of the habitat in the wild. This can be done, for example, inside an esky chilled with ice. In the case of very cold-tolerant large spiny mountain crayfish hosts and their worms, it can be valuable to cool them down slowly during transit i.e. until the hosts are torpid. This reduces host and worm damage and benefits safe removal of the worms during processing. Aggressive aeration of the water is likely to be harmful to temnocephalans, particularly those of the external carapace. If small containers are used to hold crayfish hosts, then a piece of plastic mesh should be placed into each container with the crayfish to support the crayfish in the air in case the oxygen content of water becomes depleted. Temnocephalans naturally move to regions on the host where they can remain moist and thus they can tolerate short of exposure of the host to air.

Hosts can be searched for temnocephalans using a dissecting microscope with cold incident light. Indeed, a great amount can be learned from observation of live worms, either on, or off the host. Video footage can be a valuable adjunct to detailed notes, drawings and still images. Worms can be removed alive from the surface of the host exoskeleton external carapace using a sharp wooden point, fine forceps or moist brush, generally without harm to the host. Quick transfer (seconds) to fresh water or fixative is desirable. For most worms, the use of a pipette will result in frustration as they are very difficult to dislodge once attached inside! For worms that live in the branchial chamber, it may be necessary to remove the carapace and gills to a shallow vessel containing water from the habitat. The gills break down quickly and worms should be removed to clean water as soon as possible. For isolated live worms in a shallow glass dish, a dissecting microscope with both incident and transmitted light allows effective observation and imaging.

For examination with a compound light microscopy, smaller worms can be transferred alive to a glass microscope slide and a cover slip added. Movement can be slowed effectively by careful regulation of the amount of water under the coverslip. The use of Nomarski interference optics is particularly useful to examine taxonomic details of the reproductive organs. Larger worms can be dissected and the component parts removed to a slide examined in the same way. Resolution of internal structures may not be possible otherwise, as can also be the case for species with dense body pigmentation.

Only adequate fixation for light microscopy can generally be achieved by the routine use of standard fixatives such as Bouin’s fixative or 10% phosphate buffer formalin, either cold or at room temperature. These fixatives can cause live worms to contract and thus mask detail of epidermal structures. The use of hot fixatives is preferable to extend the worms and to reveal the syncytial mosaic (Sewell and...
Cannon, 1995). There is, however, no one fixation technique suitable to reveal all the taxonomic features of temnocephalans, although the use of 100% ethanol comes closest (see below).

Some effective fixation protocols for routine light microscopy of temnocephalans are summarised below. Details on fixation protocols suitable for electron microscopy are not provided here but information on these can be found in Sewell and Cannon (1995), Joffe et al. (1998a,b) and Damborenea and Cannon (2001).

Cold 100% ethanol is a valuable ‘all round’ 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; worms can be cleared and mounted unstained without the need for further dehydration; and 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, e.g., cirrus and vagina.

For light microscopy to show the epidermal mosaic that is characteristic for temnocephalans, live worms can be fixed by flooding with a solution of 2% silver nitrate heated to about 60°C, washed in distilled water then exposed to bright sunlight for 15 to 30 minutes, dehydrated in ethanol and mounted in Euparol.

**Techniques to examine the sclerotic components of the cirrus and vagina**

To show fine details of the cirrus and vagina (e.g. for species discrimination), Faure’s mounting medium (distilled water 50 ml; chloral hydrate 50g; glycerol 20ml and gum arabic 30g) is most valuable to clear the tissue surrounding the sclerotic components (Figure 2). Faure’s medium is particularly effective on live worms or worms fixed in 100% ethanol, but less so on worms fixed with routine histological fixatives such as Bouins or 10% formalin. For large worms or those with dense body pigmentation, it may be necessary to carefully dissect out the reproductive organs prior to clearing. Sewell et al. (2006) provided details on how to prepare the cirrus and vagina using Faure’s medium, and these techniques have been applied and expertly refined for Neotropical temnocephalans (see, for example, Damborenea and Brusca, 2009; Amato et al., 2010). These organs occur in the posterior end of the worms and allow for routine retention of this part for morphological identification (i.e. after mounting in Faure’s medium) while allowing the anterior end to be available for DNA sequence studies.

