




Upside-down behaviour of certain ribbon worms (phylum Nemertea)

Hiroshi Kajihara¹ , Audrey Falconer^{2,3} and Alexei Viktorovich Chernyshev⁴

Field Note

Cite this article: Kajihara H, Falconer A, and Chernyshev AV (2024). Upside-down behaviour of certain ribbon worms (phylum Nemertea). *Journal of Tropical Ecology*. **40**(e2), 1–3. doi: <https://doi.org/10.1017/S0266467423000330>

Received: 6 October 2023

Accepted: 12 December 2023

Keywords:

Archinemertea; cephalotrichellidae; cephalotrichidae; dorsoventral inversion; marine invertebrates; palaeonemertea

Corresponding author:

Hiroshi Kajihara;
Email: kajihara@eis.hokudai.ac.jp

¹Faculty of Science, Hokkaido University, Sapporo 060-0810, Hokkaido, Japan; ²Sciences Department, Museums Victoria Research Institute, Museums Victoria, GPO Box 666, Melbourne, VIC 3001, Australia; ³Marine Research Group, The Field Naturalists Club of Victoria, 1 Gardenia Street, Blackburn, VIC 3130, Australia and ⁴A.V. Zhirmunsky National Scientific Centre of Marine Biology, Far East Branch of the Russian Academy of Sciences, Palchevskogo Street 17, Vladivostok, 690041, Russia

Abstract

Ribbon worms in the genus *Balionemertes* from Vietnam, the Philippines, Australia, and Guam—as well as *Cephalothrix suni* from Vietnam—were examined. Our observations indicate that the worms crawl mostly with their ventral surface upwards (the ventral surface being where the mouth opens), a behaviour that has not been documented in previous literature. Like many other worm species with colour patterns, they have a darker-coloured and/or more intensely patterned behavioural dorsal surface (= anatomical ventral surface in *Balionemertes* and *C. suni*) than the other side. This type of behavioural dorsoventral body-axis inversion among vermiform benthos seems to be rare—not having hitherto been known at least in the phylum Nemertea—and may be related to their feeding strategy, which should be observed in future studies.

The ribbon worms depicted in [Figure 1](#) are members of the palaeonemertean genus *Balionemertes*, which were collected and observed independently by us. These specimens are the basis of our previous publications regarding geographical occurrence (Baker *et al.* 2015, Chernyshev 2016), molecular phylogeny (Kvist *et al.* 2015, Chernyshev and Polyakova 2021), and morphological investigations (Chernyshev 2015, Magarlamov *et al.* 2018, 2021, Chernyshev and Kajihara 2019, Kajihara 2020).

Little is known about the biology of *Balionemertes* due to their rare occurrence. Two decades ago, the genus *Balionemertes* was established for the single species *Balionemertes australiensis* based on material from the Great Barrier Reef, Australia (Sundberg *et al.* 2003) but since then only a handful of occurrences have been reported. In Australia, *Balionemertes* ribbon worms were subsequently found in Western Australia (Whisson 2023), South Australia (Baker *et al.* 2015) ([Fig. 1a–c](#)), and New South Wales (Riek 2022). Apart from Australia, they have been reported from India (Shrinivaasu *et al.* 2015), Vietnam (Chernyshev 2016) ([Fig. 1d, e](#)), the Philippines (Kajihara 2020) ([Fig. 1i, j](#)), and Guam (Magarlamov *et al.* 2018) ([Fig. 1f–h](#)); they are also distributed in the Nansei Islands of Japan (Kajihara *pers. obs.*). At least four different colour morphs are recognised, each probably representing a different species. However, because the colouration of the holotype is not precisely known, species-name allocation to some of these colour morphs is currently problematic, with *B. australiensis* being the sole valid species name in the genus.

One thing that has not been documented in the existing *Balionemertes* literature is that the worms crawl and swim upside down. When placed on a Petri dish in seawater, they move like a long, slender pipe fish or a robust horsehair worm, and can swim by wriggling fast from side to side upon stimulus. The mouth is usually tightly closed, thus can be inconspicuous ([Fig. 1d](#)), and almost unrecognisable in quick motion; however, it becomes obvious in a narcotised/fixed state due to muscular relaxation/contraction ([Fig. 1g](#)), eventually manifesting the worm's ventral side (the mouth generally opens on the ventral side at a certain distance from the tip of the head in ribbon worms belonging to Palaeonemertea and Piliophora). In the living state, the worms often appear to lack a clear sense of up and down, lying on either dorsal or ventral surfaces. They have groups of eyespots on the dorsal, ventral, and lateral surfaces of the head ([Fig. 1b, c, g, h](#)), and this might indicate that they can live on both sides. Still, however, the side with the mouth mainly faces upward while the worm crawls. This behavioural dorsoventral inversion is consistent with the difference in the body colour shades. Like many other worm species with colour patterns, members of *Balionemertes* also have a darker-coloured and/or more intensely patterned behavioural dorsal surface than the other side ([Fig. 1a–j](#)). What is peculiar in *Balionemertes* is that the behavioural dorsal side is the anatomical ventral side.

