Namanereis tiriteae, New Zealand's freshwater polychaete: new distribution records and review of biology

Duncan P. Gray[1], Jon S. Harding and Michael J. Winterbourn

School of Biological Sciences, University of Canterbury, Private Bag 4800, Christchurch, New Zealand
[1]Corresponding author's email: duncan.gray@pg.canterbury.ac.nz

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Abstract

A review of the biology of the poorly known freshwater polychaete *Namanereis tiriteae* is provided and new information on its distribution and habitat reported. *N. tiriteae* is now known from Wainisavulevu Creek, Fiji and four river systems (Manawatu, Tukituki, Ngaruroro, Waiapu) in the North Island, New Zealand. It has been found in open- canopied streams and rivers, including braided river channels and spring-fed, floodplain streams. Its habitats are typically a mixture of gravels, cobbles, sand and silt. Gut contents of individuals from a spring-fed stream were predominantly silt particles and diatoms, although a few arthropod fragments were also present. These observations suggest *N. tiriteae* may be a relatively indiscriminate deposit-feeder rather than an active predator as previously assumed.

Keywords: Annelida - Polychaeta - *Namanereis tiriteae* - *Namalycastis* - freshwater - distribution - feeding.

Introduction

Most of the approximately 9000 species of bristle worms (Annelida: Polychaeta) are marine or estuarine organisms, although some 168 species in 70 genera and 24 families appear to be restricted to freshwater environments (Glasby & Timm 2008). They are widely distributed across the world but are most diverse in the Palaearctic region (67 species in 32 genera described from Europe, northern Asia and Africa) and least diverse in Australasia (31 species in 15 genera) (Glasby & Timm 2008). The best represented family, the Nereididae (Phyllodocida), includes 55 freshwater species, over half of which are in the subfamily Namanereinae (Greek, Nama, refers to a spring or stream). They include a single New Zealand species, *Namanereis tiriteae*, which was described from three specimens collected in the Tiritea (now Turitea) Stream near Palmerston North in 1968 (Winterbourn 1969).

Aspects of the biology and systematics of the genus *Namanereis* in the Caribbean region were reviewed by Williams (2004) who also provided a table summarising the distributions and habitats of 15

Namanereis species and species-groups. Seven of the nine Caribbean species have been found in springs and various subterranean habitats, as were several others including *Namanereis gesae*, a species found in Yemen (Fiege & Van Damme 2002) and not included in Williams' list. More recently, Glasby & Timm (2008) discussed the global diversity of all polychaetes in freshwater and touched on questions of their endemicity, phylogeny and zoogeography. A Gondwanan origin and radiation has been postulated for *Namanereis* (Figure 1) with a single colonisation of freshwater before the break up of Gondwana (Glasby & Timm 2008). Similarly, Haase *et al*. (2006) hypothesised a Gondwanan origin for the fresh-brackish water snail *Fluviopupa* (Hydrobiidae), although colonisation of Fiji, whose oldest islands are only about 40 million years old, must have been by long distance dispersal most likely from New Zealand or New Caledonia. A similar scenario may apply to *N. tiriteae*, but will require comprehensive phylogenetic analyses of the genus based on molecular data.

The purpose of the present paper is to review knowledge of *N. tiriteae*, document new distributional records from the North Island and provide information on the habitats occupied by this elusive organism.

The New Zealand species of *Namanereis*

Two species of *Namanereis* are known from New Zealand, the euryhaline and morphologically variable *N. quadraticeps* (Blanchard) (regarded as a species group by Glasby 1999) and the freshwater species *N. tiriteae* (Winterbourn). The former is widely distributed in southern temperate and sub-antarctic regions, and in the New Zealand region specimens have been collected from brackish water and seawater pools on the Auckland and Campbell islands and from littoral clay banks on the Otago Peninsula, South Island (Winterbourn 1969). In contrast, *N. tiriteae* has been found only in inland rivers and streams; little is known of its biology (Scarsbrook *et al*. 2003).

