Gastrotricha

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INTRODUCTION

Gastrotricha are microscopic (0.6–3.0 mm in body length) aquatic invertebrates closely related to Nematoda, with most of which they share a meiobenthic life style. In marine habitats they are mainly interstitial whereas in fresh waters they are an important component of the periphyton and benthos; members of three freshwater families are semipelagic. The phylum is cosmopolitan with about 690 species grouped into two orders: Macrodasyida, with 240 species, all but two marine, and Chaetonotida, with 450 species, 300 of which are freshwater taxa.

Chaetonotidans have a tenpin-shaped, diaphanous (transparent), small-sized body (60–770 µm) composed of three regions: a rounded head, an ovate trunk and a caudal furca formed by two adhesive tubes (Fig. 1 A,B). The body is completely covered with a cuticle which generally bears scales and spines. Two ventral ciliary bands running from the head up to the furcal base allow swimming or gliding on the sediment surface. The head shows four clusters of sensory cilia, several protective, cuticular plates, and the subapical mouth, often provided with a ring of protrusible, hook-like structures. A strong, muscular pharynx, with a triradiate lumen, similar to that of Nematoda, extends for about a third of the total body length and is surrounded by a large, bilobed brain. The gut is straight and opens into the ventral, subterminal anus. Two protonephridia lie at the sides of the anterior intestine emptying into two ventral pores. The reproductive system is made up of two ovaries located in the posterior portion of the trunk (Remane 1936; Ruppert 1991). Functional testes are present in some marine forms (Neodasyidae, Xenotrichulidae, *Musellifer*), but apparently absent in freshwater species that all reproduce by apomictic parthenogenesis (Hummon 1984; Balsamo 1992).

GENERAL BIOLOGY

Gastrotrichs belong to the microphagous, detritivorous, benthic community, and like nematodes swallow food by means of the powerful sucking action of the pharynx.

They are mainly found in the upper layers of the sediment and in association with aquatic vegetation. Interstitial gastrotrichs penetrate down to 1 m depth in sandy sediments, while semipelagic species freely swim in the water column.

