



New species of *Heteropathes* (Anthozoa: Antipatharia) expands genus distribution to the NE Atlantic

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Abstract

Heteropathes opreski, a new antipatharian species from the northern border of the Oceanographer Fracture Zone is here described and illustrated. An emended diagnosis of the genus and a dichotomous key containing the four *Heteropathes* species are presented. This species is unique in that it forms smaller colonies compared to the other species in the genus, with some of the lateral pinnules presenting a small ramified subpinnule. Additionally, the polypar spines found on the lateral pinnules are the highest so far recorded in the genus. This record greatly expands the known distribution of this genus, as it was not previously reported to occur in the Northeastern Atlantic.

Key words: Black corals, Cladopathidae, *Heteropathes opreski* **spec. nov.**, distribution, taxonomy, dichotomous species key

Introduction

The Northeast Atlantic has a long history of biogeographic research that can be traced back to Otto F. Müller (1730–84) using a modified oyster dredge in the deep waters of the southern Norway fiords (Spärck 1932) and the HMS Lightning (1868) and HMS Porcupine (1869) cruises around Scotland and Ireland. These early efforts grew into greater endeavors such as the global HMS Challenger expedition (1872–76), the Prince Albert I of Monaco Oceanographic Campaigns (1886–1915) and the Percy Sladen Trust Expedition to the Indian Ocean (1905) that enabled the first records, descriptions and taxonomies of many of the currently known deep-water taxa (Brook 1889; Roule 1905, Cooper 1909) to be established.

Since the second half of the 20th century, a greater number of research cruises to the Northeast Atlantic and the use of modern technology have contributed to the accumulation of a wealth of data on deep-water corals, including antipatharians (e.g. Molodtsova, 2006; Molodtsova *et al.*, 2008; Morris *et al.*, 2012; de Matos *et al.*, 2013). Most Northeast Atlantic deep-sea coral records come from steeply sloping seamounts, oceanic islands and along the continental slope, with antipatharians being the third most commonly recorded group, after alcyonaceans and scleractinians (Braga-Henriques *et al.* 2013; Hall-Spencer *et al.* 2007).

Antipatharians are colonial hexacorals reported to present longevities ranging from decades to millennia (Carreiro-Silva *et al.* 2013; Love *et al.* 2007; Roark *et al.* 2009), and occurring between 20 and 5440 m (Gravier 1921; Braga-Henriques *et al.* 2013) in the Northeast Atlantic Ocean. This taxon was generally assumed to be azooxanthellate, due to a preference for low-light environments that do not allow photosynthesis, but recently, several species occurring at up to 396 m of depth were shown to associate with *Symbiodinium* (Bo *et al.* 2011; Wagner *et al.* 2011).

In a revision of Northeast Atlantic antipatharian fauna, Molodtsova (2006) reported 33 species for this region. However, this did not include *Trissopathes tetracrada* Opresko, 2003 (Opresko 2003a) and *Allopathes denhartogi* Opresko, 2003 (Opresko 2003b) from Cape Verde. Further on, *Schizopathes affinis* Brook, 1889 from the Mid-Atlantic ridge (Molodtsova, 2008), *Leiopathes montana* Molodtsova, 2011 from the Great Meteor (Molodtsova,

2011), as well as *Leiopathes* sp. A and *Distichopathes* sp. from the Azores EEZ (Braga-Henriques *et al.*, 2013) have since been recorded, elevating this number to a total of 39 species.

None of these belong to the genus *Heliopathes* which was established by Opresko (2003b) for *H. americana* Opresko, 2003, collected in the western Atlantic. This genus also contained *Heliopathes heterorhodzos* (Cooper, 1909) (Opresko 2003b) and *Heliopathes pacifica* Opresko, 2005 collected in the Indian Ocean and north Pacific oceans, respectively. Recently, the genus name was changed to *Heteropathes* Opresko, 2011 as the original name was shown to be preoccupied by the darkling beetle genus *Heliopathes* (Coleoptera: Tenebrionidae).