Animals in a wide variety of taxa are known to live with their belly oriented upward, either continually or temporarily. Speaking of aquatic creatures alone, the list can include (not exhaustive): pelagic sea slugs in the genus *Glaucus* (Mollusca: Gastropoda) (Huang *et al.* 2017);

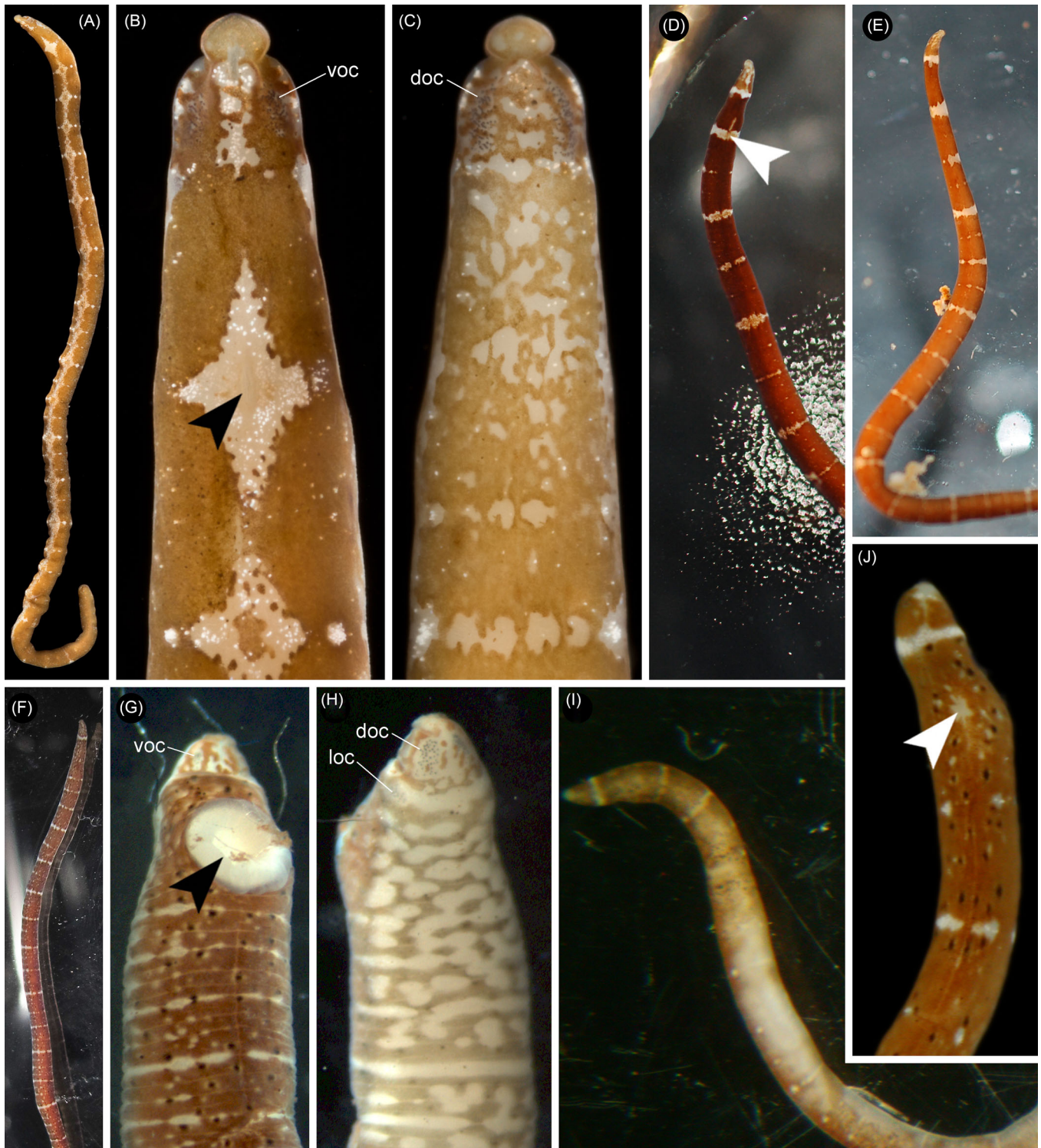


Figure 1. Unidentified *Balionemertes* spp. A–C, among the seagrass *Amphibolis antarctica* collected at a depth of 2 m in Mozzie Flat, Yorke Peninsula, South Australia, 35.1130°S, 137.4970°E, 17 April 2014, by the South Australian Conservation Research Divers (see Baker *et al.* 2015) (photographs taken by Leon Altoff); anterior fragment, 55 mm in length. D, E, intertidal, among calcareous red algae, Van Phong Bay, Vietnam, 12.66°N, 109.33°E, 21 May 2010, by Alexei V. Chernyshev. F–H, among calcareous red algae at a depth of 1 m in Biti Bay, Guam, 6 May 2015, by Alexei V. Chernyshev. I, J, intertidal, under rock, Buente, Carmen, Cebu, Philippines, 10.6208°N, 124.0277°E, 22 September 2006, by Hiroshi Kajihara; anterior fragment, 3 cm in length. A, B, E, F, G, I, ventral view; C, E, H, I, dorsal view; A–F, I, J, living state; G, H, fixed state; arrowheads indicating the position of the mouth. Abbreviations: doc, dorsal ocellus; loc, lateral ocellus; voc, ventral ocellus.

giant clams in the genus *Tridacna* (Mollusca: Bivalvia) (Yonge 1975); brine shrimp (Crustacea: Anostraca: *Artemia*) (Fryer 2006); barnacles (Crustacea: Cirripedia) (Essock-Burns et al. 2017); marine-cave-dwelling remipedians (Crustacea: Remipedia) (Koenemann et al. 2007); the anchialine shrimp *Procaris ascensionis* (Crustacea: Decapoda) (Abele and Felgenhauer 1985); backswimmers (Hemiptera: Notonectidae) (Gittelman 1976); the upside-down catfish *Synodontis* (Actinopterygii: Mochokidae) (Blake and Chan 2007); and the upside-down pipefish *Heraldia nocturna* (Actinopterygii: Syngnathidae) (Paxton 1975). The upside-down jellyfish *Cassiopeia* are excluded since their body plan does not have a dorsoventral axis, as they are not bilaterally symmetrical. All these animals in the list are either neustons, nektons, or sessile organisms. So far as we know, there are no benthic, non-sessile animals that can be included in the list other than *Balionemertes* and another species of ribbon worm, *Cephalothrix suni* (Chernyshev pers. obs.). In the latter species, only the behavioural dorsal side (= anatomical ventral side) is pigmented (Chernyshev and Polyakova 2021). We suppose another congener, *Cephalothrix queenslandica*, may also crawl with its ventral side up; the dorsoventral orientation was likely misidentified in the original description of the species (Sundberg et al. 2003).

Dorsoventral body-axis inversion is believed to have happened in ancestral chordates, which were likely free-living (non-sessile) and worm-like (e.g., Satoh et al. 2014). To what extent the inversion is comparable between the ancestral chordates and the present *Balionemertes* is unknown, but it is obviously an interesting example of parallel evolution. The open question is why *Balionemertes* and *C. suni* (and possibly *C. queenslandica* as well) move the way they do. We also have no idea why their geographic distribution is limited to the tropical and subtropical Indo-West Pacific. At the moment we can only speculate that their behaviour may be related to the way they hunt their prey, which should be observed in future studies.

Acknowledgements. We thank Leon Altoff for providing digital images of *Balionemertes*.

Financial support. This study was partially supported by the Russian Foundation for Basic Research grants (No. 14-04-01067) for AVC and by the Japan Society for the Promotion of Science (Core University Program 'Studies on development and utilisation of fisheries resources in the coastal waters in the Philippines') for HK.

Competing interests. The authors declare none.

