A new species of *Maldivea* Gerlach, 1962 (Nematoda, Oxystominidae) from Felidhoo atoll (Maldives, Indian Ocean) and an emended diagnosis of the sub-family and genus

SEMPRUCCI FEDERICA* & BALSAMO MARIA

*Department of Biomolecular Sciences (DiSB), University of Urbino, loc. Crocicchia, 61029 Urbino, Italy*

*Corresponding author: e-mail: federica.semprucci@uniurb.it*

Received 2 January 2019 | Accepted by V. Pešić: 20 January 2019 | Published online 22 January 2019.

**Abstract**

*Maldivea* Gerlach, 1962 is a possible endemic genus of the Maldivian archipelago for which only *M. xarifae* Gerlach, 1962 has been described so far. A new species of this genus, *M. complexa* n.sp., was recently found in Felidhoo atoll. It reveals a more complex structure of gubernaculum than in type species which appears to be divided into two pieces: one is a sort of long wing in the ventral part of the spicule and the other one, more complex, is characterized by several curved stripes which envelop the dorsal side of the spicule distal part. According to the present considerations, diagnoses of Paroxystomininae and *Maldivea* are emended.

**Key words:** Paroxystomininae, *Maldivea*, shallow subtidal habitats, carbonate sediments, endemisms, Maldives.

**Introduction**

In Maldivian archipelago an extensive research project was carried out on the taxonomy and ecology of free-living nematodes (Sandulli *et al.* 2014; Semprucci 2015; Semprucci & Burattini 2015; Semprucci *et al.* 2010, 2011, 2013, 2014, 2016, 2017, 2018) which comprise the most abundant and diverse component of the benthic domain (Semprucci and Balsamo 2012).

A new species of *Maldivea* genus was collected during a scientific cruise carried out in 2005 in the Felidhoo Atoll, a location south to the type locality of *M. xarifae* (Semprucci & Balsamo 2014). It was found in coarse carbonate sediments of a shallow subtidal habitat same as for the type species.

*Maldivea* belongs to the family Oxystominidae Chitwood, 1935 and the sub-family Paroxystomininae De Coninck, 1965, in which only two genera have been described: *Paroxystomina* Micoletzky, 1924, the type genus, and *Maldivea* Gerlach, 1962. *Maldivea xarifae* Gerlach, 1962 was described from Fadiffolu atoll in the Maldivian archipelago after the “Xarifa-Expedition 1957/1958” in the Indian Ocean. Since then, this species was no longer found and no other species has been assigned to this genus. Furthermore, only two species are included in the genus *Paroxystomina* suggesting that the sub-family Paroxystomininae may be a very rare taxon in the phylum Nematoda.
Given the rarity of the representatives of this sub-family, even this one specimen was used to describe the new species in order to get new morphological details of the genus which will be useful to integrate the sub-family and genus diagnoses.

**Material and Methods**

Sampling was carried out at Felidhoo atoll in the Central part of the Maldivian Archipelago (Indian Ocean) (Fig. 1). Sediment was directly collected by a Scuba diver using a plexiglass corer (Ø: 2 cm). Samples were previously treated with 7% MgCl₂ aqueous solution and then fixed with a 4% formaldehyde solution (Semprucci et al. 2015). First, meiofaunal organisms were separated from sediments following decantation through a 42 µm mesh sieve (see Semprucci et al. 2010 for details). Retrieved organisms were then counted and sorted by taxon level using a stereo-microscope. Nematodes were isolated and studied with a Nikon Optiphot 2 interferential contrast (Nomarski) microscope under a 100x oil immersion objective. All measurements were obtained using the NIS Elements software on a Nikon Optiphot 2 microscope and reported in micrometers, while drawings were made using a camera lucida on a Zeiss Universal microscope.

The abbreviations used in the text are as follows: L = total body length; hd = head diameter; PL = pharynx length; cbd = corresponding body diameter; mbd = maximum body diameter; abd = anal body diameter; a = total body length divided by maximum body diameter; b = total body length divided by pharynx length; c = total body length divided by tail length; s’ = spicule length divided by anal body diameter.