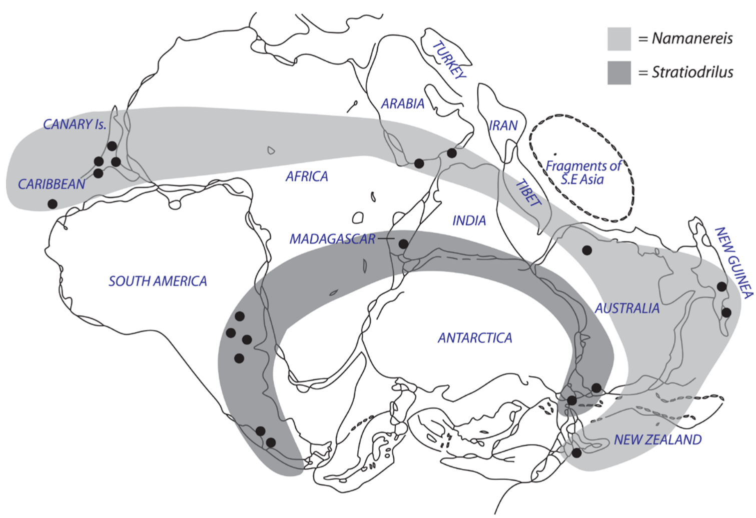

Figure 1. Distribution of species of *Namanereis* (Nereididae) and *Stratiodrilus* (Histriobdellidae) across Gondwana before its break-up in the mid to late Jurassic. Reproduced with kind permission of Chris Glasby.

Namanereis tiriteae

N. tiriteae was originally placed in *Namalycastis* Hartman based primarily on parapodial characters, although it was acknowledged at the time that it displayed features of both *Namalycastis* and *Namanereis* Chamberlin as then defined (Winterbourn 1969). Subsequently, Glasby (1999) transferred the New Zealand species to *Namanereis* and synonymised the Fijian freshwater species *Namalycastis vuwaensis* Ryan with it, stating that in terms of setal morphometrics the two groups of specimens were indistinguishable. All preserved New Zealand worms we have seen are unpigmented (white), although Ryan (1980) found that living specimens from Fiji were "a pronounced pink colour attributable to haemoglobin". In his original description of the species, Winterbourn (1969) also noted that

Table 1. Physico-chemical factors and benthic detritus biomass at sites where *N. tiriteae* was collected in the 2006-07 survey of braided rivers (n = 9).

	Mean	Minimum	Maximum
pH	-	7.0	9.4
Conductivity (μS_{25} cm^{-1})	167	146	199
Temperature (°C)	23	21	26
Dissolved oxygen (% saturation)	84	30	120
Max width (m)	6.6	1.0	21.0
Max depth (m)	0.24	0.04	0.70
Width/depth ratio	39	13	78
Max velocity cm s^{-1}	39	20	100
Substrate size (mm)	61	<1	420
Detritus (>1 mm) (g dry wt m^{-2})	2.81	0.39	11.11

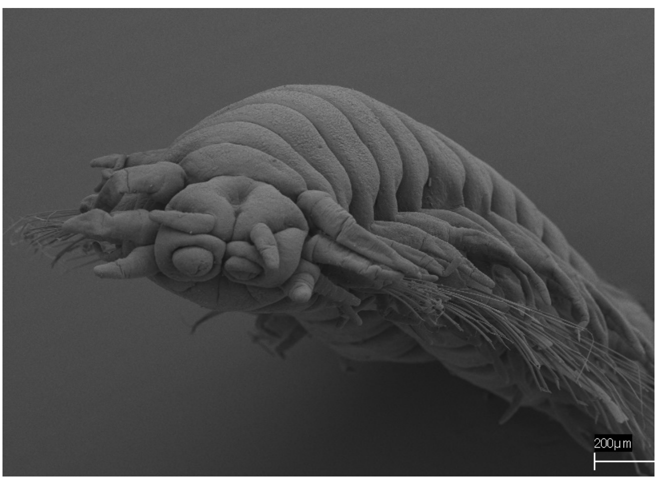

Figure 2. Scanning electron micrograph of *N. tiriteae* showing the head with antennae, prostomial palps, and three pairs of peristomial tentacular cirri. The parapodia of body segments have prominent setae and dorsal and ventral cirri.