An undescribed species of *Heteropathes*, recently collected at the Oceanographer Fracture Zone, is described here, establishing the first record of this genus for the Northeast Atlantic Ocean.

Material and methods

The antipatharian colony here described was collected during leg 2 of the multidisciplinary campaign EMEPC/AÇORES/G3/2007 on board SV Kommandor Jack, a geo/biological cruise to the seamounts south of the Azores. The specimen was retrieved from the D09 dredge sample collected on the north border of the Oceanographer Fracture Zone. It was preserved in 70% ethanol, deposited at the EMEPC collection, and subsequently examined following the terminology and general format of description by Opresko (2003b; 2005).

Measurements of the structures discernible by the naked eye were taken using a Vernier caliper, while the microscopic structures were measured from images obtained with a digital camera attached to a vertical light microscope (Leica DM6000) and a scanning electron microscope (JEOL JSM-5410), using the software ImageJ (NIH). The diameter of the pinnules was defined as the diameter of the axis (disregarding the additional height of the axial spines). The height of spines was defined as the distance between the center of the spine's base and its apex. The spine spacing was defined as the distance between the center of the base of two adjacent spines in a given longitudinal row.

Abbreviations

EMEPC Estrutura de Missão para a Extensão da Plataforma Continental (Portuguese Task Force for the Extension of the Continental Shelf)

Heteropathes Opresko, 2011 emended

Diagnosis. Corallum monopodial and pinnulate. Pinnules in two lateral rows and in one or more anterior rows. Lateral pinnules simple or with a small ramified subpinnule; anterior pinnules short, generally not longer than 1 cm, and subpinnulate. Polyps 5 to 6 mm in transverse diameter.

Remarks. The new species, described below, followed the original description by Opresko (2005) with the exception of some of the lateral pinnules presenting a ramified subpinnule similar to the anterior pinnules in all but its smaller size.

Species assigned to *Heteropathes*. Included in the genus are *H. americana* Opresko (2003b), *H. heterorhodzos* Cooper (1909), and *H. pacifica* Opresko (2005).

Distribution. *Heteropathes americana* is known to occur in the western Atlantic Ocean at 3563 and 4511 m depths, *H. heterorhodzos* (Cooper, 1909) (Opresko 2003b) in the Indian Ocean at 1079 m depths and *H. pacifica* Opresko, 2005 in the north Pacific Ocean at 2200 m depths.

Heteropathes opreski, spec. nov.

Fig. 1(a–e), Fig. 2(a–h)

Material. Holotype (EMEPC D09–Ma007), NE Atlantic, Oceanographer Fracture Zone, EMEPC/AÇORES/G3/2007 sta. 514, (34° 46.722'–34° 47.142' N, 32° 32.94'–32° 32.868' W), 2602–2270 m, rocky bottom, dredge, coll. V. de Matos, 23 May 2007.

Diagnosis. Corallum monopodial and pinnulate; pinnules arranged in two lateral rows and one irregular anterior row. Lateral pinnules simple or with a small and extensively ramified subpinnule. Primary lateral pinnules, elongated, arranged alternately, inclined and curved distally and up to 7 mm in length. Secondary lateral pinnules, short, inclined distally, up to 2.5 mm in length and ramified up to the 3rd order. Anterior pinnules short, up to 6 mm in height, subpinnulate. Primary anterior pinnules inserted nearly perpendicularly to the plane containing the stem and lateral pinnules, presenting more than 10 secondary pinnules and forming an arborescent structure with up to 4 orders of ramification. Higher order pinnules slightly shorter than primary, inserted in an acute angle and presenting several pinnules on the upper and lower sides.

Spines on primary lateral pinnules simple, up to 0.12 mm in height, triangular and often compressed and distally inclined. Spines on secondary and tertiary lateral pinnules are bigger than those on primary (up to 0.18 mm in height), simple, conical, acute and distally inclined. Spines on anterior pinnules simple, conical, acute, often distally inclined and bigger than those on lateral pinnules (up to 0.19 mm in height) becoming higher, more spaced and less regularly inserted towards the terminal pinnules that often present a distinctive, blunt and crowned by spines, apex.

