

Nectonemertes mirabilis (Nemertea: Hoplonemertea: Pelagica) from deep waters of the Gulf of Mexico, first sighting of a pelagic nemertean in the gulf

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Abstract: The deep-water bathypelagic nemertean *Nectonemertes mirabilis*, previously found in the Atlantic and Pacific oceans, was confirmed for the first time in the Gulf of Mexico. This new record is represented by a juvenile male collected by a stratified plankton sampling at 800–1,000 m depth in the southern gulf (20.5°N, 94.5°W), during summer 2014. This is the first record of a pelagic nemertean in the gulf; extending our knowledge about the species' global distribution, the number of nemertean species present in Mexican Atlantic waters, and the need to explore the mesopelagic zone of the oceans.

Key words: mesopelagic zone, ribbon worms, stratified sampling, western Atlantic, zooplankton

The phylum Nemertea Schultze, 1851 is scarcely studied due to the difficulties in correctly identifying species. Worldwide, the number of nemertean species currently recognized as valid is approximately 1,275 (Kajihara et al. 2008). Nemerteans, also called ribbon worms, predominantly live in marine benthic habitats, but they are also found in inland freshwater ponds and the marine pelagic environment (Coe 1926, Gibson 1999, Herrera-Bachiller 2016). The systematics and taxonomy of this phylum remain unresolved (Gibson 1999, Sundberg et al. 2016), and in some cases, the classification of the taxa is related to the habitat of the species. An example of this is the order Polystilifera Brinkmann, 1917, which has two suborders the suborder Reptantia Brinkmann, 1917, comprising exclusively benthic species, and the suborder Pelagica Brinkmann, 1917, composed of pelagic species (Brinkmann 1917, Gibson 1999, Norenburg et al. 2020).

The suborder Pelagica includes 98 species belonging to 40 genera (Kajihara et al. 2008). The species' distribution

range of pelagic nemerteans encompasses deep waters. Among the pelagic nemerteans, the genus *Nectonemertes* Verril, 1892 is recognized as the most common and abundant taxon, particularly the species *Nectonemertes mirabilis* Verril, 1892 (Gibson 1999). As a group, pelagic nemerteans are considered bathypelagic animals with their upper limit between 500 to 1000 m depth; however, *N. mirabilis* can reach 300 m depth during winter in the Mid North Atlantic (van der Spoel 1985, Gibson 1995). Knowledge on the global distribution of nemertean species is still limited.

In the Gulf of Mexico, 42 nemertean species have been recorded, all of them associated with benthic habitats between 0–75 m depth (Norenburg 2009), but no previous records exist of any pelagic species. Thus, this work presents the first record of the pelagic nemertean *Nectonemertes mirabilis* in the gulf, collected in the deep mesopelagic zone of the southern gulf during summer 2014.

Zooplankton samples were collected from June 4 to 14, 2014, at 31 oceanographic stations located in the oceanic province of the southern Gulf of Mexico (Fig. 1), using a stratified opening-closing zooplankton net system (75 cm mouth, 505 µm mesh). At each oceanographic