**Taxonomic features**

Australian temnocephalans have distinctive dorsal facies readily visible on live specimens with a stereo dissecting microscope (Figure 5). The facies derive largely from the organs of attachment and locomotion, particularly the anterior tentacles, and the posterior attachment organ. The Key to genera of Australian Temnocephalida presented below, is based largely on characters related to the temnocephalan organs of attachment and locomotion. Sewell (1998) studied these on a wide variety of Australian temnocephalans and proposed an evolutionary series of the major genera of Temnocephalidea which remains useful to illustrate the character variation (Figure 6). The evolution of the Temnocephalida was discussed in detail by Cannon and Joffe (2001) who included zoogeographical data with data from morphological analyses of a wide range of temnocephalan characters, including those associated with the attachment organs and the syncytial mosaic.

Morphological characters relevant to the Key to Genera of Australian Temnocephalida are discussed briefly below and are summarised in Table 2. Example images of these characters, where available, are presented within the key.

**Locomotory cilia**

Many Australian temnocephalans have tufts of elongate cilia on epidermal body regions, but these cilia are not used in locomotion. *Didymorchis* and *Diceratocephala* alone move using locomotory cilia that is present over all the ventral body surface i.e. they do not loop.

![Figure 5. Dorsal facies of the 13 Australian temnocephalan genera:](image)

**Figure 5. Dorsal facies of the 13 Australian temnocephalan genera:**

A, *Didymorchis*; B, *Diceratocephala*; C, *Decaudidymus*; D, *Actinodactylella*; E, *Temnomonticellia*; F, *Temnomonticella*; G, *Achenella*; H, *Temnostellidina*; I, *Notodactylus*; J, *Heptacraspedella*; K, *Craspedella*; L, *Gelasinella*; M, *Zygopella*. Scale bar = ~1 mm

**Tentacles**

Cannon and Joffe (2001) regarded as ‘true’ tentacles only those projection that with axial musculature. *Diceratocephala*, *Decaudidymus* and *Actinodactylella* have structures that are ‘tentacle-like’ but which lack axial musculature (Cannon and Joffe, 2001). *Didymorchis* lacks either ‘true tentacles’ or ‘tentacle-like’ structures. No distinction is made in the present key between ‘true’ tentacles and ‘tentacle-like’ structures i.e. both are heuristically regarded as tentacles. *Temnomonticellia* has five tentacles but the central (= medial) tentacle is shortened and ‘bulb-like’.

**Dorsal scales**

The only temnocephalan known to have scales is *Notodactylus*. The dense ‘tile-like’ dorsal scales of
*Notodactylus* are of rhabdite secretion origin according to Jennings et al. (1992).

**Dorsal papillate ridges**

The Craspedellinae are alone in having papillae raised on posterior dorsal ridges with prominent raised papillae. There are transverse rows and posterior ridges that are arranged radially behind the most posterior transverse ridge. *Notodactylus* has sparse rows of elongate papillae on the dorsal surface but these are not on ridges (Sewell, 1998).

![Diagram of major genera of Australian Temnocephalida](image)

**Conical ciliated papillae in rows on tentacles**

The Craspedellinae have prominent conical ciliated papillae arranged in rows on their tentacles. *Actinodactylella* also have prominent ciliated papillate on their tentacles. It may be that the form of these papillae relates to the branchial chamber habitat of both of these specialised taxa.

**Testes**

Most Australian Temnocephalidae have two pairs of testes i.e. an anterior and a posterior pair (Figure 2). *Decadidymus* has 10 pairs of testes and *Didymorchis, Diceratocephala* and *Achenella* each have one pair. The testes can often be seen in live worms using a dissecting light microscope with transmitted lighting, but in the case of large worms or those with dense body pigmentation, wholemounts of fixed and histologically cleared specimens may be required.
Table 2. Matrix of morphological characters used below in the Key to genera of Australian Temnocephalida.