Description of the holotype. The holotype (Fig. 1a) is approximately 5 cm high (including pinnules) and about 1 cm wide (some of the lateral pinnules seem to be broken). The stem presents a diameter of about 0.3 mm near the base thickening up to 0.6 mm in diameter in the pinnulated portion. The unpinnulated portion of the stem is approximately 3 cm and the pinnulated portion 2 cm long (Fig. 1a, b, c).

There are two types of pinnules: 1) simple or presenting a small ramified subpinnule, elongate and slightly bent inward lateral pinnules and 2) short, straight, subpinnulated anterior pinnules. The 22 lateral pinnules are arranged alternately in such a way that adjacent pinnules on the same side of the stem are less than 2 mm apart and ca. 1 mm apart from those on the opposite side, which results in about 5 pinnules per cm on a given row and about 9 pinnules per cm of stem. The lowermost lateral pinnule is on the left side of the stem, subopposite from the next more distal pinnule on the right side, distanced about 0.7 mm, while the next pinnule on the left side is distanced about 1.4 mm. The lateral pinnules do not seem to be broken off at their tip, presenting very small spines on a blunt apex, measuring up to 7 mm in length and 0.2 to 0.5 (most 0.3) mm in diameter near their base. The lower lateral pinnules point toward the base and form an angle of approximately 70° with the stem. Higher up they extend out at nearly right angles, becoming more inclined towards the apex of the colony, with the last lateral pinnule forming a 35° angle to the stem. The interior angle formed by the two planes containing the lateral pinnules is close to 150° for the lowermost pairs and 110° for the higher ones (Fig. 1d).

A few lateral pinnules have a small and extensively ramified subpinnule similar to the anterior pinnules in all but size that is only visible when the colony is cut transversally as it tends to blend into the intertwined structure formed by the anterior pinnules. The secondary lateral pinnules are inserted in an acute angle on the anterior side of the lateral pinnules, arising about 1 mm after its base and measuring up to 2.5 mm in length and 0.25 mm in diameter near their base. They are heavily subpinnulated up to the 3rd order (Fig. 1e).

The anterior primary pinnules are up to 6 mm in length, up to 0.4 mm in diameter near their base, and they are inserted 0.4–0.6 mm apart in a single irregular row, with 11 to 13 occurring along 1 cm of stem, from which they extend at almost right angles. The lowermost anterior pinnule is located between the second and third lowermost lateral pinnules. The anterior pinnules are heavily subpinnulated. The number and arrangement of the subpinnules is not strictly regular from pinnule to pinnule, but the primary pinnules seem to always present over 10, slightly shorter, secondary pinnules. They are inserted in an acute angle and curved distally, with the lowermost bilateral pair arising 0.5–0.8 mm above the base of the primary pinnule and parallel to the lateral pinnules. The subsequent pair presents a 90° rotation and is inserted slightly above the first. The subsequent pinnules tend to follow this pattern forming a thick arborescent structure with up to 4 orders of pinnulation (Fig. 1d, e).

Simple and unornamented spines are present from the youngest parts of the corallum (Fig. 2a) to the oldest, with the colony's base and first 1.75 cm of stem presenting small conical spines measuring 0.005–0.04 mm in height and irregularly spaced in longitudinal rows (Fig. 2b). Higher up the spines are replaced by 4 longitudinal ridges (from lateral view), reappearing on the pinnulated portion of the stem where they measure 0.04–0.09 mm in height and are inserted ca. 0.1–0.2 mm apart (Fig. 2c, d).

The spines on the primary lateral pinnules are triangular and often compressed and distally inclined. They measure 0.03–0.12 mm (most 0.05–0.09 mm) in height and are spaced 0.08–0.37 mm, with mostly 4–9 spines per mm within each of the longitudinal rows (Fig. 2e).

