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7

Kingdom Animalia, phylum Xenacoelomorpha

acoel & xenoturbellid worms

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CHAPTER 7

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7 Kingdom Animalia, phylum Xenacoelomorpha (acoel & xenoturbellid worms)

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Summary

Acoelomorpha are small and microscopic marine worms that abound in Aotearoa New Zealand marine environments, but only two species have been recorded to date (Table 7.1; Fig. 7.1). These are *Sterreria* cf. *variabilis* and *Polychoerus gordoni* Achatz, Hooge, Wallberg, Jondelius & Tyler, 2009. The former has changed in status from *S. psammicola* to *S.* cf. *variabilis*, being part of a species complex, and the latter was formally described after the previous review by Johns *et al.* (2009) went to press. No species of Xenoturbellida has yet been found in the South Pacific. A checklist of extant New Zealand Xenacoelomorpha is provided.

Introduction

Xenacoelomorpha is a small phylum of unsegmented invertebrate animals, consisting of two sister groups, both subphyla—Xenoturbellida and Acoelomorpha. This new phylum was named in February 2011 (Philippe *et al.* 2011) based principally on molecular-sequence data and considered a sister group of hemichordates and echinoderms in the Deuterostomia. In the 2009 volume of *New Zealand Inventory of Biodiversity* (Gordon (Ed.) 2009) the two subphyla were described in separate chapters. Acoelomorphs were included in phylum Platyhelminthes as acoel turbellarian flatworms (Johns *et al.* 2009) and xenoturbellids in phylum Xenoturbellida (Gordon 2009a). Acoela means 'no cavity', referring to the absence of a gut cavity (present in Xenoturbellida). The genus name *Xenoturbella* is a hybrid, meaning strange turbellarian, derived from the Greek *xenos* (stranger) and Latin *turbella* (diminutive of turmoil, bustle—alluding to the movement of hair-like cilia); the genus was originally thought to be a strange kind of turbellarian flatworm (Westblad 1949).

All xenacoelomorph worms are bilateral, having left-right symmetry. They may actually be the most phylogenetically basal bilaterians (Hejnol *et al.* 2009), but an affinity with early deuterostomes has not been ruled out (Mulhair *et al.* 2022). They are also triploblasts, having three germ layers (ectoderm, endoderm, and mesoderm), but do not have a true body cavity, having an acoelomate body plan. Anatomy is reviewed by Rieger *et al.* (1991). There are longitudinal and circular muscles, and the epidermis of all species is ciliated. The cilia themselves are structurally unique within Animalia, in that the axonemal shaft continues beyond the cilium tip as a filament and there is a characteristic rootlet system and basal body (Tyler 1979; Lundin 1998). The mouth is midventral and in acoels opens directly into a large endodermal syncytium (temporary in some species), while in Nemertodermatida (a class of Acoelomorpha) and Xenoturbellida there is a sac-like gut lined by unciliated cells (Gavilán *et al.* 2019). There is no anus, circulatory system or protonephridial excretory structures, and genital cells are not organised into gonads. There is no head, and whereas in *Xenoturbella* there is little concentration of neurons at the anterior end, in the majority of acoelomorphs there is a ring-shaped nerve mass, with paired ganglia in Nemertodermatida and basal acoels (Achatz *et al.* 2013). All xenacoelomorphs have a diffuse intraepithelial nerve net and multiple parallel nerve cords and the anterior end has a characteristic statocyst. Development from egg to adult is direct, with no larval forms.

Members of the phylum are free-living, parasitic or commensal, and all are marine except for two freshwater acoel species. Whereas acoels are typically very small (mostly less than 2 mm length), one species can attain 15 mm. They range from the shallow intertidal to c. 4000 m water depth and metabarcoding reveals much hidden diversity (Arroyo *et al.* 2016). All six species of xenoturbellids (sole genus *Xenoturbella*) are larger, ranging from 4 to 20 cm in length when stretched out. They occur from 20 to 3700 m water depth.

Table 7.1. Summary of xenacoelomorph diversity in Aotearoa New Zealand region expressed as total numbers and percentage change. Data for 2009 are derived from Johns *et al.* (2009: p. 107) and Gordon (2009a: p. 370).