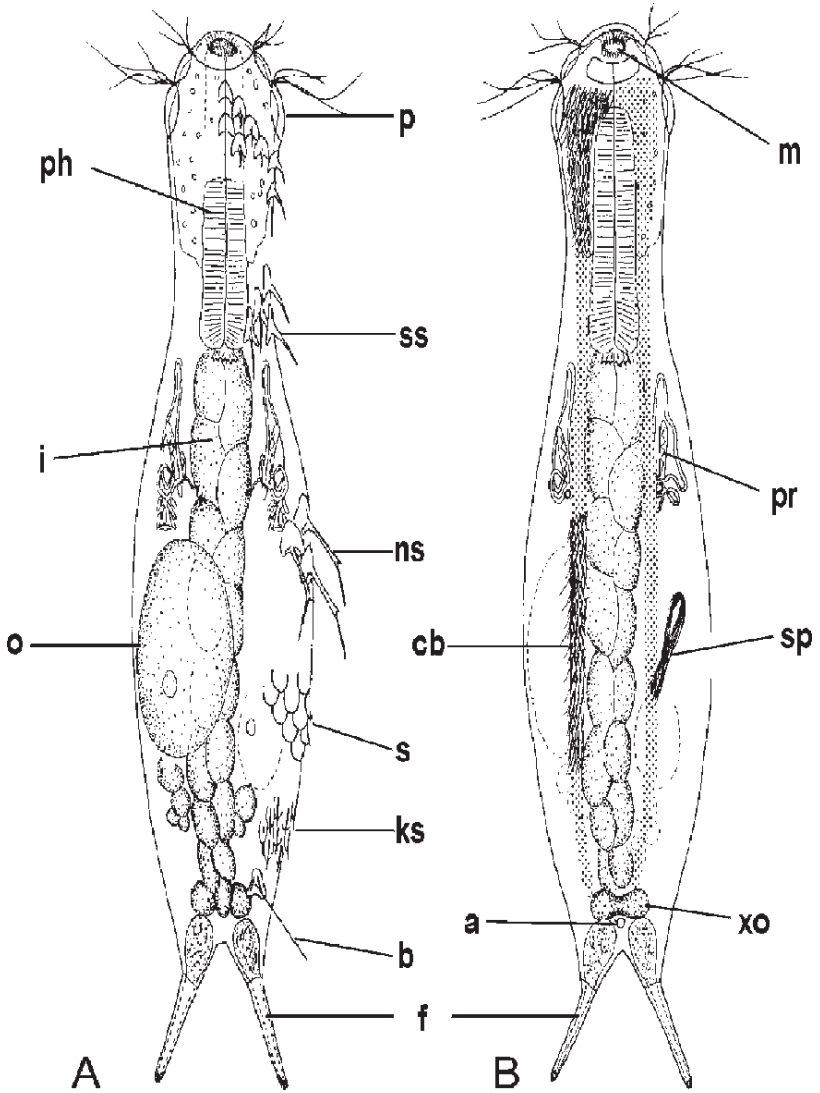

Figure 1. The anatomy of a chaetonotidan gastrotrich. A – dorsal and B – ventral views. Abbreviations: a, anus; b, sensory bristles; cb, ciliary bands; f, furcal adhesive tube; i, intestine; m, mouth; ks, keeled scales; ns, scales with notched spines; o, oocytes; p, cephalic plates; ph, pharynx; pr, protonephridium; s, smooth scales; sp, spermatozoa; ss, scales with simple spines; xo, X-organ. (Source: modified from Balsamo 1983)

The spatial and temporal distribution of gastrotrichs, which are mostly found in lentic rather than in lotic waters (Balsamo and Fregni 1995; Fregni *et al*. 1998), is often patchy and probably depends on the presence of food sources (Ricci and Balsamo 2000). Their abundance is positively influenced by the presence of aquatic vegetation and to some extent by the degree of eutrophication of the water body (Kisielewski 1981). However, freshwater gastrotrichs appear very tolerant to a variety of abiotic environmental factors, such as the particle size of the sediment, water temperature and pH (Palmer *et al*. 1997).

Life cycle

Freshwater chaetonotids have direct development, a short life cycle (15 days at 20 °C in *Chaetonotus maximus*; Balsamo and Todaro 1988) and obligatory parthenogenic reproduction. The life cycle consists of three phases: (1) a pre-reproductive phase, during which somatic growth occurs; (2) a reproductive phase, in which the animal lays 4–6 parthenogenic eggs one at a time, the last generally being a resting egg; and (3) a post-reproductive phase, during which several species produce one or two clusters of aberrant spermatozoa and an unpaired horse-shoe shaped organ, called the X-organ, which surrounds the terminal portion of the intestine ventrally (Kisielewska 1981). The functionality of both spermatozoa and X-organ are still uncertain (Hummon 1984, 1986).

The resting eggs are morphologically distinguishable from the quick-hatching eggs because of the thick and dark shell and the slightly larger size. They can survive in unfavourable conditions, so allowing maintenance of the population over seasons and species dispersal over long distances (Balsamo 1992).

REGIONAL TAXA

Current knowledge shows that most genera of Gastrotricha have a cosmopolitan distribution. Information about the geographical distribution of single species is patchy, as most studies have focused on only a few regions and samplings are not comparable.

The freshwater Gastrotricha of Peninsular Malaysia, Singapore and Borneo are unknown, with the only exception of the report of several specimens of *Chaetonotus* (*C. brevispinosus* Zelinka, 1889, *C. vulgaris* Brunson, 1950) and of *Lepidodermella* sp., found in 1955–1956 in the neighbourhood of Singapore airport, at Teck Sing Village off MacPherson Road, Paya Lebar (Packard 1960), from shallow ponds covered with the duckweed *Lemna perpusilla* and showing decaying vegetation on the bottom. Since freshwater gastrotrichs have been collected from other East Asian regions (India, Korea, Japan) (Annandale 1907; Stewart 1908; Saito 1937; Naidu 1962; Visvesvara 1963, 1964; Dhanapathi 1976; Rao and Chandra Mohan 1977; Sudzuki 1971a,b, 1975, 1976; Sharma 1980; Lee and Chang 2000), it seems likely that a specific study will find gastrotrich species in water bodies of Malaysia.