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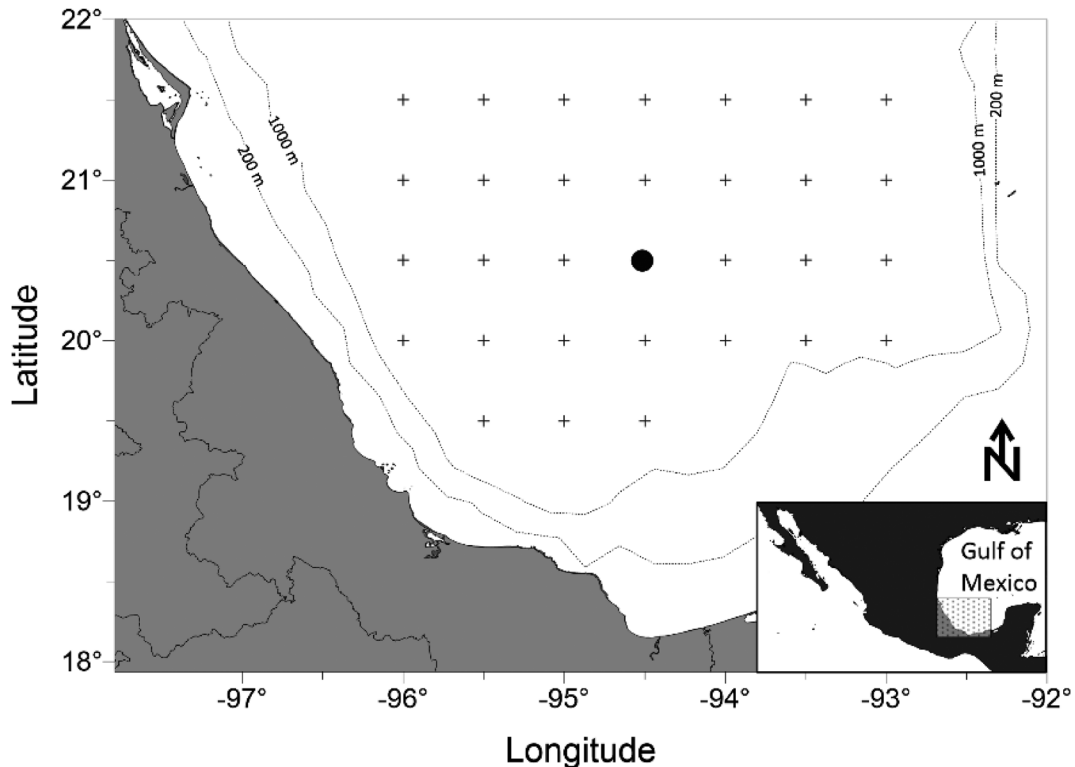


Fig. 1. Geographical location of sampling stations and that of the first record of *Nectonemertes mirabilis* (circle) in the southern Gulf of Mexico.

station, samples were obtained at five levels of the water column: 0–200 m, 200–400 m, 400–600 m, 600–800 m, and 800–1,000 m, depending on bottom depth. The biological material was fixed in 4% formalin-seawater and preserved in 70% ethanol. The zooplankton biomass of sampling stations was estimated as displaced volume (ml/1,000 m³).

In the laboratory, samples were examined and a single nemertean was separated out and identified as *Nectonemertes mirabilis* by reference to the literature (Brinkmann 1917, Coe 1920, Coe 1926, van der Spoel 1985, Gibson 1999). To make visible the intestinal diverticula, the specimen was stained with rose Bengal and mounted in glycerol. The individual was deposited in the zooplankton collection of the Laboratorio de Ecología de Sistemas Pelágicos, Instituto de Ciencias del Mar y Limnología (ICML-LESP) of the Universidad Nacional Autónoma de México. The systematics follows the current ordination available in WoRMS (Norenburg et al. 2020).

The global distribution of species was plotted using previous records inferred from literature, biogeographic databases, together with current results, using the software SURFER Ver. 15.

Phylum NEMERTEA Schultze, 1851
 Class HOPLONEMERTEA Hubrecht, 1879
 Order POLYSTILIFERA Brinkmann, 1917
 Suborder PELAGICA Brinkmann, 1917
 Family NECTONEMERTIDAE Verrill, 1892
Nectonemertes mirabilis Verrill, 1892 (Fig. 2)

Material examined.—1 juvenile ♂ (20.5°N–94.5°W, 800–1,000 m depth: 5.58°C, 34.91 PSU, zooplankton biomass 7.95 ml/1,000 m³) 12 mm length and 4 mm width, ICML-LESP 0043.

Diagnosis.—Body slender and flattened, with posterior lateral margins developed as thin horizontal fins and posterior end forming a bilobed caudal fin clearly demarcated from body; length in adults up to 60 mm and 10 mm width; rhynchocoel nearly as long as body, with wall containing separate circular and longitudinal muscle layers; proboscis is as long as body in adults, lacking accessory stylet-pouches; 30–60 pairs of intestinal diverticula as well as 6–8 pairs of diverticula on intestinal caecum; sexes dimorphic; females with 20 or more pairs of ovaries along sides of body; males with two lateral tentacles anteriorly (6 mm length in adults) and 6–25 spermaries clustered on each side of head; the number of spermaries is commonly asymmetric, the left side exceeding that on the right; mid-dorsal blood vessel extends full length of body; color in life pink, red or orange, juveniles pale grey or colorless. Sources: Coe (1920, 1926), van der Spoel (1985), Gibson (1999).