| Genus               | Locomotory cilia (Y/N) | Number of tentacles | Medial tentacle bulb-shaped (-/Y/N) | Dorsal scales (Y/N) | Number of dorsal papillate ridges | Ciliated papillae in rows on tentacles (Y/N) | Number of pairs of testes |
|---------------------|------------------------|---------------------|-------------------------------------|--------------------|----------------------------------|-----------------------------------------------|--------------------------|
| Didymorchis         | Y                      | 0                   | -                                   | N                  | 0                               | 0                                             | 1                        |
| Dicerotocephala     | Y                      | 2                   | -                                   | N                  | 0                               | 0                                             | 1                        |
| Decadidymus         | N                      | 2                   | -                                   | N                  | 0                               | N                                             | 10                       |
| Actinodactylella    | N                      | 12                  | -                                   | N                  | 0                               | 0                                             | 2                        |
| Temnoshaswellia     | N                      | 6                   | Y                                   | N                  | 0                               | 0                                             | 2                        |
| Temnomonticellia    | N                      | 5                   | N                                   | N                  | 0                               | N                                             | 1                        |
| Temnosewellia       | N                      | 5                   | N                                   | N                  | 0                               | N                                             | 2                        |
| Achenella           | N                      | 5                   | N                                   | N                  | 0                               | N                                             | 1                        |
| Notodactylus        | N                      | 5                   | N                                   | Y                  | 0                               | N                                             | 2                        |
| Zygopella           | N                      | 5                   | N                                   | N                  | 1                               | Y                                             | 2                        |
| Gelatinella         | N                      | 5                   | N                                   | N                  | 2                               | Y                                             | 2                        |
| Craspedella         | N                      | 5                   | N                                   | N                  | 3                               | Y                                             | 2                        |
| Heptacraspedella    | N                      | 5                   | N                                   | N                  | 7                               | Y                                             | 2                        |

Checklist of Australian Temnocephalida

Australian temnocephalan species and authorities derived from the database available at [http://turbellaria.umaine.edu/](http://turbellaria.umaine.edu/). Authorities are listed in the references section. Type hosts and type localities are not listed here but are available in Tyler et al. (2006-2012).

TEMNOCEPHALIDA Blanchard, 1849
TEMNOCEPHALOIDEA Baer 1953
ACTINODACTYLELLIDAE Benham 1901
Actinodactylella Haswell, 1893
Actinodactylella blanchardi Haswell, 1893
DICERATOCEPHALIDAE Joffe, Cannon, and Schockaert, 1998
Dicerotocephala Baer, 1953
Dicerotocephala boschmai Baer, 1953
Decadidymus Cannon, 1991
Decadidymus gulosus Cannon, 1991
DIDYMORCHIIDAE Bresslau and Reisinger, 1933
Didymorchis Haswell, 1900
Didymorchis astacopsidis Haswell, 1915
Didymorchis cherapsis Haswell, 1915
TEMNOCEPHALIDAE Monticelli, 1899
Achenella Cannon, 1993
Achenella cougal Cannon, 1993
Achenella sathonota Cannon, 1993
Notodactylus Baer 1953
Notodactylus handschini (Baer, 1945)
Temnoshaswellia Pereira and Cuocolo, 1941
Temnoshaswellia alpina Sewell, Cannon and Blair, 2006
Temnoshaswellia breviangularis Sewell, Cannon and Blair, 2006
Temnoshaswellia capricornia Sewell, Cannon and Blair, 2006
Temnoshaswellia comae (Haswell, 1893)
Temnoshaswellia cornu Sewell, Cannon and Blair, 2006
Temnoshaswellia crotalum Sewell, Cannon and Blair, 2006
Temnoshaswellia munificus Sewell, Cannon and Blair, 2006
Temnoshaswellia pearsoni Sewell, Cannon and Blair, 2006
Temnoshaswellia simulata (Haswell, 1924)
Temnoshaswellia subulata Sewell, Cannon and Blair, 2006
Temnoshaswellia umbella Sewell, Cannon and Blair, 2006
Temnoshaswellia verrucosa Sewell, Cannon and Blair, 2006
Temnomonticellia Pereira and Cuocolo, 1941
Temnomonticellia auriculata (Haswell, 1900)
Temnomonticellia fulva (Hickman, 1967)
Temnomonticellia pygmaea (Hickman, 1967)
Temnomonticellia quadricornis (Haswell, 1893)
Temnomonticellia tasmanica (Haswell, 1900)
Temnosewellia Damborenea and Cannon 2001
Temnosewellia acuta (Cannon and Sewell, 2001)
Temnosewellia acicularis Sewell, Cannon and Blair, 2006
Temnosewellia alba Sewell, Cannon and Blair, 2006
Temnosewellia albata Sewell, Cannon and Blair, 2006
Genera and species of Australian temnocephalans