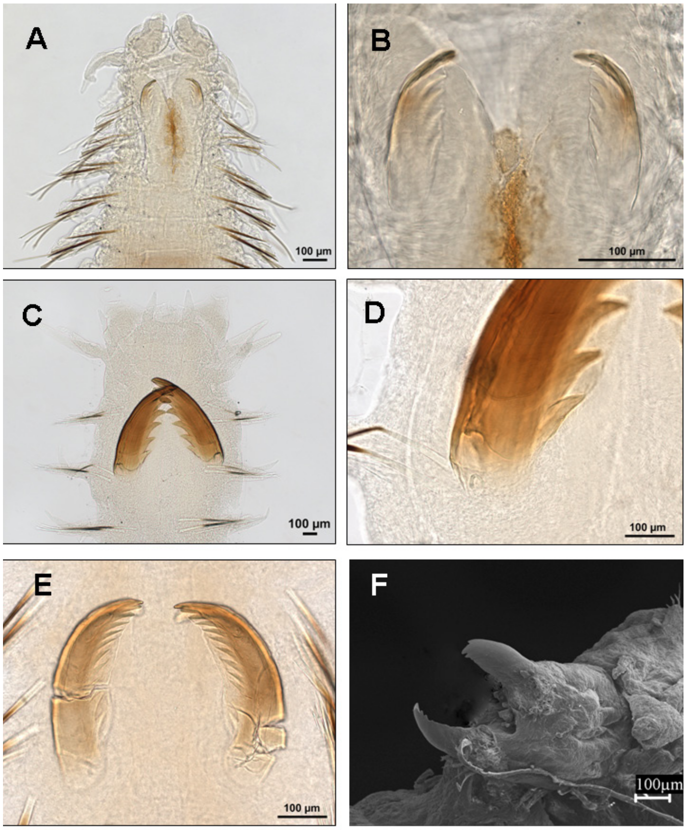

Figure 3. Light microscope images of the pharynx and jaws of *N. tiriteae*. A & B) dorsal view of head of a 10 mm long worm from the Ngaruroro River showing jaws with only 5 ensheathed proximal teeth and silt particles in the pharyngeal cavity; C & D) overview and basal growth lines in the jaw of a 50 mm long worm from Wainisavelevu Creek, Fiji collected by P. Ryan in 1974; E) jaws of a 40 mm long worm from the Tukituki River with at least 10 proximal teeth; F) scanning electron micrograph of the everted pharynx and jaws.

the longitudinal blood vessels were prominent and red.

The largest of the three original specimens of *N. tiriteae* collected from Turitea Stream had a body length of 21 mm, whereas the holotype of *N. vuwaensis* from Fiji was 67 mm long. Recently collected material from Hawkes Bay and East Cape varied in body length and included the smallest recorded specimen (6 mm). Means and ranges of body lengths of intact individuals from three rivers are as follows: Tukituki River, mean 37 mm, range 21-52 mm, n = 15; Ngaruroro River, mean 9 mm, range 6-15 mm, n = 4; Waiapu River, 22 mm, n = 1. *Namanereis* species have giant-size ova and may have separate sexes or be hermaphroditic (Glasby 1999). However, we have found no individuals with eggs.

The head of *N. tiriteae* (Figure 2) bears a pair of antennae, prominent prostomial palps with hemispherical palpostyles, and three pairs of tentacular cirri. Eyes are absent. The eversible pharynx is armed with a pair of sclerotised, toothed jaws derived from the pharyngeal cuticle and formed by specialized epithelial cells called gnathoblasts (Tzetlin & Purschke 2005) (Figure 3). The jaws are "twisted

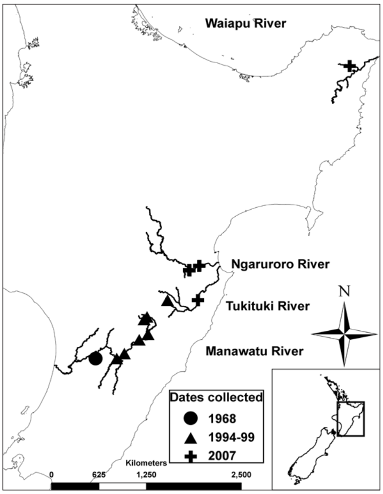

Figure 4. Locations of river systems and sites on North Island, New Zealand where *N. tiriteae* has been collected.

about their long axis" (Ryan 1980) giving them a somewhat spoon-like form.