**Figure 1.** Type localities of *Maldivea xarifae* and *M. complexa* n. sp.
Results

Systematics

Order Enoplida Filipjev, 1929

Superfamily Ironoidea de Man, 1876

Family Oxystominidae Chitwood, 1935

Diagnosis (after Smol & Coomans 2006). Body elongated and very thin at the anterior end. Anterior sensilla in three separate circles, the second and third circle clearly separated; the inner labial sensilla papilliform or setiform, outer labial and cephalic setae very slender. Buccal cavity narrow, tubular or funnel-shaped and without teeth. Among species, amphids are unusually polymorphic. Only orthometanemes with very short caudal filament present. Pharynx inserts into the body cuticle in the region of the buccal cavity; however, the cephalic capsule is not well developed. The posterior section of the pharynx has an undulating outline. Females didelphic-amphidelphic with antidromously reflexed ovaries or monodelphic-opisthodelphic. Males diorchic with opposed testes or only one anterior testis. Position of caudal glands variable.

Subfamily Paroxystomininae De Coninck, 1965

Diagnosis (after Smol & Coomans 2006). Buccal cavity small, conical. Males with winged precloacal supplements arranged in two subventral rows. Females with supplements anterior and posterior to the vulva. Two marine genera.

Type genus: Paroxystomina Micoletzky, 1924.

Genus Maldivea Gerlach, 1962

Diagnosis (after Smol et al. 2014). Similar to Paroxystomina, but supplements different: two subventral pair of short stout setae on a raised papilla. No wings/apophyses. Marine species.

Type species: Maldivea xarifae Gerlach, 1962.

Maldivea complexa n. sp.

Figs. 2-4; Table 1

Etymology: The species name refers to the complexity of the gubernaculum.

Material studied: one male collected by Giuseppe Baldelli on May 2005 and mounted on glycerin slide. The studied specimen is held in the author’s collection at the Department of Biomolecular Sciences (DiSB), University of Urbino, Italy.

Locality: Indian Sea, Maldivian Archipelago, Felidhoo atoll (3° 33.600’ N – 73° 29.859’ E). Samples were collected at a depth of 1.50 m in coarse sands (Fig. 1).

Description of the male: Body very long (L = 4654 µm, a = 78) and thin from the anterior end to the nerve ring region (Fig. 2). Cuticle smooth over the entire body. Six inner labial sensilla, six outer labial sensilla 3 µm long and four cephalic sensilla 6 µm long. Somatic setae about 5 µm long along the pharynx region, shorter in the remaining part of the body (~3 µm long). Anterior end truncate, buccal cavity cup-shaped and surrounded by the pharynx. Buccal wall characterized by 6 folds that are completely cuticularized (Fig. 3a, 4a,b). Distance from anterior edge to base of buccal cavity 7 µm. Amphidial aperture as a large transverse slit. Fovea large and pocket-shaped, located just after the cephalic sensilla at 15 µm from the anterior end (Fig. 3a, 4c). Diameter of the amphidial fovea 6 µm, i.e. ~36% of the cbd. Pharynx cylindro-conical very long (1166 µm long, b = 4) widening slightly as from the nerve ring region to the posterior end where the musculature appeared more developed than in the first region (Fig. 2). Nerve ring at ~ 23-43% of the PL. Cardia well-developed (~20 µm long) and embedded in the intestine. No metanemes observed.
Table 1. Measurements of the male of *Maldivea complexa* n. sp. (absolute numbers in µm).

| Character                                               | male   |
|---------------------------------------------------------|--------|
| total L                                                 | 4655   |
| hd                                                      | 11     |
| length of labial sensilla                               | 2      |
| length of anterior cephalic sensilla                    | 3      |
| length of posterior cephalic sensilla                   | 6      |
| cbd at level of posterior cephalic setae                | 15     |
| distance from anterior edge to cephalic setae           | 13     |
| distance from anterior edge to base of buccal cavity   | 7      |
| distance from anterior to anterior edge of amphid      | 15     |
| diameter of amphid                                      | 6      |
| cbd at widest part of amphid                            | 16     |
| distance from anterior edge to nerve ring               | 502    |
| cbd at nerve ring                                       | 40     |
| distance from anterior edge to base of oesophagus      | 1166   |
| cbd at base of oesophagus                              | 53     |
| length of cardia                                        | 20     |
| mbd                                                     | 60     |
| distance from anterior to anus                          | 4491   |
| abd                                                     | 54     |
| length of spicules measured along the arc               | 84     |
| length of gubernaculum                                  | 50     |
| length of tail                                          | 164    |
| a                                                       | 78     |
| b                                                       | 4      |
| c                                                       | 28     |
| c’                                                      | 3      |
| s’                                                      | 1.6    |