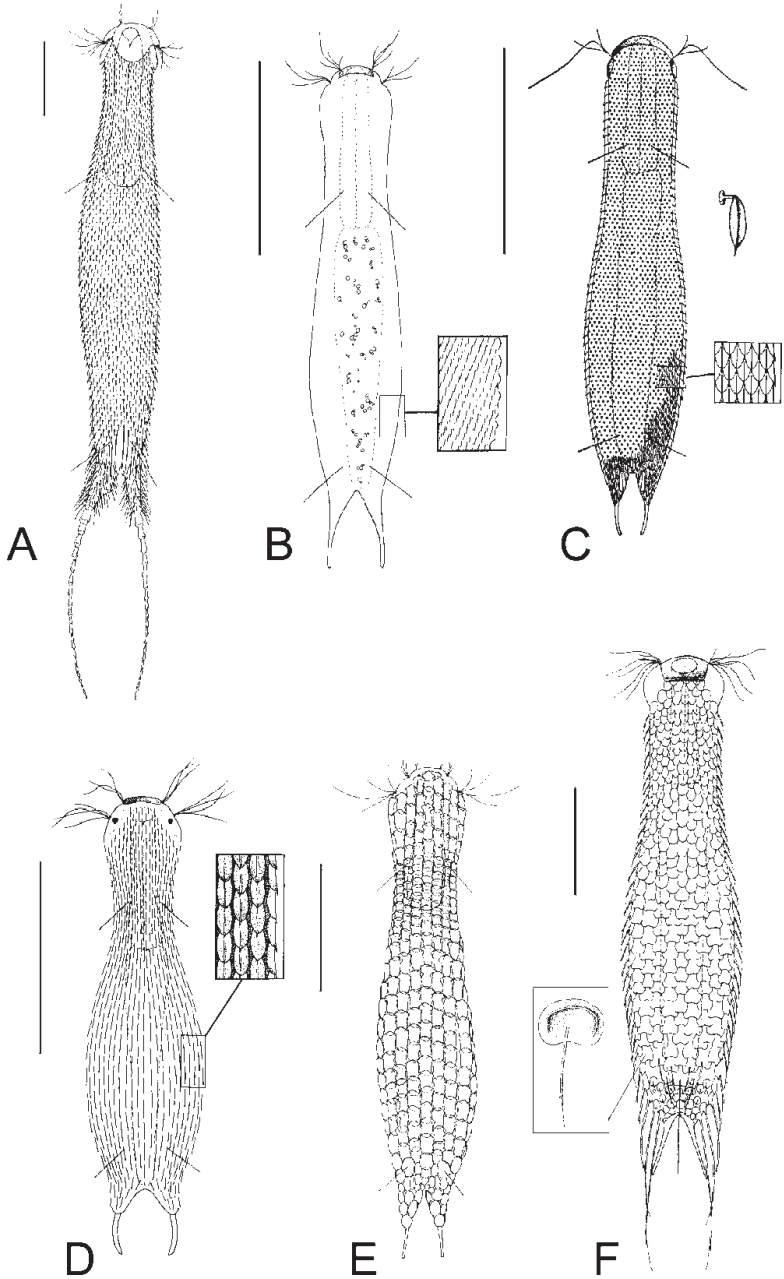

Figure 2. Morphotypes of some freshwater chaetonotidan genera. Dorsal views. A – *Polymerurus*; B – *Ichthydium*; C – *Aspidiophorus*; D – *Heterolepidoderma*; E – *Lepidodermella*; F – *Lepidochaetus* (Chaetonotidae). Scale bars = 50 µm. (Sources: A, E, modified from Schwank 1990; B, C, D, F, modified from Balsamo 1983)

KEY TO CHAETONOTIDA FAMILIES AND GENERA

All but two freshwater gastrotrich species belong to the order Chaetonotida, which includes seven families and 28 genera. Four families (12 genera) are only freshwater, and two only marine. The other family consists of 12 genera, five freshwater, two marine and five both marine and freshwater.

The most numerous genus, with about 150 freshwater species, is *Chaetonotus*, for which several taxonomical subdivisions have been proposed (Remane 1936; Schwank 1990; Kisielewski 1997). The great morphological variability of freshwater species often makes the identification difficult, and consequently the present taxonomy is unstable (Kisielewski 1981, 1991; Schwank 1990). The following taxonomic key includes all the freshwater chaetonotid families and genera known in the world.

1. Furcal branches present, with or without adhesive tubes 2
- No furcal branches; truncated or rounded posterior body end which may have two protuberances or spines 14

2. Furcal branches ending with two pairs of adhesive tubes; smooth body cuticle. Rare; fresh water: interstitial ..... DICHAETURIDAE: *Dichaetura*
- Furcal branches ending with one pair of adhesive tubes, or without adhesive tubes 3

3. No cuticular scales or spines; sickle-shaped caudal adhesive tubes; cephalic cilia not grouped into tufts. Very rare; fresh water: hyperbenthic or semiplanktonic ……PROICHTHYDIIDAE ..4
- Cuticular scales and spines generally present; if present caudal adhesive tubes mostly straight, long to very short; cephalic cilia grouped into tufts. Common (except *Arenotus* and *Undula*); fresh water, marine and brackish-water species: periphytic, epibenthic and interstitial .... CHAETONOTIDAE ..5