In phyllodocid polychaetes such as Nereididae, jaw growth continues throughout life and is restricted to the basal region where growth lines may be seen (Figure 3c & d). New teeth are added at the base of the jaw as the worm grows (Tzetlin & Purschke 2005). Large individuals have up to 10 teeth (Figure 3e) and five were present in a 10 mm specimen (Figure 3a & b). Because the proximal, sub-terminal teeth are ensheathed, only the terminal teeth are visible on a scanning electron micrograph (Figure 3f).

Distribution

All known distributional records for *N. tiriteae* are collated in Table 1 and its New Zealand distribution seems limited to several North Island rivers (Figure 4). In Fiji the species is known only from above the Vuwa Falls on Wainisavulevu Creek, Viti Levu, at least 100 km by river from the sea (Ryan 1980). At 700 m a.s.l. this is the highest altitude at which the species has been found.

In New Zealand *N. tiriteae* has been found only in the North Island where its known distribution is restricted to four river systems (Figure 4). The original collection site, Tiritea (now Turitea) Stream, is a tributary of the Manawatu River. Subsequently, worms were found in other tributaries and the main stem of the Manawatu River and also the Tukituki River system in Hawkes Bay (Henderson 1995; Glasby 1999; McGuiness 2001). During a survey by one of us (DPG) in 2006-07 the known distribution was extended to further sites in the Tukituki, the Ngaruroro River north of the Tukituki and the Waiapu River near Ruatoria, East Cape. Sites where *N. tiriteae* has been found are on 3rd to 6th order reaches of rivers and streams flowing through pastoral land. Channels were all weakly shaded and ranged in width from 1 – 21 metres (Table 2). Altitudes at which *N. tiriteae* has been found in New Zealand range from 40 to 406 m (Table 2).

N. tiriteae appears to have a strong affiliation for alluvial subterranean habitats and its distribution may be limited by the availability of such habitat. Thus, it is absent from river systems in the west and north of the North Island that do not exhibit the alluvial characteristics of those in the east. The apparent absence of *N. tiriteae* from large alluvial river systems in the South Island is a mystery but may be explained by the lower average annual temperature of subterranean waters. Summer water temperatures 6 metres below the surface in wells in Hawkes Bay (east coast North Island) and on the Canterbury Plains (eastern South Island) were 20.0 °C and 14.1 °C, respectively (Scarsbrook & Fenwick 2003). Water temperature may also influence the distribution of the stygobiontic isopod *Cruregens fontanus*, which has been found regularly in surface springs in the north but in deeper habitats such as wells and the hyporheic zone in the South Island (D. P. Gray unpublished data).

Habitat

Most worms have been collected in benthic samples taken from stony riffles dominated by gravels and in some instances sand. Most of the worms discovered in the 2006-07 survey were taken from a spring-fed creek on the Tukituki River floodplain (Figure 5), but others were collected from major braids, side braids and up-welling zones of the Tukituki, Ngaruroro and Waiapu rivers. Ninety percent of the individuals found in the study were associated with upwelling groundwater and in several instances the stygobiontic isopod *Cruregens fontanus* was present in the same samples. Although few individuals have been found at most sites, Reece Fowler (pers. comm.) took 116 worms from 42 benthic samples in the Manawatu River system, and 34 worms were taken in a single 0.1 m^2 sample in a spring-fed creek on the Tukituki River floodplain (Gray unpublished data).

Physico-chemical factors measured at sites in the 2006-07 survey are summarised in Table 2. Although streams and river channels varied considerably in size, they were generally shallow with a large width:depth ratio. Current velocities were also variable (range 20-100 cm s^{-1}). Substrata were generally a mixture of cobbles, gravels and finer substrata but their relative proportions varied considerably among sites. No sites consisted solely of sand, silt or mud, but low concentrations of benthic detritus were typically present (Table 2). Most streams had circum-neutral to moderately alkaline pH and water temperatures greater than 21°C, reflecting their lack of canopy cover and sampling in summer.