Only anterior male gonad observed, situated ventrally to the intestine (Fig. 2). Spicules equal, strongly cuticularized and arcuate (84 µm long, i.e. 1.6 abd) (Fig. 3c, 4d). Gubernaculum without apophysis. It consists of two pieces: a wing lateral to the distal part of the spicule and a dorsal part with a complex structure of stripes (Fig. 2b, 3d). Gubernaculum lateral wing envelops the spicule for about the 60% of its length. In the precloacal region, a longer pair of setae (~7 µm long) at about 11 µm from the cloacal opening and two sub-ventral pairs of short and stout setae (~4 and 5 µm long, respectively) at about 23 and 40 µm from cloaca (Fig. 3c, 4e,f). At about 123 µm from the cloacal opening towards the anterior end, a sub-ventral pair of very short and stout setae (~3 µm long) located in an elevation of the cuticle (Fig. 3c, 4f). Five setae arranged in two sub-ventral rows in the post-cloacal region at about 58 µm from the cloaca (Fig. 3c, 4g). The first three pairs of setae are 8 µm long and the last two are shorter and stouter (~4 µm long). Tail short, 164 µm long corresponding to 29 of the ratio c and 3 of c’. Caudal glands observed. Terminal pore and canal well developed (Fig. 3c). Subterminal seta observed.
Figure 2. Drawing of the total body of the male of *Maldivea complexa* n. sp. Scale bar: 100 µm.
A NEW SPECIES OF THE GENUS MALDIVEA

Figure 3. Drawings of the male of *Maldivea complexa* n. sp. A) Detail of the anterior end of the male. B) Detail of the amphideal fovea of the male. C) Detail of the copulatory apparatus and caudal region. Scale bar: A: 10 µm, B: 50 µm.

**Remarks:** *M. complexa* n.sp. is very similar to *M. xarifae* in the general morphology, but differs in a and c de Man ratios which are lower in the new specimens compared to those of *M. xarifae* (a = 78 vs. 90-106; c = 29 vs. 34-39). Also the spicule length appears greater in the new species than in the type species (84 µm long vs. 60 µm) along with the s’ ratio (1.6 vs. 1.2). However, the most evident difference between *M. complexa* n.sp. and *M. xarifae* is the more complex structure of the gubernaculum in *M. complexa* in which it consists of two pieces: one is a sort of long wing in the ventral part of the spicule and the other, more complex, is characterized by several curved stripes enveloping the dorsal side of the spicule distal part (Fig. 3b).

**Discussion**

The subfamily Paroxystomininae De Coninck, 1965 belongs to the family Oxystominidae Chitwood, 1935 and includes only two genera: *Paroxystomina* Micoletzky, 1924 and *Maldivea* Gerlach, 1962 which only differ in the type of precloacal supplements. The genus *Maldivea*, made up of only *M. xarifae* Gerlach, 1962 and *M. complexa* n.sp., was only recorded from Maldives suggesting its possible endemism for these islands. Among the two representatives of the genus *Paroxystomina*, *P. asymmetrica* Micoletzky, 1924 and *P. micoletskyi* Wieser, 1953, only *P. asymmetrica* Micoletzky, 1924 shows a relatively wider distribution: Red Sea (Strait of Suez, type locality), Adriatic Sea (Rovigno, Bocche di Cattaro, Meleda) (Travisi and Vidakovic, 1997), North Sea (Moore, 1971) and North Atlantic Ocean (Platt and Warwick, 1983; De Smet et al., 2001), while *P. micoletskyi* Wieser, 1953 was found only in Chile (San Antonio area) (Fig. 5).
To our knowledge, all these species were collected in sheltered and shallow subtidal habitats; however, *P. asymmetrica* Micoletzky, 1924 was found in a rocky pool, *P. micoletzkyi* Wieser, 1953 was associated to algae, while *M. xarifae* Gerlach, 1962 and *M. complexa* n. sp. (present study) were found in carbonate sediments.

