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Designation of a neotype for the dendrochirotid holothuroid, *Thyone fusus* (Müller) (Echinodermata: Holothuroidea: Dendrochirotida: Thyonidae)

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Abstract

The genus *Thyone* Oken, 1815 is complex, and has even been called a 'supergenus', which currently contains 67 nominal species (WoRMS, 2023) and is urgently in need of revision. This contribution provides an accurate description of the here designated neotype and as such, it brings clarity to the taxonomic definition of the type species of the genus: the previously poorly understood *Thyone fusus.*

Key words: Dendrochirotida, Thyonidae, sea cucumber, taxonomy, nomenclature

Abbreviation: NHMUK—Natural History Museum, United Kingdom.

Introduction

Arumugam (2011), after reviewing the 66 putative species within *Thyone* Oken, 1815 based on examinations of available specimens and literature accounts and the current co-author's visits to several foreign institutions, reduced the number of species to 46.

Some of these re-assignments have already been published [(see Thandar (2021) & Thandar & Arumugam (2022)]. The main taxonomic character to justify these decisions was the structure of the calcareous ring with the ossicle assemblage of the introvert. The latter observation was based on the elaborate revision of the Cucumariidae by Panning (1949), a revision which was subsequently used by many other workers since then, such as Pawson & Miller (1981), in their study of some West Atlantic *Thyone*, by Thandar (1990) in his revision of the southern African Phyllophoridae, and Thandar (1989, 2022), the latter in his comprehensive monograph of the southern African sea cucumbers. A potential neotype was designated in Arumugam's dissertation (2011) based on material from the type locality. This specimen was compared with descriptions provided by other workers, including Madsen (1941), Madsen & Hansen (1994) and McKenzie (1991). This current contribution formally describes and establishes this specimen as neotype for the type species, *Thyone fusus*.

Material and methods

Material for this study was obtained on loan from the Natural History Museum, Oslo and studied through conventional methods by macro- and microscopy. Ossicles and the calcareous ring were removed from tissue after having been treated with household bleach. Ossicles were washed with 3 changes of distilled water and passed through several changes of 70% ethanol. Illustrations were made using a *camera lucida*.

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Results

Taxonomy

Order Dendrochirotida Grube, 1840

Family Thyonidae Panning, 1949 (*sensu* Smirnov 2012)

Genus *Thyone* Oken, 1815

Thyone Oken, 1815: 351; Jaeger, 1833: 8; Panning 1949: 467; Pawson & Miller, 1981: 394; Thandar, 1990: 211; Paulay & O'loughlin, 2012.
Anaperus Troschel, 1846: 60 (partim).

Diagnosis (after Panning 1949, Thandar 1990, McKenzie 1991, amended herein)

Small to medium-sized dendrochirotid holothuroids, reaching a length of ?200 mm, according to Mortensen (1927) but usually much shorter. Tube feet numerous, distributed throughout the body, more numerous in ambulacra, scattered in interambulacra, often more crowded ventrally; in young individuals restricted to ambulacra. Tentacles 10, ventral pair reduced. Calcareous ring tubular, radial and interradial plates sub-divided; radials with long, paired subdivided posterior processes. Body wall ossicles comprise only two-pillared tables or the like, often reduced with age or absent. Introvert variously supported: tables only, rosettes only, tables and rosettes, tables and plates (?reduced tables), plates only, or introvert deposits absent or unknown.

Remarks

Pawson & Miller (1981) commented that Oken's work (1815–1816) was listed under the Official Index of Rejected Works by the International Commission on Zoological Nomenclature (opinion 417, 1956). They then suggested that the genus *Thyone* must therefore be attributed to Jaeger (1833) who was the first to validate the genus in accordance with the requirements of the International Code of Zoological Nomenclature (ICZN). This step was followed by a.o Thandar (1990) but the genus name continued to be attributed to Oken (1815). In order to resolve this nomenclatural issue, Paulay & O'Loughlin (2012), submitted an appeal to the ICZN, resulting in the validation of Oken's (1815) publication under opinion 3598. Therefore, the genus must again be attributed to Oken.

Type species: *Holothuria fusus* Müller, 1776, by subsequent designation Jaeger (1833).