Temnosewellia aphyodes Sewell, Cannon and Blair, 2006
Temnosewellia apiculus Sewell, Cannon and Blair, 2006
Temnosewellia arga Sewell, Cannon and Blair, 2006
Temnosewellia argentea Sewell, Cannon and Blair, 2006
Temnosewellia aspinosa Sewell, Cannon and Blair, 2006
Temnosewellia aspra Sewell, Cannon and Blair, 2006
Temnosewellia athertonensis (Cannon, 1993)
Temnosewellia bacriro Sewell, Cannon and Blair, 2006
Temnosewellia bacrioniculus Sewell, Cannon and Blair, 2006
Temnosewellia batiola Sewell, Cannon and Blair, 2006
Temnosewellia belone Sewell, Cannon and Blair, 2006
Temnosewellia butlareae (Cannon, 1993)
Temnosewellia caeca (Haswell, 1900)
Temnosewellia caliculus Sewell, Cannon and Blair, 2006
Temnosewellia cestus Sewell, Cannon and Blair, 2006
Temnosewellia chaerapsis (Hett, 1925)
Temnosewellia christineae (Cannon and Sewell, 2001)
Temnosewellia cita (Hickman, 1967)
Temnosewellia comythus Sewell, Cannon and Blair, 2006
Temnosewellia cypellum Sewell, Cannon and Blair, 2006
Temnosewellia dendyi (Haswell, 1893)
Temnosewellia engaei (Haswell, 1888)
Temnosewellia fasciata (Haswell, 1888)
Temnosewellia fax Sewell, Cannon and Blair, 2006
Temnosewellia flavimontana Sewell, Cannon and Blair, 2006
Temnosewellia geonoma (Williams, 1980)
Temnosewellia gingrina Sewell, Cannon and Blair, 2006
Temnosewellia gracilis Sewell, Cannon and Blair, 2006
Temnosewellia heringi (Haswell, 1893)
Temnosewellia improcera (Cannon, 1993)
Temnosewellia keraio Sewell, Cannon and Blair, 2006
Temnosewellia maculata Sewell, Cannon and Blair, 2006
Temnosewellia magna Sewell, Cannon and Blair, 2006
Temnosewellia maxima Sewell, Cannon and Blair, 2006
Temnosewellia minima Sewell, Cannon and Blair, 2006
Temnosewellia minor (Haswell, 1888)
Temnosewellia minuta (Cannon, 1993)
Temnosewellia neae (Cannon, 1993)
Temnosewellia mascalculata Sewell, Cannon and Blair, 2006
Temnosewellia phantasmella (Cannon and Sewell, 2001)
Temnosewellia possibilitas Sewell, Cannon and Blair, 2006
Temnosewellia punctata (Cannon, 1993)
Temnosewellia queenslandensis (Cannon, 1993)
Temnosewellia rouxi (Merton, 1914)
Temnosewellia semperi (Weber, 1890)
Temnosewellia unguiculus Sewell, Cannon and Blair, 2006

CRASPEDELLINAE Baer 1931

Craspedella Haswell, 1893
  Craspedella brieniensis Sewell and Cannon, 1998
  Craspedella cooranensis Sewell and Cannon, 1998
  Craspedella gracilis Cannon and Sewell, 1995
  Craspedella joffei Sewell and Cannon, 1998
  Craspedella pedum Cannon and Sewell, 1995
  Craspedella shorti Cannon and Sewell, 1995
  Craspedella simulatae Cannon and Sewell, 1995
  Craspedella spenceri Haswell, 1893
  Craspedella sahba Cannon and Sewell, 1995

Gelasinella Sewell & Cannon, 1998
  Gelasinella powellorum Sewell and Cannon, 1998

Heptacraspedella Cannon and Sewell, 1995
  Heptacraspedella peratus Cannon and Sewell, 1995

Zygopella Cannon and Sewell, 1995
  Zygopella deimata Cannon and Sewell, 1995
  Zygopella pista Cannon and Sewell, 1995
  Zygopella stenota Cannon and Sewell, 1995
Key to the genera of Australian Temnocephalida

*Note:* This key is heuristic and not meant to imply phylogenetic relationships.

1a. With tentacles................................................................................................................. 2
1b. Without tentacles............................................................................................................. Didymorchis (Figure 7)

2a(1a). With two tentacles...................................................................................................... 3
2b(1a). With more than two tentacles .................................................................................... 4

3a(2a). With functional locomotory cilia ........................................................................... Diceratocephala (Figure 8)
3b(2a). Without functional locomotory cilia ....................................................................... Decadidymus (Figure 9)

Figure 7. *Didymorchis*
Dorsal view (LM image). Scale = ~500μm.