4. A transverse row of short dorsal cephalic cilia; ventral cilia arranged in tufts only present on the head and neck regions. Hyperbenthic ..... *Proichthydium*
- No dorsal cephalic cilia; ventral cilia arranged in two longitudinal bands. Semiplanktonic .... *Proichthydioides*

5. Furcal branches without adhesive tubes ..... *Undula*
- Furcal branches with adhesive tubes 6

6. Very long (up to 1/3 of the total length), segmented furcal branches eventually bearing very small scales or spines. Common; fresh water: epibenthic, periphytic (Fig. 2A) ..... *Polymerurus*
- Short or very short, unsegmented furcal branches without scales or spines 7

7. Body cuticle bearing numerous spined and/or keeled scales; short to very long spines, simple or with 1–2 lateral notches 8
- Body cuticle smooth or with numerous, non-spined scales; occasionally a few spines at the furcal base 9

8. Dorsal scales with a double anterior edge, lacking a keel but with or without a spine; ventral, interciliary scales similar in shape to the dorsal scales; some pairs of long and very thin spines at the sides of the furcal base. Common; fresh water: epibenthic, periphytic (Fig. 2F)... *Lepidochaetus*

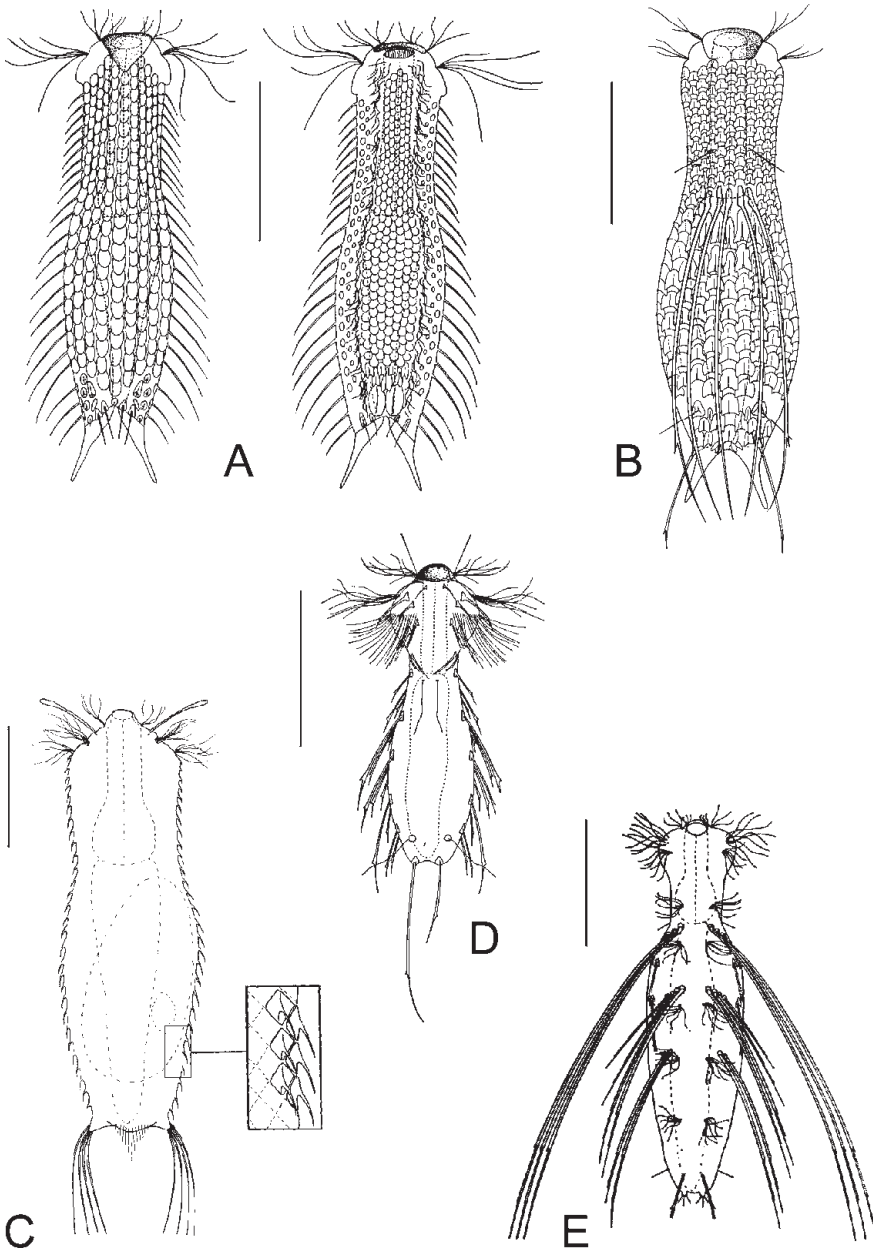

Figure 3. Morphotypes of some freshwater chaetonotidan genera. A – *Chaetonotus* (*Euchaetonotus*), dorsal and ventral views; B – *Chaetonotus* (*Zonochaeta*) (Chaetonotidae); C – *Neogossea* (Neogosseidae); D – *Setopus* dorsal view; *E – Stylochaeta*, ventral view (Dasydytidae). Scale bars = 50 µm. (Source: modified from Balsamo 1983)