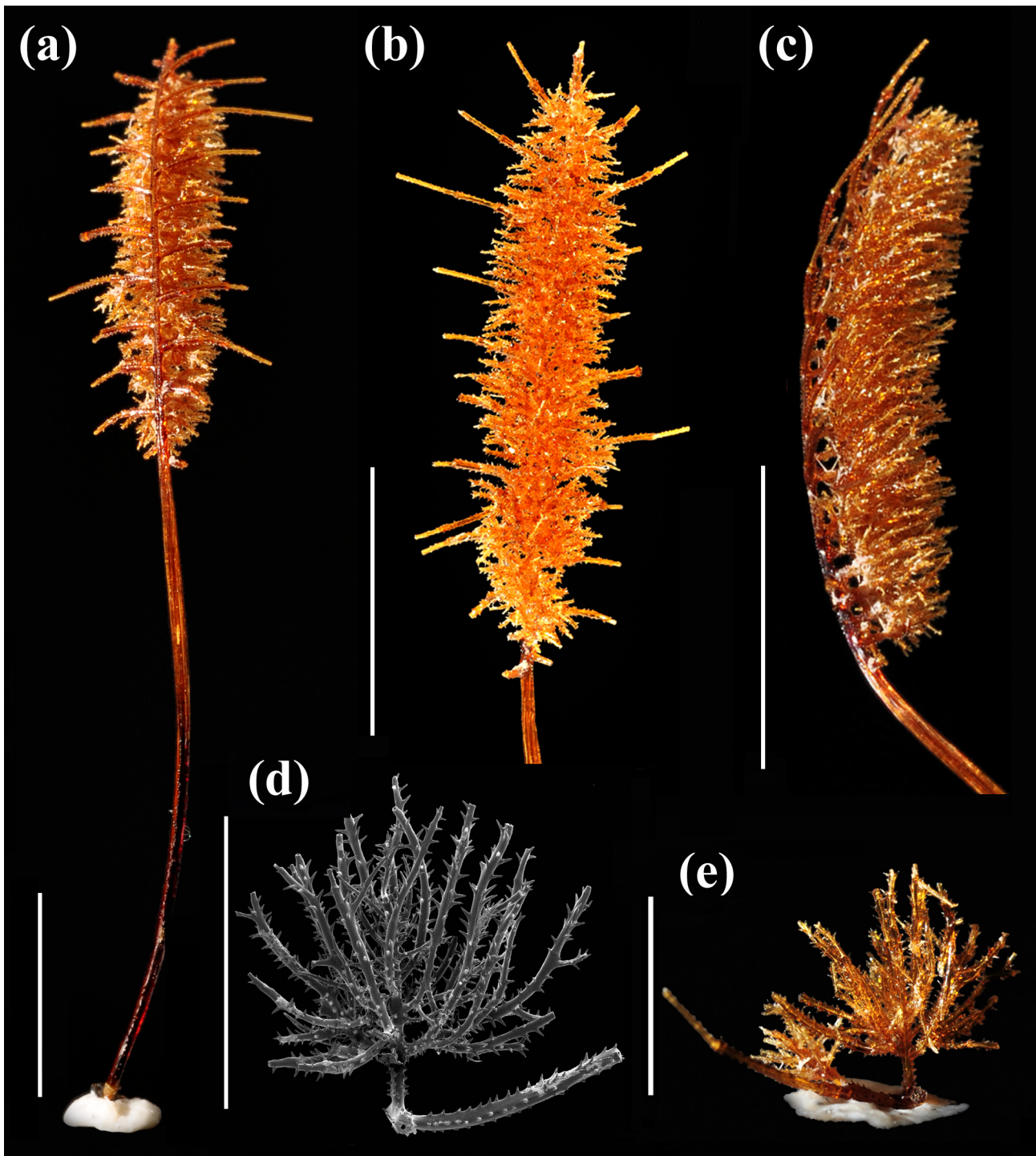


FIGURE 1. *Heteropathes opreski*, **spec. nov.** holotype (EMEPC D9–Ma007): (a) posterior view; (b) anterior view; (c) lateral view; (d) close-up view of anterior pinnule; (e) close-up view of lateral pinnule and subpinnules. Scale bars are 10 mm for a–c and 5 mm for d–e.