Figure 8. *Diceratocephala*
Dorsal view (LM image).

Figure 9A. *Decadidymus*
Dorsal view (LM image from video).

Figure 9B. *Decadidymus*
Ventral view (X-ray image).
Genera and species of Australian temnocephalans

4a(2b). With 12 tentacles................................................................. *Actinodactylella* (Figure 10)

4b(2b). With fewer than 12 tentacles.................................................................5

5a(4b). With 5 tentacles..............................................................................6

5b(4b). With 6 tentacles ..............................................................................7

6a(5a). With medial tentacle transformed into a short bulb............................ *Temnomonticellia* (Figure 12)

6b(5a). With medial tentacle not transformed into a short bulb...........................
7a(6b). With scales on dorsal body surface ................................................................. *Notodactylus* (Figure 13)
7b(6b). Without scales on dorsal body surface ........................................................................... 8

---

8a(7b). With prominent ciliated papillae in rows on tentacles (see, for example, Figure 14, below) ................. 9
8b(7b). Without prominent ciliated papillae in rows on tentacles ......................................................... 12

---

9a(8a). Dorsal body with one papillate transverse ridge ...................................................................... 10
9b(8a). Dorsal body with more than one papillate transverse ridge ...................................................... 10

---

Figure 13A. *Notodactylus*
Dorsal view of silver nitrate stained worm (LM image).
Scale = 500 µm.

Figure 13B. *Notodactylus*
Dorsal view of worm (SEM image). Scale = 500 µm.

Figure 14. Row of prominent ciliated papillae on tentacle From *Craspedella* (LM image).

Figure 15. *Zygopella*.
Dorsal view showing the single transverse ridge (white arrow) (SEM image). Scale = 200 µm.
Genera and species of Australian temnocephalans

10a(5a). Dorsal body with two papillate transverse ridges

Gelasinella (Figure 16, below)

10b(5a). Dorsal body with more than two papillate transverse ridges

11

11a(10b). Dorsal body with 3 transverse ridges bearing raised papillae

Craspedella (Figure 17A, B, below)

11b(10b). Dorsal body with 7 transverse ridges bearing raised papillae

Heptacraspedella (Figure 18, above)

12a(8b). With a one pair of testes

Achenella (Figure 19, below)

12b(8b). With a two pairs of testes

Temnosewellia (Figure 20A, B, below)
Acknowledgements

My sincere thanks to Phil Suter for inviting me to the 2013 Taxonomy Research Information Network (TRIN) Taxonomy Workshop, and thereby affording me an unexpected, and probably final, opportunity to research the Temnocephalida. I also thank Lester Cannon who provided enthusiastic encouragement for me to attend the workshop. David Blair, James Cook University, Townsville generously provided the image of Temnocephala cf. rouxi. Thanks are also due to Mal Bryant for locating old VHS tapes of temnocephalans at the Queensland Museum, thought to be long lost, and for personally transporting them to me. I acknowledge gratefully the support of the Queensland Museum (QM) and The University of Queensland (UQ) during the periods when I was a student and researcher. I thank Rachel Gorman and Susan Lawler for assisting respectively, to organise my travel and accommodation for this workshop. Finally, I gratefully acknowledge the facilities, and the scientific and technical assistance, of the Australian Microscopy & Microanalysis Research Facility (AMMRF) at the Centre for Microscopy and Microanalysis (CMM), The University of Queensland.

References

Amato, J.F.R., Amato, S.B., Seixas, S.A., Fonseca, M., & Ilário, R.J. 2010. Temnocephala pignaulieriae Dionis, 1967 (Platyhelminthes, Temnocephalida) from two allopatric populations of Dilocoecinae pagei Stimpson, 1861 (Crustacea, Decapoda) — first record for Brazil. Zoosystema 26(3): 15–28.

Amato, J.F.R., Seixas, S.A., & Amato, S.B. 2007. A new species of Temnocephala Blanchard (Platyhelminthes, Temnocephalida) etosymbiont on creeping water bugs, Cryptohoris granulosus De Carlo (Hemiptera, Naucoridae) from southern Brazil. Revista Brasileira de Zoologia 24: 1043–1051.