References

- Abele LG and Felgenhauer BE (1985) Observations on the ecology and feeding behavior of the anchialine shrimp *Procaris ascensionis*. *Journal of Crustacean Biology* 5, 15–24.
- Baker J, Falconer A, Kinasz D, Futterer A, Crawford H, Puxley K, Baker-Johnson J, Ruxton S, Newton A, Hart K, Moffat B, Strous A, Sutcliffe M, Butvilla W, Santiago J and Baade L and Aston D (2015) *Marine Invertebrates of the Northern and Yorke NRM Region: Results of 2013–2014 Field Work, Including Records of New Species*. NRM Community Grant Report for Northern and Yorke NRM Board, and S.A. Department for Environment, Water & Natural Resources, 59 pp. <http://dx.doi.org/10.13140/RG.2.2.10957.61926> (accessed 25 September 2023).
- Blake RW and Chan KH (2007) Swimming in the upside down catfish *Synodontis nigriventris*: it matters which way is up. *Journal of Experimental Biology* 210, 2979–2989.
- Chernyshev AV (2015) CLSM analysis of the phalloidin-stained muscle system of the nemertean proboscis and rhynchocoel. *Zoological Science* 32, 547–560.
- Chernyshev AV (2016) Nemerteans of the coastal waters of Vietnam. In Adrianov AV and Lutaenko KA (eds), *Biodiversity of the Western Part of the South China Sea*. Vladivostok: Dalnauka, 279–314.
- Chernyshev AV and Kajihara H (2019) Comparative muscular morphology in Archinemertea (Nemertea: Palaeonemertea). *Zoomorphology* 138, 193–207.
- Chernyshev AV and Polyakova NE (2021) An integrative description of a new *Cephalothrix* species (Nemertea: Palaeonemertea) from the South China Sea. *Zootaxa* 4908, 584–594.
- Essock-Burns T, Gohad NV, Orihuela B, Mount AS, Spillmann CM, Wahl KJ and Rittschof D (2017) Barnacle biology before, during and after settlement and metamorphosis: a study of the interface. *Journal of Experimental Biology* 220, 194–207.
- Fryer G (2006) The brine shrimp's tale: a topsy turvy evolutionary fable. *Biological Journal of the Linnean Society* 88, 377–382.
- Gittelman SH (1976) Swimming ability of Notonectidae (Hemiptera). *Psyche: A Journal of Entomology* 83, 319–323.
- Huang HD, Chiu WC, Chang M and Lee KS (2017) First record of a rare aggregation of the neustonic nudibranch *Glauca marginatus* (Mollusca: Gastropoda: Glaucaidae) from Kenting National Park, Southern Taiwan. *Collection and Research* 30, 17–21.
- Kajihara H (2020) Three species of ribbon worms (Nemertea) from Cebu, the Philippines. *Species Diversity* 25, 251–273.
- Koenemann S, Schram FR, Iliffe TM, Hinderstein LM and Bloechl A (2007) Behavior of Remipedia in the laboratory, with supporting field observations. *Journal of Crustacean Biology* 27, 534–542.
- Kvist S, Chernyshev AV and Giribet G (2015) Phylogeny of Nemertea with special interest in the placement of diversity from Far East Russia and northeast Asia. *Hydrobiologia* 760, 105–119.
- Magarlamov TY, Chernyshev AV and Turbeville JM (2018) Pseudocnidae of archinemerteans (Nemertea, Palaeonemertea) and their implications for nemertean systematics. *Journal of Morphology* 279, 1444–1454.
- Magarlamov TY, Turbeville JM and Chernyshev AV (2021) Pseudocnidae of ribbon worms (Nemertea): ultrastructure, maturation, and functional morphology. *PeerJ* 9, e10912.
- Paxton JR (1975) *Heraldia nocturna*, a new genus and species of pipefish (family Syngnathidae) from eastern Australia, with comments on *Maroubra perserrata*. *Proceedings of the California Academy of Science, 4th Series* vol. 40. San Francisco: California Academy of Science, 429–447.
- Riek D (2022) Family: Cephalotrichellidae; *Balionemertes* sp? <http://www.roboastra.com/Worms/brwo27.html> (accessed 1 October 2023).
- Satoh N, Rokhsar D and Nishikawa T (2014) Chordate evolution and the three-phylum system. *Proceedings of the Royal Society B: Biological Sciences* 281, 20141729. <https://doi.org/10.1098/rspb.2014.1729>
- Shrinivaasu S, Venkataraman K and Venkataraman C (2015) Checklist of nemerteans with a new record in Indian coastal waters. In Venkataraman K, Raghunathan C, Mondal T and Raghuraman R (eds), *Lesser Known Marine Animals of India*. Kolkata: Zoological Survey of India, 173–175.
- Sundberg P, Gibson R and Olsson U (2003) Phylogenetic analysis of a group of palaeonemerteans (Nemertea) including two new species from Queensland and the Great Barrier Reef, Australia. *Zoologica Scripta* 32, 279–296.
- Whisson G (2023) iNaturalist observation. <https://www.inaturalist.org/observations/160057855> (accessed 1 October 2023).
- Yonge CM (1975) Giant clams. *Scientific American* 232, 96–105.