

FIRST RECORD OF THE BLACK CORAL *Antipathella wollastoni* (ANTHOZOA: ANTIPATHARIA) OUTSIDE OF MACARONESIAN WATERS

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ABSTRACT

The first record of the antipatharian coral *Antipathella wollastoni* outside Macaronesian waters is reported. The species was found in the Ceuta littoral (southwest Mediterranean) at a depth of 35 m. The morphological characteristics of the Ceuta colony are compared to those of type specimen of the species. The cnidae of the species are described for the first time. The occurrence of the species in the Mediterranean is discussed in relation to possible changes in climate.

Key words: Antipatharia, *Antipathella wollastoni*, range extension, Mediterranean Sea, Ceuta littoral.

RESUMEN

Se registra por primera vez la presencia del antipatario *Antipathella wollastoni* fuera de las aguas de la Macaronesia. La especie fue encontrada en el litoral de Ceuta (Mediterráneo suroccidental) a una profundidad de 35 m. Las características morfológicas de la colonia son comparadas con las del ejemplar tipo. El cnidoma de la especie se describe por primera vez. Su presencia en el Mediterráneo es discutida en relación con la posible influencia del cambio climático.

Palabras claves: Antipatarios, *Antipathella wollastoni*, extensión del rango, Mediterráneo, litoral de Ceuta.

1. INTRODUCTION

Five known species of antipatharian corals are currently assigned to the genus *Antipathella* Brook (see OPRESKO [23]): three occur exclusively in New Zealand waters, *A. aperta* (Totton, 1923), *A. strigosa* Brook, 1889, and *A. fiordensis* (Grange, 1990); one is known only from the Mediterranean Sea, *A. subpinnata* (Ellis & Solander, 1786); and the

fifth, *A. wollastoni* (Gray, 1857), is a common species in the Macaronesian archipelagos (see BRITO & OCAÑA [3]). Recently, one of us (O. Ocaña) discovered a colony of *A. wollastoni* in the Ceuta littoral, the first record of this species outside Macaronesian waters. This discovery adds to our understanding of the complex biogeography of the Mediterranean Sea, and, in addition, may be important as a faunal indicator of environmental changes occurring in the Mediterranean. The Ceuta littoral is a marine biodiversity hot spot at the entrance to the Mediterranean and its benthic communities may be especially vulnerable to changes in environmental conditions, such as those resulting from climatic fluctuations. The easy accessibility of the Ceuta littoral by diving makes this location especially suited for monitoring changes in species composition of benthic communities and also for studying other aspects of the biology and ecology of the organisms found there.

In taxonomic studies of antipatharian corals, the general growth form of the colony, the arrangement and density of the branches and pinnules, and the morphology of the spines are the main characters used to distinguish species. In this report the taxonomic characteristics of the Ceuta specimen of *A. wollastoni* are compared with information derived directly from the type material of the species, including the first published scanning electron micrographs of the skeletal spines. Although other morphological features of antipatharians, such as the histology and microanatomy of the polyps, have been used in some species descriptions (see ROULE [25]; VAN PESCH [29]), the value of these characters at the species level is limited. One feature, however, that may provide some useful information pertains to the characteristics of the cnidom. Although some general studies have been conducted on the cnidae of antipatharians (SCHMIDT [27]), few efforts have been made to use these data in species descriptions. Information on the cnidae may also be of value at higher taxonomical levels. Descriptions of the cnidae of the Ceuta specimen of *A. wollastoni* are included in this report.

2. MATERIAL AND METHODS

1.1. Material examined

Ceuta: (FMM-BM-AP-1) Punta Almina, Monte Hacho, 9.ii.2007, 35°53'37.0"N 005°16'33.2"W, O. Ocaña leg. (Fundación Museo del Mar de Ceuta), 35 meters, growing on wall in circalittoral community among banks of *Astroides calycularis* corals; branch 40 centimetres long and 20 centimetres wide with 2 secondary branches, all belonging to a medium size colony (height about 45 centimetres; width about 150 centimetres); coenenchyme brown in color, polyps white.

British Museum: Type of *Antipathella wollastoni*, Madeira, coll: Wollaston, no other data; several dry specimens. Fragment of the type in the USNM (No. 100357).