Baer, J.G. 1945. Un Temnocéphale nouveau, Temnocephala handschini n. sp. de la Nouvelle Guinée. Revue Suisse de Zoologie 52: 505-512.

Baer, J.G. 1953. Temnocéphales. Zoological results of the Dutch New Guinea Expedition 1939. Number 4. Zoologische Mededelingen (Leiden) 32: 119-139.

Blanchard, E. 1849. Anularés. Gay’s Historia física y política de Chile 5: 51.

Bresslau, E. & Reisinger, E. 1933. Temnocephala. In: Handbuch der Zoologie 2 (edited by Kükenthal, W. & Krumbach, T.), pages 294-308. Walter de Gruyter and Company, Berlin and Leipzig.

Cannon, L.R.G. 1991. Temnocephalan symbionts of the freshwater crayfish Cherax quadricarinatus from northern Australia. Hydrobiologia 227: 341-347.

Cannon, L.R.G. 1993. New temnocephalans (Platyhelminthes): etosymbionts of freshwater crabs and shrimps. Memoirs of the Queensland Museum 33: 17-40.

Cannon, L.R.G. & Joffe, B.I. 2001. The Temnocephalida. In: Interrelationships of the Platyhelminthes, D.T.L. Littlewood and R.A. Bray (Eds.) London Taylor and Francis: 83-91.

Cannon, L.R.G. & Sewell K.B. 1995. Craspellidinae Baer, 1931 (Platyhelminthes: Temnocephalida) etosymbionts from the branchial chamber of Australian crayfish (Crustacea: Parastacidae). Memoirs of the Queensland Museum 38: 397-418.

Cannon, L.R.G. & Sewell K.B. 2001. A review of Temnoosewelia (Platyhelminthes: Temnocephalida) etosymbionts of Cherax (Crustacea: Parastacidae) in Australia. Memoirs of the Queensland Museum 46: 385-389.

Damborenea, M.C. & Busca, F. 2009. A new species of Temnosewelia (Platyhelminthes, Temnocephalida) etosymbiont on Villopotamon thalii (Crustacea, Decapoda, Potamidae) from Vietnam. Zoosystema 31: 321-332.

Damborenea, M.C. & Cannon L.R.G. 2001. The mosaic of the epidermal cilia in Didymorchis sp. (Didymorchidae, Temnocephalida). Belgian Journal of Zoology 131: 167-171.

Damborenea, M.C. & Cannon L.R.G. 2001. On neotropical Temnocephala (Platyhelminthes). Journal of Natural History 35: 1103-1118.

Ehlers, U. 1985. Das Phylogenetische System delt Plathelminthes. Gustav Fischer Verlag, Stuttgart, New York, 317 pages.

Fyfe, M.L. 1942. The anatomy and systematic position of Temnocephala nova-zealandiae Haswell. Transactions and Proceedings of the Royal Society of New Zealand 72: 253-267. Fyfe, 1942

Haswell, W.A. 1888. On Temnocephala, an aberrant monogenetic trematode. Quarterly Journal of Microscopical Science 28: 279-302, plates 20-22.

Haswell, W.A. 1893a. A monograph of the Temnocephalae, Linnean Society of New South Wales, Macleay Memorial Volume: 93-152.

Haswell, W.A. 1893b. On an apparently new type of the Platyhelminthes (Trematode?). Linnean Society of New South Wales, Macleay Memorial Volume: 153-158.

Haswell, W.A. 1900. Supplement to a ‘Monograph of the Temnocephalae’. Proceedings of the Linnean Society of New South Wales 25: 430-435.

Haswell, W.A. 1915. Studies on the Turbellaria. III. Didymorchis. Quarterly Journal of Microscopical Science 61: 161-169.

Haswell, W.A. 1924. Critical notes on the Temnocephalidea. Proceedings of the Linnean Society of New South Wales 49: 509-520.

Hett, M.L. 1925. On a new species of Temnocephala (T. chaeropsis) (Trematoda) from West Australia. Proceedings of the Zoological Society of London 95: 569-575.

Hickman, V.V. 1967. Tasmanian Temnocephalidea. Papers and Proceedings of the Royal Society of Tasmania 101: 227-250.

Jennings, J.B., Cannon, L.R.G. & Hick, A.J. 1992. The nature and origin of the epidermal scales of Notodactylus handschini - an unusual temnocephalid turbellarian ectosymbiotic on crayfish from northern Queensland. Biological Bulletin 182: 117-128.