Although most specimens of *N. tiriteae* have been found within the top 5 or 10 cm of river beds, their lack of eyes and body pigment suggest that groundwater or the hyporheic zone may be more typical habitats (Henderson 1995, R.

Figure 5. Spring creek in the Tukituki River bed, Hawkes Bay, where 34 *N. tiriteae* were found in a single Surber sample.

Table 2. Locations, altitude and distance from the sea (river distance) of collection sites for *N. tiriteae* in North Island, New Zealand and Fiji.

Collection localities	Latitude South	Longitude East	Altitude (m a.s.l.)	Distance from sea (km)
D.P. Gray survey (2006-07)				
Tukituki River, Patangata Bridge	39° 53.31′	176° 43.40′	80	53
Ngaruroro River, above Fernhill Bridge	39° 35.97′	176° 43.34′	40	22
Ngaruroro River, Maraekakaho	39° 38.39′	176° 37.24′	80	34
Waiapu River, Waiorongomai	37° 51.95′	178° 11.34′	120	39
R. Fowler & I. Henderson (1994-2001 records; pers. comm.)				
Manawatu River, Hopelands Bridge	40° 21.70′	175° 57.64′	100	130
Manawatu River, Weber Rd	40° 14.37′	176° 06.84′	160	170
Manawatu River, Maunga Rd	40° 11.41′	176° 12.44′	200	190
Manawatu River, Ellison Rd	40° 02.72′	176° 11.36′	406	227
Mangatewainui River, Gundries Rd	40° 04.07′	176° 09.64′	383	213
Mangatainoka River, between Manawatu River confluence and Mangatainoka township	40° 24.18′	175° 52.89′	80	123
Manawatu River at Palmerston North	40° 22.40′	175° 36.87′	25	75
Ongaonga Stream, Ongaonga	39° 53.24′	176° 23.27′	220	100
Winterbourn (1969)				
Turitea Stream, Turitea	40° 24.91′	171° 39.71′	76	74
Ryan (1980)				
Wainisavulevu Creek, Viti Levu, Fiji	17° 49.92′	178° 02.50′	700	100+

Fowler pers. comm.). According to Williams (2004) loss of eyes suggests a longtime association with subterranean habitats and springs, and all seven eyeless caribbean species of *Namanereis* occur in these habitats. Nevertheless, despite extensive sampling of alluvial and karst aquifers throughout New Zealand, including aquifers alongside the Ngaruroro and Tukituki rivers, there have been no reports of *N. tiriteae* from groundwaters (M. R. Scarsbrook pers. comm.). However, Reece Fowler (pers. comm.) found three worms at a depth of 40 cm in hyporheic samples taken from the Ongaonga Stream, a tributary of the Tukituki River, and as already mentioned, 90 % of individuals collected in the 2006-07 survey were from up-welling reaches and therefore in contact with the hyporheic zone.

Food and feeding

Little is known about the feeding habits of namanereidid polychaetes, but it is usually assumed they are predatory (Williams 2004) or omnivorous (Glasby *et al.* 1990). The jaws of some phyllodocid polychaetes are used to capture and hold prey or to tear off pieces of algae and decaying matter, while those of some