2.2. Methods

The Ceuta specimen was collected by scuba diving and preserved in 8% formaldehyde in sea water. The general morphology and anatomy were studied by means of a stereo dissecting microscope. The general characteristics of the colony from Ceuta are described, and unique and interesting features are discussed. Nematocysts were examined and studied with a light microscope equipped with Nomarski differential interference contrast optic sys-

tem. Permanent slides of the cnidom were prepared with glycerine gel, the same technique used for studying meiofauna (see OCAÑA [20]). The classification and terminology for describing the nematocysts is essentially that of SCHMIDT [26] y [27], as adapted by DEN HARTOG [17], DEN HARTOG *et al.* [18] and by the present authors. We were able to take samples from different tissues: tentacles, actinopharynx and mesenteric filaments, and also the coenenchyme. Due to the tiny size of the polyps, it was not possible to completely separate tissues of the actinopharynx and the mesenteric filaments; therefore, cnidae of these tissues could not be completely differentiated. Some information about the cnidae is presented in the text; including the relative abundance of the various types. The dimensions (length and width) of each type can be obtained directly from the photographic images.

The type material of *Antipathella wollastoni* was re-examined at the British Museum by one of us (D. Opresko), and important features not noted by earlier workers are reported here. Photographs of branches and pinnules of the type specimen are presented, and the skeletal spines of the type (fragment in the USNM, Cat. No. 100357) are illustrated from scanning electron micrographs taken with an Amray 810 Scanning Electron Microscope at the U.S. National Museum of Natural History, Smithsonian Institution, Washington, DC.

3. RESULTS

3.1. Description of the Ceuta specimen

Corallum.- Densely branched with simple elongate pinnules arranged in several irregular rows (fig. 1). Some of the pinnules are subpinnulate (fig. 1), a feature which was previously reported for specimens from Macaronesia (see BRITO [2]). The pinnules are 0.2 to 4.5 centimetres long, and there are 4-20 pinnules along one centimetre of branch.



Fig. 1. Pinnules and subpinnules on a branch of the Ceuta specimen.

Spines.- There are numerous conical spines which are longer on the polyp side of the axis (fig. 2). The spines range in size from 0.16 to 0.21 mm, but most are 0.17-0.18 mm, as measured from the tip to the centre of the base. Small, elongated tubercles are present on the distal half of the surface of the spines (fig. 3).

Polyps.- The polyps of the Ceuta specimen measure not more than 1 mm in transverse diameter and some may be as small as 0.55 mm. There are commonly 11-12 polyps per centimetre (range 9-13 per centimetre). When alive, they are white in colour and the rest of the colony surface (coenenchyme) is brown.



Fig.2. Spines from the pinnules: disposition and size.



Fig. 3. Single spine showing tubercles.

Cnidom.- As expected, there are spirocysts, two categories of spirulae (basitrichous isorhizas) and also two categories of penicilli A (microbasic mastigophores) (fig. 4). Basically all the cnidom types are present in all the tissues although there are some slight differences in their abundance. Spirocysts are more abundant in the tentacles than in the other tissues. The smaller type of penicilli A seems to be more common in the tentacles and the actinopharynx/mesenteric filaments than in the other tissues. The most common type of spirulae is much more abundant in the tentacles. In fact, the greatest concentration of cnidae is found in the tentacles. The second type of spirulae is rare, but it can occur in all tissues. The larger penicilli A were observed only in the coenenchyme.