- Dorsal scales with a single anterior edge and a keel and/or a spine; ventral, interciliary scales different in shape from the dorsal scales. Common; fresh water, brackish-water, marine: epibenthic, periphytic, interstitial (Fig. 3A,B) ..... *Chaetonotus*

9. Body cuticle smooth 10
- Body cuticle with non-spined scales 11

10. Thin, smooth cuticle which may show very tiny, longitudinal lines; rarely a few spines at the furcal base. Common; fresh water, brackish-water, rarely marine: epibenthic, periphytic, interstitial (Fig. 2B) ..... *Ichthydium*
- Very thick, smooth, soft cuticle clearly distinguishable from the epidermis. Rare; fresh water: interstitial ..... *Arenotus*

11. Small scales with a stalk or a keel 12
- Large, flat scales, polygonal or circular in shape 13

12. Stalked scales. Common; fresh water, brackish-water, marine: epibenthic, periphytic, interstitial (Fig. 2C) ..... *Aspidiophorus*
- Keeled scales. Common; fresh water, brackish-water, marine: epibenthic, periphytic, interstitial (Fig. 2D) ..... *Heterolepidoderma*

13. Numerous polygonal scales. Common; fresh water, rarely brackish-water and marine: epibenthic, periphytic, interstitial (Fig. 2E) ..... *Lepidodermella*
- Few circular scales. Rare; fresh water: periphytic ..... *Fluxiderma*

14. Two club-shaped, cephalic tentacles; small scales with very short spines on the trunk; truncated or rounded body end bearing several spines. Rare; fresh water: epibenthic and semipelagic .... NEOGOSSEIDAE ..15
- No cephalic tentacles; scales reduced or absent; very long and motile spines arranged into groups on the trunk; truncated or rounded body end which may show bristly protuberances or spines. Rare; fresh water: epibenthic, periphytic, hyperbenthic and semipelagic.....DASYDYTIDAE ..16

15. Truncated body end showing two protuberances, each with a tuft of long spines; fine spined scales. Epibenthic and semipelagic (Fig. 3C) ..... *Neogossea*
- Rounded body end with a central group of spines and no protuberances; keeled scales. Epibenthic and semipelagic ..... *Kijanebalola*

16. Several long spines, up to 1/4 of the body length, scattered on the dorsal trunk region, or only two caudal spines; two longitudinal, ventral ciliary bands; pharynx with two bulbs.....*Anacanthoderma*
- Long, lateral spines arranged into groups or longitudinal rows; tufts of ventral cilia; pharynx with one or no bulbs 17

17. Lateral spines with or without lateral denticle; few large, elliptic scales, if present; pharynx with no bulb 18
- Lateral spines with a bifurcate apex and one lateral denticle, or with a sharp apex and 2–3 lateral denticles; numerous, small and keeled scales, if present; pharynx with one bulb 19

18. Dorsal spines; two caudal spines per side; thick trunk and caudal spines with an evident lateral denticle; a few very large dorsal scales with a lace-like surface ..... *Ornamentula*
- No dorsal spines; one caudal spine per side or none; if very long, the lateral spines are strongly bent at the base gradually becoming thinner up to a hair-like apical portion; spines with or without a lateral denticle. If present, small and weakly keeled scales 20

19. Lateral spines with a sharp apex and 2–3 lateral denticles; scales absent; body end extending into two bristled protuberances (Fig. 3E) ..... *Stylochaeta*
- Lateral spines with a bifurcate apex and one lateral denticle; scales present; rounded body end ..... *Dasydytes*

20. Caudal spines present or absent; straight, lateral spines of medium length; ventral saltatorial spines absent 21
- Caudal spines absent; very long, strongly bent lateral spines extending up the dorsal side; ventral saltatorial spines present ..... *Haltidytes*

21. Caudal spines present (Fig. 3D) ..... *Setopus*
- Caudal spines absent ..... *Metadasydytes*

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