The spines on the secondary and tertiary lateral pinnules are conical, acute, distally inclined and bigger than those on the primary pinnules. They are inserted in longitudinal rows 0.07–0.3 mm apart and measure 0.04–0.18 mm in height (2f).

The spines on the anterior pinnules and subpinnules are larger than those on the lateral pinnules but also conical, acute and often distally inclined. The spines on the unpinnulated portion of the primary pinnules measure 0.05–0.07 mm in height and are spaced ca. 0.1–0.2 mm. The spines on the ramified portions measure 0.04–0.19 mm (most 0.05–0.15 mm) in height and are spaced ca. 0.1–0.4 mm, becoming larger towards the distal part of the ramifications, which often end in a blunt apex crowned by spines (Fig. 2g, h).

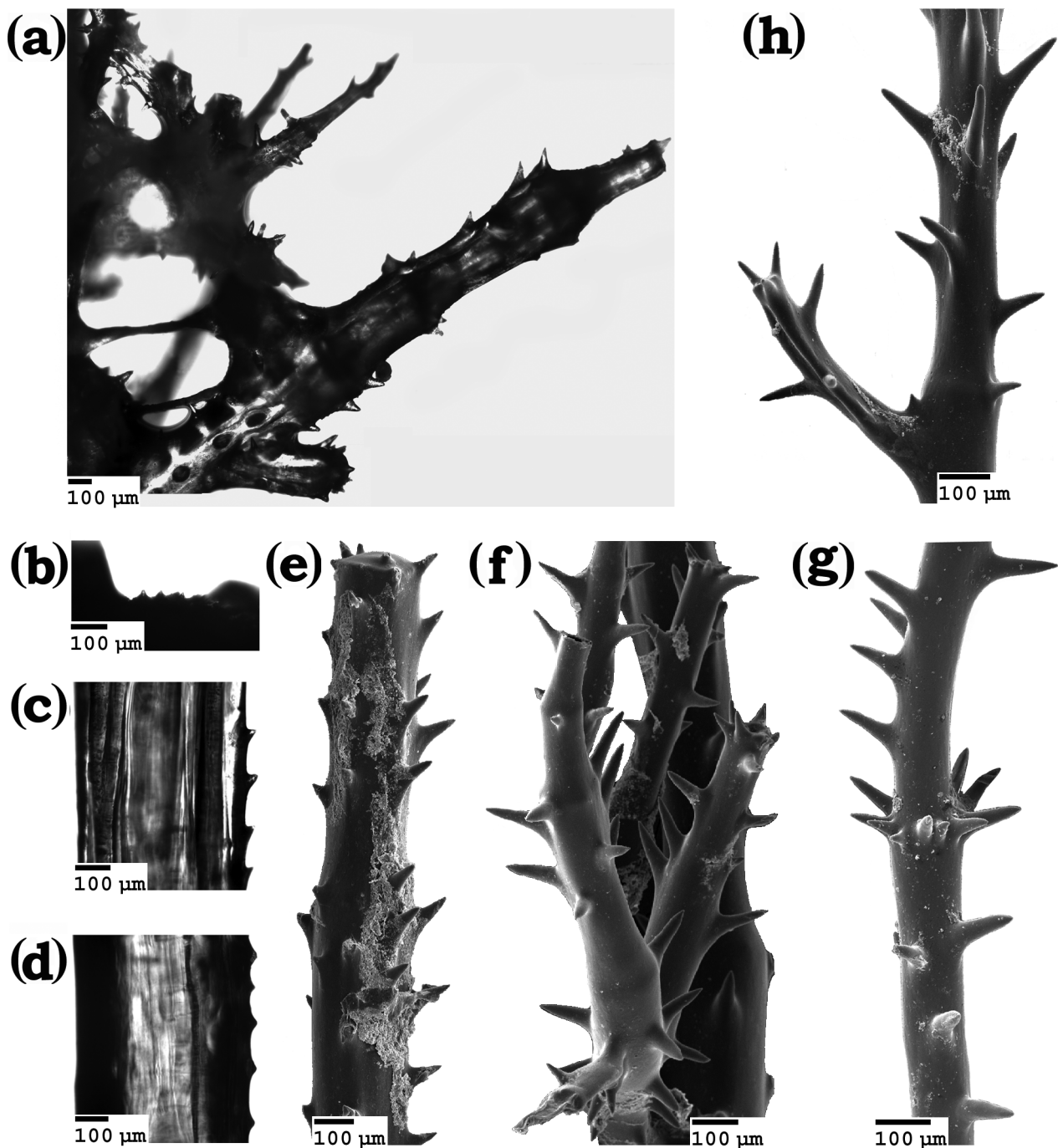


FIGURE 2. *Heteropathes opreski*, **spec. nov.** holotype (EMEPC D09–Ma007), detail of: (a) apex of colony; (b, c) unpinnulated portion of stem; (d) base of colony; (e, f) primary, secondary and tertiary lateral pinnules; (g, h) tertiary and quaternary anterior pinnules. Scale bars are 0.1 mm for a–h.

The spines are all similar in size on the unramified portion of the primary pinnules, but closer to the distal part of the anterior pinnules they are sometimes up to 0.05 mm higher on one side than on the opposite side, which suggests that these may be polypar spines. Additionally, they are not all placed in the same direction on all the pinnules. Assuming that these are indeed polypar spines, this suggests that the polyps are inserted randomly on the higher order pinnules. Since the specimen did not present any soft tissues, no further information regarding the polyps is available.