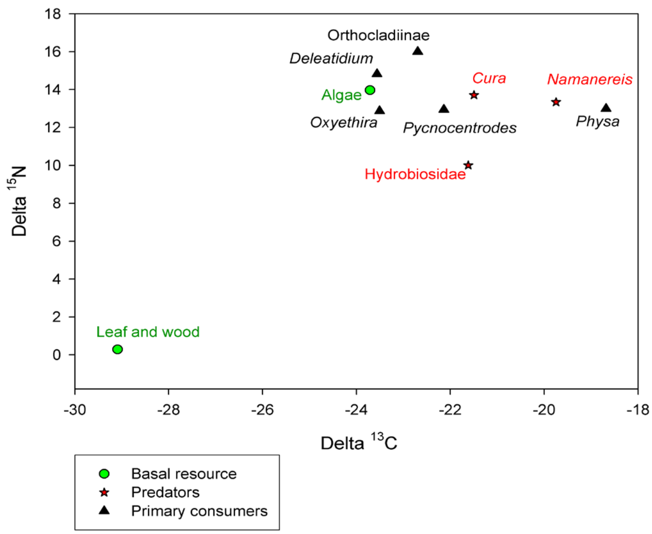

Figure 6. Stable isotope ratios of carbon and nitrogen from a spring creek in the Tukituki River, Hawkes Bay where 34 *N. tiriteae* were found. Material was stored in ethanol for 3 months prior to analysis.

Eunicida are used for scraping food particles from hard substrates (Tzetlin & Purschke 2005). Like other species in the family, *N. tiriteae* has a muscular, eversible pharynx equipped with a pair of toothed, opposing jaws (Figure 3).

To determine what materials are ingested by worms we removed the gut contents from six individuals collected in a spring-fed stream on the Tukituki River floodplain. Most other worms appeared to have empty guts but the dissected individuals contained dark material that could be seen through the body wall.

Gut contents were mounted on slides in lactophenol-PVA and examined at up to 200 x magnification. Silt particles and diatoms were the most abundant materials found along with some fragments of filamentous algae, pollen grains and higher plant tissue. We also found a few arthropod fragments including claws, leg segments and sections of mayfly antennae. Ryan (1980) found chaetae of megascolecid oligochaetes in faecal material produced by *N. tiriteae* in Fiji and noted that oligochaetes were numerous in the polychaete's habitat. No oligochaete chaetae were seen on our slides, and few oligochaetes were found in the benthic samples that contained *N. tiriteae*. Instead the numerically dominant invertebrates were larval chironomids, mayflies (*Deleatidium*), tipulids (Eriopterini) and micro-caddisflies (*Oxyethira*). The most abundant "worm" taxon was the turbellarian *Cura pinguis*. It is possible that soft-bodied invertebrates, which are not visible in gut content analyses, were also eaten, or that the jaws are used to capture and dismember prey, and that only soft tissues and/or body fluids are actually ingested.

Stable carbon and nitrogen isotope analyses of various potential foods and prey species in the Tukituki spring stream were also made as described in Winterbourn (2007). All material had been stored in ethanol for at least three months prior to analysis but this should have had little effect on the results (Kaehler & Pakhomov 2001; Sarakinos *et al*. 2002). Stable isotopes gave equivocal results (Figure 6), and did not help resolve the feeding question. Thus, although the stable carbon signature of *N. tiriteae* was similar to that of the predatory flatworm *Cura pinguis*, its nitrogen signature was almost identical to that of algae, lower than those of some primary consumers and higher than those of others. It is possible that *N. tiriteae* feeds relatively indiscriminately, and more in the manner of a deposit-feeding oligochaete than an active predator, as indicated by the predominance of silt and diatoms in guts. Additionally, the presence of silt in the pharynx in Figure 3a suggests that jaws may actually be used to shovel material into the buccal cavity.

Conservation and biodiversity

N. tiriteae is one of the least frequently encountered aquatic invertebrates in New Zealand. In 1995 Henderson published a request for further records of *N. tiriteae* in the newsletter of the New Zealand Limnological Society (now New Zealand Freshwater Sciences Society). However, after 12 years only two subsequent reports eventuated, including this one (I. Henderson pers. comm.). Finding specimens of *N. tiriteae* at sites where they have been found previously has also been difficult, and no individuals have been found in either the Turitea Stream or Wainisavulevu Creek since the initial discoveries. Furthermore, although specimens have been collected intermittently at three sites in the Manawatu River catchment between 1994 and 2001, they have not been found subsequently in comparable numbers (I. Henderson pers. comm.). Collier (1992) listed *N. tiriteae* as a species of potential conservation interest and the few rivers in which it is known are in predominantly agricultural catchments susceptible to development, water abstraction and flood management. Clearly, further research is needed on this enigmatic member of our fauna to better understand its habitat requirements and population dynamics in order to enhance its conservation.

Acknowledgments

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