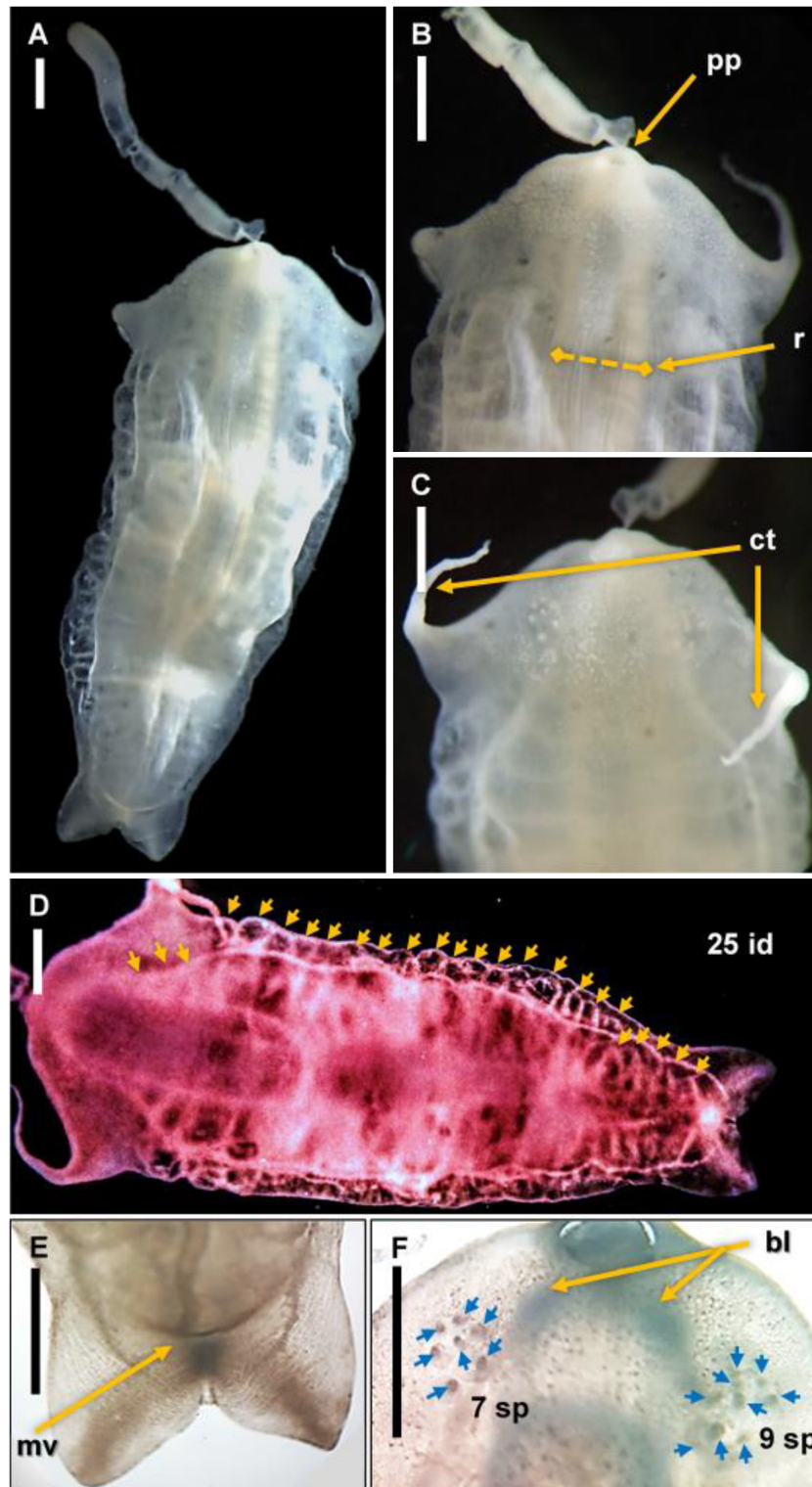


Fig. 2. *Nectonemertes mirabilis* juvenile male from the southern Gulf of Mexico. **A** dorsal view; **B** head in dorsal view, showing the proboscis pore (pp) and rhynchoeol (r); **C** head in ventral view, showing the cephalic tentacles (ct); **D** ventral view, showing the intestinal diverticula (id); **E** caudal fin, showing the mid-dorsal blood vessel (mv); **F** head, showing the brain lobe (bl) and the clustered spermaries (sp). Scale bars 1 mm.