Remarks

After transferring some species to other genera, Arumugam (2011) attempted to separate the remaining species on the bases of introvert ossicles, where known,-a character introduced by Panning (1949). According to WoRMS (2023) *Thyone* now contains some 67 nominal species. Hence, the genus still remains a "supergenus". Thandar & Rajpal (1999), at the 5th European Echinoderm Conference in Milan, and Thandar (2001), at the 10th International Echinoderm Conference in Dunedin reported on some differences in the gross structure of the calcareous ring. Thandar (2001), reported some evidence of geographic variations in the gross structure of the calcareous ring, based on the following three characters: a) dorsal radial plates posteriorly prolonged before bifurcating into paired processes, b) dorsal radial plates bifurcate at the posterior border of the interradial plates and c) dorsal radial plates bifurcate well before the posterior border on the interradial plates (producing posteriorly cleft or deeply incised radial plates. He reported certain geographic variations in the structure of the ring: e.g. in the Indo-West Pacific region, including southern Africa, all three types of ring exist, whereas in Madagascar, including the Mascarene Islands, and the North East Atlantic waters, including the Mediterranean and North Seas, only the former two types are prevalent, with some exceptions, while in the West Atlantic and East Pacific waters, with a couple of exceptions from the West Atlantic, only the third type predominates. However, relating these differences in the calcareous ring to the ossicles of the general body wall, introvert and tentacles proved unsuccessful.

The diagnosis of the genus is here amended, now based upon our better knowledge of the species it contains and the varied forms of its introvert ossicles. The taxonomic classification follows that of Smirnov (2012), who elevated the subfamily Thyoninae Panning, 1949 to full family status. Although this system has not yet been adopted by WoRMS[2] (accessed 21/09/2023), it proposes it as an alternative classification. Smirnov's (2012) system was used by Thandar (2018) for his paper on some miscellaneous holothuroids in the South African Museum and also

in his subsequent papers (Thandar 2021; Thandar & Arumugam 2022), and more recently, in his comprehensive monograph of the southern African sea cucumbers (Thandar 2022).

When reporting on the holothuroids of the Norwegian Sea and adjacent waters, Madsen & Hansen (1994) erroneously attributed *T. fusus* and *T. gadeana* to the family Cucumariidae. Although they stated that the type material of *T. fusus*, is in all probability lost, they made no attempt to designate a neotype with ample material at hand. McKenzie (1991) also shied away from this prerogative in his revision of north Atlantic dendrochirotid fauna. Our attempt to trace the holotype from German museums proved unsuccessful. Thus, the establishment of the neotype is imperative since this species is the type species of *Thyone* and has been confused several times with many of its congeners, especially those coming from the North Atlantic, Adriatic and Mediterranean waters. This omission is here rectified from material obtained from the type locality.

Thyone fusus (Müller, 1776)

(Figure 1A–F)

Holothuria fusus O.F. Müller, 1776: 232, pl. 10, figs. 5–6.
Thyone fusus Madsen, 1941: 17, text-figs. 12–16; Madsen & Hansen, 1994: 40, fig. 5, 23–24, map 10; McKenzie, 1991: 136 (synonymy).
Thyone flexus Hodge, 1867: 44, pl. 10, fig. 2–11.

Diagnosis (from Madsen & Hansen 1994, McKenzie 1991, amended herein)

Medium-sized species, reaching about 70 mm in length (an exceptional figure of 200 mm was reported by Mortensen (1927) but this needs verification). Body fusiform to spindle-shaped, tapering posteriorly. Colour in life greyish-white to light brown to fawn, brown in alcohol. Tube feet well developed, distributed over entire body, numerous ventrally, scattered dorsally, often with adhering sand grains or other debris. Anal teeth present. Calcareous ring long, tubular, both ring and processes sub-divided; radial plates deeply notched anteriorly, dorsal radial plates extended posteriorly before bifurcating beyond posterior border of interradial plates, posterior processes of radial plates long; interradials prolonged, two ventral ones slightly longer. Deposits of body wall 2-pillared tables, disc with four primary holes and often a few additional, smaller, peripheral holes around the primary ones; spire of moderate height, ending in inconspicuous teeth. Supporting tables of tube feet with curved disc and endplate, the latter delicate in smaller individuals. Tentacle deposits perforated rods and plates. Introvert supported by rosettes and tables with multilocular disc and a spire with or without a cross-bar..

Material examined: Four specimens, identified as *T. fusus,* originating from the type locality, were received on loan from the Natural History Museum, Oslo, Norway. The largest specimen was selected for dissection and ossicle study and is here designated as the neotype, while the other three were only studied for their body wall ossicles. The current material corresponds well with the descriptions of the species presented by especially Madsen (1941), Mckenzie (1991) and Madsen & Hansen (1994).

***Neotype* E1279, N.V. for Stormeberget, Drøbak, Oslo Fjord, 25.x.1952, M.E. Hammerstad, det. B. Christiansen (designated herein)**.