Joffe, B.I. 1982. The Temnocephalids: their Morphology and Phylogeny. Unpublished PhD Thesis, 277 pages, Zoological Institute RAN, St Petersburg.

Joffe, B.I. & Cannon, L.R.G. 1998. The organisation and evolution of the mosaic of the epidermal syncytia in the Temnocephalida (Platyhelminthes: Neodermata). Zoologischer Anzeiger 237: 1-14.

Joffe, B.I., Cannon, L.R.G., & Schockaert, E.R. 1998. On the phylogeny of families and genera within the Temnocephalida. In: Schockaert, E., Watson, N. & Justine, J.-L. (eds.) Biology of the Turbellaria. Hydrobiologia 383: 263-268.

Joffe, B.I., Solovei, I.V., Sewell, K.B. & Cannon, L.R.G. 1995a. Organisation of the epidermal syncytial mosaic in Diceratocephala boschmai (Temnocephalida: Platyhelminthes). Australian Journal of Zoology 43: 509-518.
Genera and species of Australian temnocephalans

Joffe, B.I., Solovei, I.V., & Cannon, L.R.G. 1995b. The structure of the epidermis in Didymorchis (Temnocephalida: Platyhelminthes). *Australian Journal of Zoology* 43: 631-641.

Merton, H. 1914. Beiträge zur Anatomie und Histologie von Temnocephala. *Abhandlungen der Senckenbergischen Naturforschenden Gesellschaft* 35: 1-58.

Moquin-Tandon, A. 1846. *Monographie de la family des Hirudinées*. 300 pages. Paris.

Monticelli, F.S. 1899. Sulla Temnocephala brevicornis Mont. 1889 e sulle Temnocefale in generale. *Bollettino della Società di Naturalisti i Napoli* 12: 72-127.

Pereira, A.C. & Cuocolo, R. 1941. Estudos sôbre ‘Temnocephalidae Monticelli, 1899’, com establecimento de dois novos géneros Australianos e descrição de duas novas espécies neotrópicas. *Arquivos do Instituto Biologio, São Paulo* 12: 101-127.

Schockaert, E.R., Hooge, M., Sluys, R., Schilling, S., Tylre, S. & Artois, T. 2008. Global diversity of free lining flatworms (Platyhelminthes, “Turbellaria”) in freshwater. *Hydrobiologia* 595: 41-48.

Semper, C. 1872. Zoologische Aphorismen II. Über die Gattung Temnocephala. *Zeitschrift für Wissenschaftliche Zoologie* 22: 307-310.

Sewell, K.B. 1998. *Craspedella pedum* (Craspedellinae: Temnocephalidae): A model for ectosymbiosis. Unpublished PhD Thesis, 308 pages, University of Queensland.

Sewell, K.B. & Cannon, L.R.G. 1995. A scanning electron microscope study of Craspedella sp. from the branchial chamber of redclaw crayfish, *Cherax quadricarinatus*, from Queensland, Australia. *Hydrobiologia* 305: 151-158.

Sewell, K.B. & Cannon, L.R.G. 1998. New temnocephalans from the branchial chamber of Australian *Euastacus* and *Cherax* crayfish hosts. *Proceedings of the Linnean Society New South Wales* 119:21-36.

Sewell, K.B., Cannon, L.R.G. & Blair, D. 2006. Review of *Temnohaswellia* and *Temnosewellia* (Platyhelminthes: Temnocephalidae: Temnocephalidae) ectosymbionts from Australian crayfish *Euastacus* (Parastacidae). *Memoirs of the Queensland Museum* 52(1): 199-279

Tyler, S., Schilling, S., Hooge, M. & Bush, L.F. (comp.) 2006-2012. *Turbellaria* taxonomic database. Version 1.7 [http://turbellaria.umaine.edu](http://turbellaria.umaine.edu)

Weber, M. 1890. Über Temnocephala Blanchard. *Zoologische Ergebnisse einer Reise in Niederlandische Ostindien* 1: 1-29.

Williams, J.B. 1980a. Morphology of a species of Temnocephala (Platyhelminthes) ectocommensal on the isopod *Phreatoicopsis terricola*. *Journal of Natural History* 14: 183-199.

Williams, J.B. 1981. Classification of the Temnocephaloidea (Platyhelminthes). *Journal of Natural History* 15: 277-299.