Comparisons. *Heteropathes opreski* **spec. nov.** differs from the three other species assigned to this genus (*H. americana*, *H. heterorhodzos* and *H. pacifica*) in forming smaller colonies with shorter lateral pinnules (0.7 vs

respectively 9, 6 and 14 cm) that sometimes present a small and extensively ramified subpinnule and presenting bigger spines on the primary lateral pinnules (up to 0.12 vs respectively 0.05, 0.05 and 0.06 mm in height) (for more details see dichotomous key below).

Dichotomous key to *Heteropathes* species

- 1 Lateral pinnules longer than the stem 2
- 1 Lateral pinnules shorter or having the same length as the stem 3
- 2 Lateral pinnules up to 9 cm in length; anterior pinnules pinnulated up to third order, 6–8 mm long; spines on lateral pinnules up to 0.05 mm in height; spines on anterior pinnules up to 0.13 mm in height *H. pacifica*
- 3 Tertiary anterior pinnules absent 4
- 3 Tertiary anterior pinnules present 5
- 4 Lateral pinnules up to 6 cm in length; anterior pinnules up to 10 mm in length; spines on lateral pinnules up to 0.05 mm in height; spines on anterior pinnules up to 0.2 mm in height *H. heterorhodzos*
- 5 Lateral pinnules up to 14 cm in length; anterior pinnules up to 7 mm in length; spines on lateral pinnules up to 0.06 mm in height; spines on anterior pinnules up to 0.07 mm in height *H. americana*
- 5 Primary lateral pinnules up to ca. 7 mm and secondary up to 2.5 mm in length; anterior pinnules up to 6 mm in length; spines on primary lateral pinnules up to 0.12 mm in height; spines on secondary lateral pinnules up to 0.18 mm in height; spines on anterior pinnules up to 0.19 mm in height *H. opreski spec. nov.*

Etymology. The specific name is dedicated to Professor Dennis Opresko, the leading authority on antipatharians, for guiding and inspiring the new generation of taxonomists working with black corals.