Description of neotype

Specimen young spindle-shaped male, tapering posteriorly. Length 34 mm, breadth in mid-body 9 mm. Colour in alcohol greyish-white, true colour masked by debris on tube feet. Tube feet non-retractile, distributed over entire body but never long and slender, more numerous ventrally, in two rows per ambulacrum, continuing posteriorly; interambulacra at posterior end naked. Mouth and anus terminal; anus surrounded by five calcareous teeth. Tentacles 10, retracted, dendritic, ventral pair reduced.

Calcareous ring tubular (Figure 1A), sub-divided, but mosaic pattern not readily visible without some clearing by dissection and bleach, length almost two-third that of body. Radial plates anteriorly notched for attachment of retractor muscles; prolonged posteriorly before bifurcation into two fragmented processes. Interradial plates differing slightly in length, ventral ones longer and posteriorly lobed, slightly pointed and notched anteriorly. Both ring and processes fragmented (Fig. 1A). Polian vesicle single, large, stone canal also single, madreporite rounded,

almost kidney-shaped. Gonad on its way to maturation, as unbranched tubules, situated on the left side of mid-body. Retractor muscles thick, branched at point of origin, arising from thick, unpaired longitudinal muscles, the two dorsal ones originating more anteriorly. Respiratory trees well-branched, left one much longer, reaching anterior tip of body, right one reaching only half body-length.

Ossicles of body wall tables with regular 4–8-holed disc, peripheral holes vary in number from 1–5 (disc 59–83 µm, mean 68.4 µm, ± 7.1, n = 20); spire two-pillared, unfused, meeting distally, terminating in a few inconspicuous teeth (Figure 1B). Transverse bar usually absent. Tube feet tables with curved, supporting disc with four large central holes and 1–3 holes at each extremity (disc length 88–113 µm, mean 97.3 µm, ± 11.1, n = 20), spire 2-pillared (Figure 1D), with or without a transverse bar; endplate present, delicate, often broken. Tentacles with slender rods (81–104 µm, mean 91.7 µm, ± 9.5, n = 20), sometimes expanded and perforated at ends, plus perforated plate-like rods, some elongated (51–117 µm, mean 73.1 µm, ± 23.9, n = 20) (Fig. 1E). Introvert supported by rosettes and multilocular tables with disc slightly larger than that of body wall tables (99.5–119 µm, mean 107.8 µm, ± 8.2, n = 20); spire two-pillared with cross-bar, ending in two diverging teeth (Figure 1F); rosettes closed, mulberry-like, either elongated or oval to circular (Fig. 1C).