Description of juvenile male.—body flattened, with posterior lateral margins developed as thin horizontal fins and posterior part of body ending in a bilobed caudal fin,

clearly demarcated from the body; body length 12 mm and 4 mm width; rhynchoeol nearly as long as body, 1 mm width; head with a pair of slender tentacles on the lateral

margins posterior to brain, tentacles length 1.7 mm; proboscis about half of the body length, lacking accessory stylet-pouches; 25 pairs of intestinal diverticula; spermaries clustered on each side of head with an asymmetric number (7 in the right side and 9 in the left) and located entirely posterior to brain; mid-dorsal blood vessel extends full length of body; body color white in ethanol, rhynchocoel yellowish.

Remarks.—A peculiar characteristic of some pelagic nemertean males is the development of two lateral tentacles next to the head (Gibson 1999), as in *Nectonemertes* and *Balaenanemertes* Bürger, 1909, slenderer and longer in the former (Coe 1926). Males of these genera are easily differentiated by the position of the spermaries: beside or entirely anterior to the brain in *Balaenanemertes*, and beside or posterior to the brain in *Nectonemertes* (Brinkmann 1917, Coe 1926). Also, *Pelagonemertes excisa* Korotkevitch, 1955 was described with a pair of cephalic tentacles; recently however, Chernyshev & Chaban (2005) questioned this feature because no traces of the tentacles were observed on the transverse sections of the body after reviewing the holotype. Furthermore, *P. excisa* differs from *Nectonemertes* species in the length of the mid-dorsal blood vessel: it ends near the brain in *P. excisa*, whereas in *Nectonemertes* it extends the full length of the body (Gibson 1999).

In *Nectonemertes* species, the length of tentacles, number of spermaries, and number of intestinal diverticula are correlated with the developmental state of males (Brinkmann 1917, Coe 1926, van der Spoel 1985). The present individual, a juvenile of *N. mirabilis*, has 7 and 9 spermaries clustered on each side of the head (Fig. 2F), indicating the immature developmental state of the specimen. As stated, the asymmetry in the number of spermaries on each side of the head is a diagnostic character for *N. mirabilis* (Coe 1926). Clustered spermaries distinguish *N. mirabilis* from *N. minima* Brinkmann, 1915, *N. primitiva* Brinkmann, 1917 and *N. tenuis* Korotkevitch, 1964, species in

which spermaries are arranged in a single row on each side of the head (Coe 1926, Korotkevitch 1964, Gibson 1999). In addition, the body length-body width (12–4 mm) relationship in the present individual (Fig. 2A) is similar to that observed by van der Spoel (1985) in other juveniles (10–3 mm) of *N. mirabilis*.

Nectonemertes mirabilis is morphologically similar to *Nectonemertes japonica* Foshay, 1912, however the taxonomic status of *N. japonica* remains unresolved because some authors (Brinkmann 1917, Coe 1954) have doubted its validity and synonymized it with *N. mirabilis*. Brinkmann (1917) associated the gonad characteristics and the reduced number of intestinal diverticula of *N. japonica* with young specimens of *N. mirabilis*. In a recent review of Japanese nemerteans, Kajihara (2007) suggested the need for further taxonomic studies on *N. japonica* to solve this nomenclatural problem.

Unfortunately, the species *Nectonemertes acutilobata* Korotkevitch, 1964 was described based on a single female and is only known from Chile (Korotkevitch 1964), with the males still being unknown (Chernyshev pers. comm. Aug. 2020). Therefore, we cannot compare the present immature male individual with the holotype of *N. acutilobata*, considering the sexually dimorphic external features.

For years, histological techniques have been used for nemertean species identification through examination of the internal musculature (Coe 1926, Gibson 1995). Recently however, Sundberg et al. (2016) have cast doubt on these techniques due to the high level of intraspecific variability of internal forms. Furthermore, the application of these techniques involves the destruction of tissues. Since we had only a single *N. mirabilis* specimen, only the external features were considered for identification (Fig. 2).

Depth range.—300–3,000 m depth at temperatures $\leq 9^{\circ}\text{C}$ (Brinkmann 1917, van der Spoel 1985, Gibson 1999).