It is problematic to define a meiofaunal species as endemic, because the punctual distribution of a species could be related to its small body size, to the low number of specialists and to the scarce availability of the literature especially on the species described in the first 19th century (see Semprucci 2013 for review). However, the few world records of the sub-family Paroxystomininae and the remote areas in which *P. micoletzkyi* Wieser, 1953 and *M. xarifae* Gerlach, 1962 were found could support that hypothesis.

The new finding in the Felidhoo atoll is fundamental since it gives additional data on the *Maldivea* genus. One of the differences detected between the new species and *M. xarifae* Gerlach, 1962 is the gubernaculum structure that appears more complex in *M. complexa* n.sp.. Note of worthy is that the gubernaculum of the new species seems rather similar to that documented in *P. asymmetrica* Micoletzky, 1924 and *P. micoletzkyi* Wieser, 1953 in showing lateral wings even if they appear much more developed then in the new species.

As Gerlach (1962) underlined, *Paroxystomina* and *Maldivea* show completely different pre-cloacal supplements, which appear as winged precloacal supplements in *Paroxystomina* and short and stout setae in *Maldivea*. However, a common feature of both genera is the arrangement of the supplements in two sub-
ventral rows. According to the present considerations, the sub-family and genus diagnoses are emended as follows.

**Subfamily Paroxystomininae De Coninck, 1965**

*Emended diagnosis.* Buccal cavity small, conical. Males with winged or short stout setae; precloacal supplements arranged in two sub-ventral rows. Females with supplements anterior and posterior to the vulva. Two marine genera.

**Genus Maldivea Gerlach, 1962**

*Emended diagnosis.* Similar to Paroxystoma (after Smol et al. 2014), but winged precloacal supplements absent and replaced by sub-ventral pairs of short stout setae located on a raised papilla.

![Figure 5](image.png)

**Figure 5.** World distribution of the species belonging to the subfamily Paroxystomininae De Coninck, 1965.

**Acknowledgements**

We would like to thank Dr. Giuseppe Baldelli (University of Urbino) for his valuable help during the sample collection.

**References**

De Smet, G., Vincx, M., Vanreusel, A., Vanhove, S., Vanaverbeke, J. & Steyaert, M. (2001) Nematoda - free living. In: Costello, M.J. et al. (Eds.) (2001). European register of marine species: a check-list of the marine species in Europe and a bibliography of guides to their identification. *Collection Patrimoines Naturels*, 50, Pp 161-174.

Gerlach, S. A. (1962) Freilebende Meeresnematoden von den Malediven. *Kieler Meeresforschung*, 18, 81-108.

Micoletzky, H. (1924) Weitere Beiträge zur Kenntnis freilebender Nematoden aus Suez. *Sitzungsberichte der Akademie der Wissenschaften in Wien Mathematische-naturwissenschaftlichen Klasse*, 132, 225-262.

Moore, P. G. (1971) The nematode fauna associated with holdfasts of kelp (*Laminaria hyperborea*) in North-East Britain. *Journal of Marine Biological Association U.K.*, 51, 589-604.

Platt, H. M. & Warwick, R. M. (1983) Free-living marine nematodes part I, British enoplids: pictorial key to world genera and notes for the identification of British species. Synopises of the British fauna (New Series), 28. Cambridge University Press: Cambridge. ISBN 0-521-25422-1. VII, 307 pp.
Sandulli, R., Semprucci, F. & Balsamo, M. (2014) Taxonomic and functional biodiversity variations of meiobenthic and nematode assemblages across an extreme environment: a study case in a Blue Hole cave. *Italian Journal of Zoology*, 81, 508-516.

Smol, N. & Coomans, A. (2006) Order Enoplida. In: Eyualemen-Abebe, A. & Traunspurger, W. (Eds.) *Freshwater Nematodes: Ecology and Taxonomy*. CABI Publishing, Wallingford. Pp. 225 – 292.