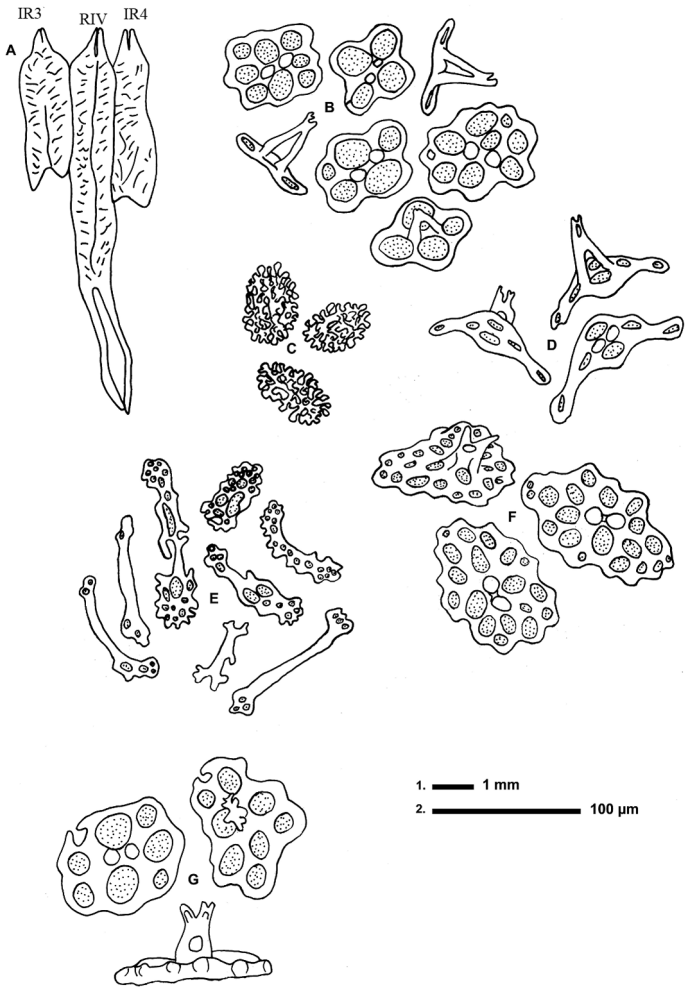

FIGURE 1. *Thyone fusus* (Müller). Neotype (designated herein). A. calcareous ring (ir = interradial plate; r = radial plate, labelled according to Ludwig's system); B. tables of body wall; C. rosettes of introvert; D. supporting tables of tube feet; E. rods and plates of tentacles; F. tables of introvert, G. tables of body wall of *T. flexus* (reproduced from holotype slides examined at NHMUK)) (A = Scale 1; B–G = Scale 2).

Name-bearing type

Neotype E1279, here designated; in Natural History Museum, Oslo, Norway.

Type locality

Drøbak, Oslo Fjord, Norway.

Habitat

Mud and shell debris.

Distribution

Western Norway from Trondheim Fjord and southwards to coast of Skagerrak and northern Kattegat, North Sea, Faroes, 10–200 (400) m (Madsen & Hansen 1994) and the British Isles (McKenzie 1991) and perhaps the Mediterranean region (Koehler 1921, McKenzie 1991).

Remarks

The calcareous ring is of a spongy nature and very fragile and, as is typical of all *Thyone,* clearly fragmented, but much clearing is required to observe it.

Thyone fusus and its congeners were assessed by McKenzie (1991). He differentiated and elaborated on morphology and the habitat of all congenerics in the region studied, providing a key to separate them. According to him *T. fusus* has a thin, soft, usually opaque, fawn body and is rotund and barrel-shaped, with scattered tube feet, making the ambulacra indistinct, with debris often attached to the suckers. The tube feet are often red in living specimens due to the presence of haemocytes within the water-vascular canals. The tentacles are brownish, often with lighter tips, and the introvert is streaked with dark brown. The body wall ossicles are usually 4-holed with sometimes a few accessory holes. According to Madsen (1941) the Mediterranean records of *T. fusus* must be treated with caution as the Mediterranean form has rosettes in the tentacles which are absent in the real *T. fusus* from the north-east Atlantic waters. Further, we state that several congenerics from the Meditrranean have previously been confused with *T fusus* but later clarified by Reys (1959).

The adult is most likely to be confused with *Thyone wahrbergi* Madsen, 1941, however, in *T. fusus* the tentacle rods reach a maximum length of 250 µm while they are usually around 500 µm in *T. wahrbergi*. Deichmann (1947) argued that *T. wahrbergi* is a juvenile form of *T. fusus*, but Brun (1967) considered it a valid species. Reys (1959) on the other hand thought that *T. wahrbergi* is a junior synonym of the Mediterranean *T. gadeana* Perrier, 1898.

According to McKenzie, *Thyone flexus* Hodge, 1865 may represent the missing link in distribution between *T. wahrbergi* and *T. gadeana* but the description of *T. flexus* given by Hodge (1867) is insufficiently detailed to judge whether or not it is senior synonym of either *T. wahrbergi* or *T. gadeana*. Until these problems are resolved, he states that it is prudent to retain *T. wahrbergi*. Madsen (1941) presented a good argument on the validity of *T. flexus* Hodge, citing its affinities to *T. wahrbergi*, *T. gadeana* and *T. fusus* but kept all four species separate. Madsen & Hansen (1994) mention that the former species has tables and endplates similar to those of *T. gadeana* but the tentacle deposits of *T. gadeana* were not described. Thus McKenzie (1991) dubiously added *T. flexus* to the synonymy of *T. fusus* but suspected that it may represent a clinal link in distribution between *T. gadeana* and *T. wahrbergi*.

Thyone flexus is known only from the holotype which may be lost according to McKenzie (1991) and Madsen & Hansen (1994). A search for the holotype at the NHMUK proved unsuccessful but the co-author did find two permanent slides of the body wall ossicles of the holotype, labelled as *T. flexus* at the NHMUK, collected in 1864, from Holy Island, Northumberland. These ossicles are illustrated in Figure 1G. It is unknown whether McKenzie studied these slides or not. They are slightly larger but do somewhat correspond well with those of the neotype of *T. fusus* here described. Thus, *T. flexus* is here designated as a synonym of *T. fusus* as is done in WoRMS[1], and also in view of McKenzie's suspicions and Madsen's (1941) comment that it perhaps represents an abnormal form of *T. fusus*.

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