Distribution. The holotype was collected at the Oceanographer Fracture Zone (NE Atlantic) between 2602 and 2270 m depth. *Heteropathes* spp. colonies have also been collected in the Indic Ocean at 1079 m, Pacific Ocean at 2200 m and Northwest Atlantic Ocean at 3563 and 4511 m of depth (Fig. 3).

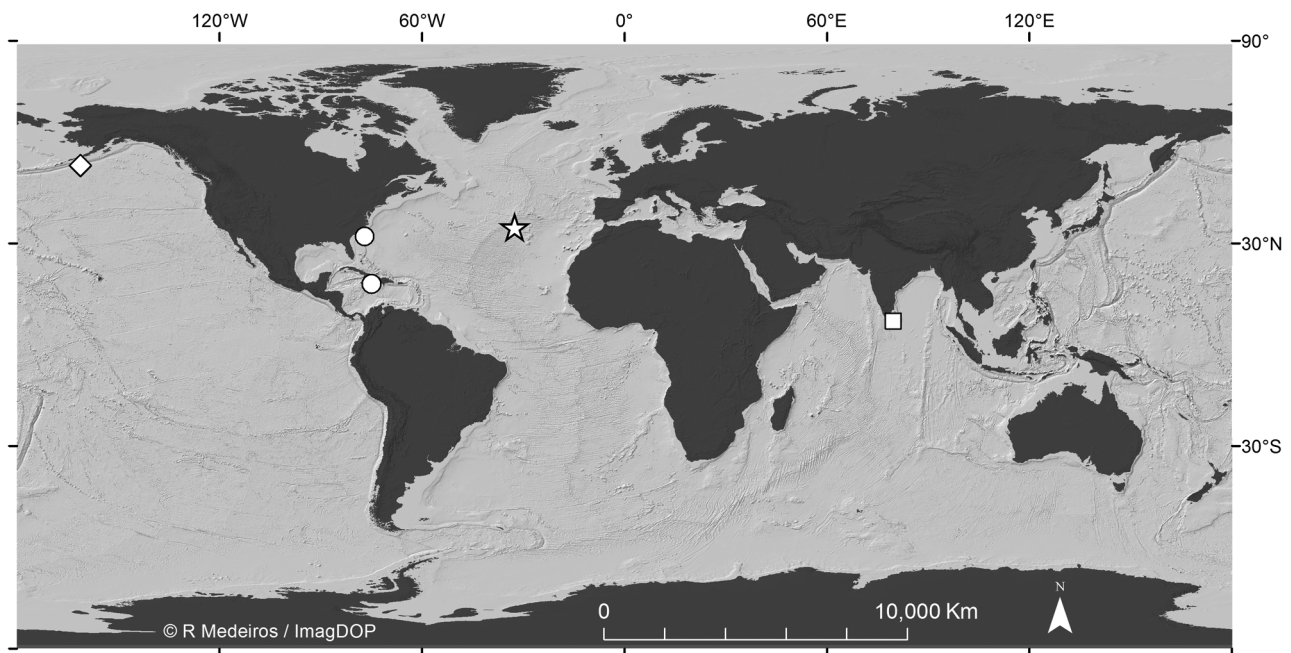


FIGURE 3. Known global distribution of genus *Heteropathes*: *H. pacifica* (diamond), *H. Americana* (circle), *H. heterorhodzos* (square) and *H. opreski spec. nov.* (star).

Remarks. The holotype did not present soft tissues at the time of collection, so it is unclear if this was a dead colony or if it was a living colony whose coenenchyme was destroyed during the dredging operations (2 x Chain–Sack 1.44 m³, 800 kg).

The endemic status of *H. opreski* to the Oceanographer Fracture Zone cannot currently be established. Nonetheless, the species appears to be very rare, given that a single colony was collected for the first time in the course of 20 deep-water dredging operations performed on the slopes of seamounts south of the Azores during the EMEPC/AÇORES/G3/2007 campaign.

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