Smol, N., Muthumbi, A. & Sharma, J. (2014) Order Enoplida In: Schmidt-Rhaesa A. (Ed). *Handbook of Zoology, Gastrotrichia, Cycloneuralia and Gnathifera, Nematoda*. De Gruyter, Berlin. Pp. 193-249.

Semprucci, F. (2013) Marine nematodes from the shallow subtidal coast of the Adriatic Sea: species list and distribution. *International Journal of Biodiversity*, 1, 1-9.

Semprucci, F. (2015) A new species of *Paracomesoma* (Comesomatidae) from Maldives (Indian Ocean) with an emended diagnosis and an updated key of the genus. *Journal of Marine Biological Association of the United Kingdom*, 95, 339-347.

Semprucci, F. & Balsamo, M. (2012). Key role of free-living nematodes in the marine ecosystem. In: Boeri F. & Jordan A. C. (Eds.) *Nematodes: Morphology, Functions and Management Strategies*. NOVA Science Publishers, Inc. Hauppauge, NY, pp. 109-134.

Semprucci, F. & Balsamo, M. (2014) New records and distribution of marine free-living nematodes in the Maldivian Archipelago. *Proceedings of Biological Society of Washington*, 127, 35-46.

Semprucci, F. & Burattini, S. (2015) Re-description of *Craspodema reflectans* (Nematoda, Cyatholaimidae) using confocal laser scanning microscopy. *Zootaxa*, 3972, 407-418.

Semprucci, F., Colantoni, P., Baldelli, G., Rocchi, M. & Balsamo, M. (2010) The distribution of meiofauna on back-reef sandy platforms in the Maldives (Indian Ocean). *Marine Ecology: An evolutionary perspective*, 31, 592-607.

Semprucci, F., Colantoni, P., Sbrocca, C., Baldelli, G., Rocchi, M. & Balsamo, M. (2011) Meiofauna in sandy back-reef platforms differently exposed to the monsoons in the Maldives (Indian Ocean). *Journal of Marine Systems*, 87, 208-215.

Semprucci, F., Colantoni, P., Baldelli, G., Sbrocca C., Rocchi, M. & Balsamo, M. (2013) Meiofauna associated with coral sediments in the Maldivian subtidal habitats (Indian Ocean). *Marine Biodiversity*, 43, 189–198.

Semprucci, F., Colantoni, P., Sbrocca, C., Baldelli, G. & Balsamo, M. (2014) Spatial patterns of distribution of meiofaunal and nematode assemblages in the Huvadhoo lagoon (Maldives, Indian Ocean). *Journal of Marine Biological Association of the United Kingdom*, 94, 1377-1385.

Semprucci F., Sbrocca C., Rocchi M. & Balsamo, M. (2015) Temporal changes of the meiofaunal assemblage as a tool for the assessment of the ecological quality status. *Journal of Marine Biological Association of the United Kingdom*, 95, 247-254.

Semprucci, F., Colantoni, P. & Balsamo, M. (2016) Is maturity index an efficient tool to assess the effects of the physical disturbance on the marine nematode assemblages? A critical interpretation of disturbance-induced maturity successions in some study cases in Maldives. *Acta Oceanologica Sinica*, 35, 4, 89-98.

Semprucci, F., Burattini, S., Falcieri, E. & Balsamo, M. (2017) A re-description of *Longicyatholaimus maldivarum* Gerlach, 1964 (Nematoda, Cyatholaimidae) with an emended identification key of the genus. *Zootaxa*, 4323, 096–108.

Semprucci, F., Frontalini, F., Losi, V., Armanyot du Châtelet, E., Cesaroni, L., Sandulli, R., Coccioni, R. & Balsamo, M. (2018) Biodiversity and distribution of the meiofaunal community in the reef slopes of the Maldivian archipelago (Indian Ocean). *Marine Environmental Research*, 139, 19-26.

Travisi, A. & Vidakovic, J. (1997) Nematofauna in the Adriatic Sea: review and check-list of free-living nematode species. *Helgolânder Meeresunters*, 51, 503-519.

Wieser, W. (1953) Free-living marine nematodes I. Enoploidea. *Lunds Universitets Arsskrift. N. F. Avd.* 2, Bd 49. Nr 6.