Taxon	Acoela		Nemertodermatida		Xenoturbellida		Total		% change
	2009	2023	2009	2023	2009	2023	2009	2023	
Total species diversity	1	1	1	1	0	0	2	2	0
Described extant species	0	1	1	1	0	0	1	2	100
Described endemic extant species	0	1	0	0	0	0	0	1	100

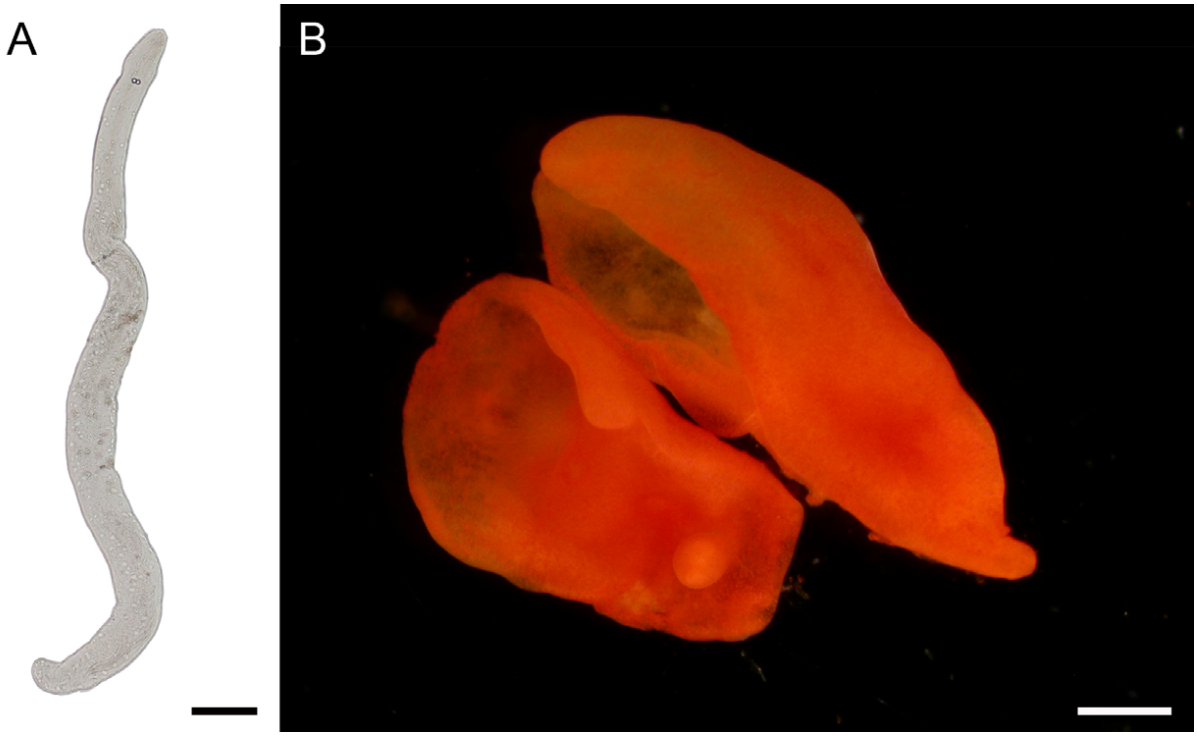

Figure 7.1. New Zealand xenacoelomorphs: **A.** *Sterreria* cf. *variabilis* Meyer-Wachsmuth, Curini Galletti & Jondelius, 2014, scale = 100 µm. **B.** Two individuals of *Polychoerus gordoni* Achatz, Hooge, Wallberg, Jondelius & Tyler, 2009, partly seen from beneath; note the expanded hood-like anterior end and, in the shorter worm, the bulbous penis under its posterior end, photographed live in reflected light against a black background, scale =1 mm. Image **A** first published as part of fig. 1 of https://doi.org/10.1371/journal.pone.0107688.g001; reproduced with permission. Image B reproduced with permission from Geoff Read.