Distribution.—North Atlantic (Cuba, Bermuda, USA, Canada, Greenland, Iceland, Portugal-Azores, Guinea),

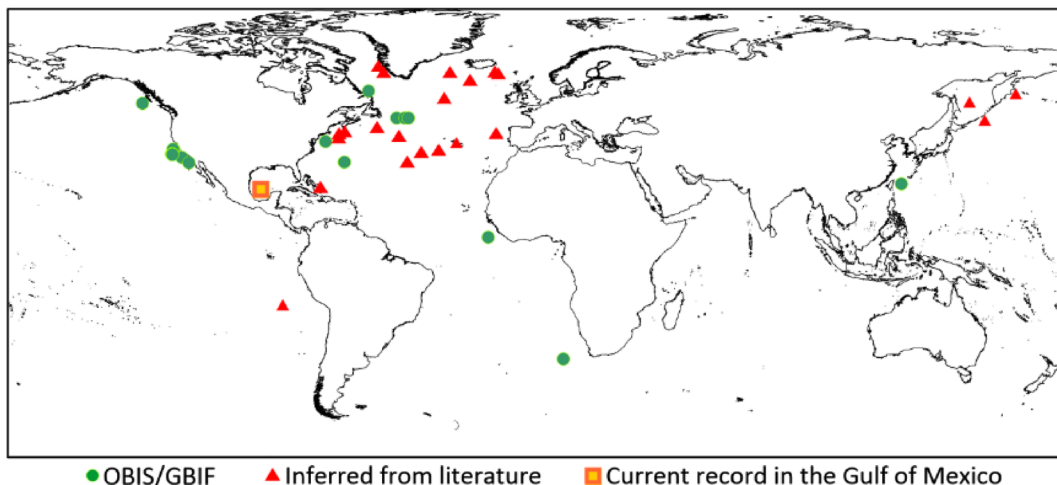


Fig. 3. Global distribution of *Nectonemertes mirabilis* according to previous and current records.

Gulf of Mexico, South Atlantic (South Africa), North Pacific (Japan-Okinawa, Russia-Okhotsk Sea, Kuril Islands and Kamchatka, Gulf of Alaska, USA, Mexico), South Pacific (next to Peru) (Coe 1926, Coe 1956, Gibson 1995, Gibson 1999, Herrera-Bachiller 2016, Chernyshev & Polyakova 2018, GBIF.org 2020, OBIS 2020, this study) (Fig. 3).

Ecology.—Nemerteans are carnivores. They eat parts of arthropods or worm-shaped animals (McDermott & Roe 1985). Brinkmann (1917) found a crustacean in the *N. mirabilis* intestine. Among the species of the genus *Nectonemertes*, a parasitism interaction has been observed only in *N. primitiva*, with it acting as a host for a sporozoan-like organism (Brinkmann 1917), but there is no other evidence of this type of interaction in any other species in the genus (McDermott 2006). It seems that the reproduction of *N. mirabilis* is independent of the season, owing to the relatively stable hydrological conditions of the deep waters that the species inhabits (Brinkmann 1917).

Nectonemertes mirabilis inhabits the meso- and bathypelagic layers, being recorded between 300 and 3,000 m depth at temperatures below 9°C (Brinkmann 1917, Coe 1926, van der Spoel 1985, Gibson 1999). In a series of vertical hauls from the surface to 2,000 m depth in the North Atlantic, the species was most frequently found around 1,300 m depth (Coe 1926). In the Pacific Ocean, Roe & Norenburg (1999) compared vertical hauls in Hawaiian and Californian waters and found a higher species richness and abundance of pelagic nemerteans off California. The authors hypothesized that these differences could be partially due to the higher productivity of Californian waters. The record of the single specimen of *N. mirabilis* in this study corresponded with a typical value for zooplankton biomass (7.95 ml/1,000 m³) in the 800–1,000 m layer.

In conclusion, the current study represents the first record of a pelagic nemertean in the Gulf of Mexico. With this record, the number of registered nemertean species in the gulf ascends to 43: one pelagic, 42 benthic (Norenburg 2009, this study). This result highlights the need to explore the mesopelagic zone and extends the knowledge of the global distribution of this poorly known pelagic group.

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