Johns *et al.* (2009) listed two species of Acoelomorpha in the New Zealand fauna—a nemertodermatid identified as *Sterreria psammicola* (Sterrer, 1970) and a convolutid acoel, *Polychoerus* sp. *Sterreria psammicola* is one of only about 18 members of class Nemertodermatida (S. Tyler pers. comm. 2022), with the North Sea as the type locality. Riser (1984) reported what was probably *S. psammicola* (but in genus *Nemertoderma*) as abundant at New Brighton Beach, Christchurch, in a transect from high to low tide, and Sterrer (1998) recorded it north of Leigh, Northland, in "fine, clean sand" in the upper intertidal, also in genus *Nemertoderma*. The species, nominally widely distributed around the world, was transferred to the genus *Sterreria* by Lundin (2000). In a more recent study using DNA-sequencing of specimens from 33 different locations worldwide (including New Caledonia but not New Zealand), Meyer-Wachsmuth *et al.* (2014) found that *S. psammicola* was a complex of at least nine cryptic species. The authors concluded that "only one in the dataset appears to be truly globally distributed: *Sterreria variabilis* n. sp." (Fig. 7.1A), which currently makes this species the best candidate for the current New Zealand inventory checklist (W. Sterrer, pers. comm.).

The unidentified *Polychoerus* species was formally named as *P. gordoni* (Achatz *et al.*, 2009). It is a scarlet-orange worm about 4 mm long that, when fully stretched out, can reach 7 mm length (Fig. 7.1B). As it moves, it contracts to a shape somewhat resembling that of a 1970s VW beetle car. The anterior half of the animal is rounded and forms a large hood, presumably used to capture prey; small crustaceans were found in the digestive syncytium. The species is phylogenetically basal in the genus. It was first discovered on the underside of low-tidal rocky slabs at Sirens Rocks, Taputeranga Marine Reserve, Wellington (Gordon 2010); no other locality is yet known.

Species of Xenoturbellida are not yet known from the South Pacific. Gordon (Ed.) (2009) included a chapter on this group (as phylum Xenoturbellida – Gordon 2009a) to draw attention to its existence, in the expectation that specimens might be found in New Zealand waters. The first-named species was found in the deep mud of fiords. *Xenoturbella* was once thought to contain perhaps two species found in Scottish, Swedish and Norwegian waters. The two species have since been merged but, in the meantime, four new bathyal species have been described from Monterey Canyon (California) to the Gulf of California (Mexico) (Rouse *et al.* 2016) and a fifth species was discovered off Honshu (Japan) (Nakano *et al.* 2017). Thus, six species of Xenoturbellida are now known and the possibility of their discovery in the South Pacific has increased.

Knowledge gaps, research progress and future priorities

Phylum Xenacoelomorpha is seriously understudied in New Zealand, with only two species identified or named so far. Paucity of knowledge reflects paucity of global expertise and there are no New Zealand specialists. Almost 500 species (~400 described and ~100 known-undescribed) are documented globally and at least 4000 more species are estimated to exist (Appeltans *et al*. 2012). Acoels especially are known to be common components of meiofauna, in turn regarded as a trophically important part of marine ecosystems. A recent study has shown that there is great potential for discovery of new acoel species, among others, even in some of the most extensively studied locations (Atherton & Jondelius 2020). Extrapolation from European data indicate that there are likely to be at least 100 xenacoelomorph species in New Zealand. Members of the phylum are economically unimportant but have great theoretical value in understanding the evolution of bilateral animals, as well as unravelling how genomes and morphology are linked.

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References to the taxonomic authorities and dates for xenacoelomorph taxa in this chapter and the associated checklist can be located in the World Register of Marine Species, Xenacoelomorpha (https://www.marinespecies.org/aphia.php?p=taxdetails&id=592916).

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Checklist of extant Xenacoelomorpha known from the New Zealand EEZ

The checklist is arranged according to the currently accepted systematics and classificatory scheme employed by the World Register of Marine Species, Xenacoelomorpha (https://www.marinespecies.org/aphia.php?p=taxdetails&id=592916). Endemic taxa are indicated by 'E'. Non-indigenous species are indicated by 'NI'. All other taxa are considered native by default, i.e., naturally occurring in New Zealand and elsewhere.

Phylum XENACOELOMORPHA
Subphylum ACOELOMORPHA
Order ACOELA
Suborder BURSALIA
Family CONVOLUTIDAE
Polychoerus gordoni Achatz, Hooge, Wallberg, Jondelius & Tyler, 2009 E

Order NEMERTODERMATIDA
Family NEMERTODERMATIDAE
Sterreria cf. *variabilis* Meyer-Wachsmuth, Curini Galletti & Jondelius, 2014

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