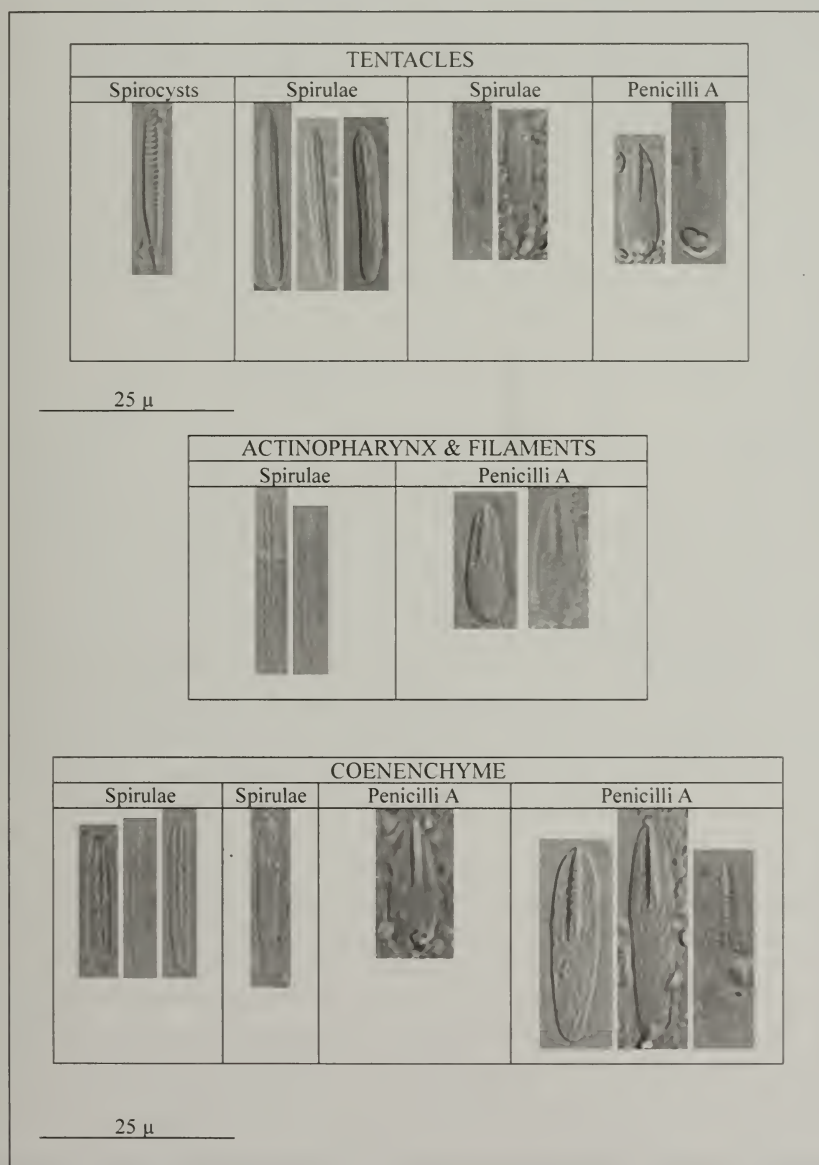


Fig. 4. Cnidom of *Antipathella wollastoni*.

Remarks.- Although taxonomic studies of antipatharians are based primarily on skeletal features, information on the cnidom may prove useful in the identification of species and in the differentiation of closely related taxa. SCHMIDT [27] studied the cnidom of antipatharians *sensu lato*, and noted that there were only a few basic types. This simplicity is seen even in the case of the specialized sweeper tentacles that GOLDBERG *et al.* [8] reported for *Antipathella fiordensis*. Only microbasic b-mastigophores occurred in the tissues of the sweeper tentacles. These were similar in general structure to the microbasic b-mastigophores found in normal tentacles; however, they were larger than normal, had a more electron-lucent matrix when mature, and stained differently, suggesting a possible change in their ultrastructure.

In general, all the types of cnidae that we found in *A. wollastoni* were previously recorded by SCHMIDT [27] for antipatharians as a whole, although some differences occur in their relative abundance in the various tissues. We were not able to distinguish scapus or column wall on the antipatharian polyp (see BRITO & OCAÑA [3]), and due to the tiny size of the polyps, we were not able to distinguish between the cnidae of the actinopharynx and those of the mesenteric filaments. In our studies, however, we also looked at the cnidae of the coenenchyme, the common tissue between the polyps, and found that the second and bigger category of Penicilli A occur exclusively in this tissue. Further studies are needed to determine if this feature is unique to *A. wollastoni*, and whether it can be used to differentiate *A. wollastoni* from related species.

3.2. Description of the type material of *A. wollastoni*

The original description of the species, as given by GRAY [12] under the name *Antipathes subpinnata*, is relatively short and pertains primarily to the branching pattern: "Coral erect, irregularly branched, branches diverging, branchlets close together, in three (rarely two or four) longitudinal series on the different sides of the stem, elongate, slender, ascending simple, and of nearly equal length". In 1889, BROOK [4] provided a more complete description and included an illustration of the skeletal spines. Brook reported that Gray's specimen was 56 cm tall, with a stem diameter of a little over 6 mm. Pinnules were described as 0.6 to 4 cm in length and coming off all sides of the branches and directed obliquely. In another part of his description, BROOK [4] states that the pinnules near the tips of the branchlets are very irregular in length, and are arranged spirally, with 3-5 per centimetre and with the average length of 2 cm. The spines are described as being long and slender, with a sharp bend near the base so that the apical portion of the spines takes a "subvertical" direction. The length of the spines was reported to be equal to the diameter of the pinnule. As estimated from the figure given by BROOK [4] (plate XI, fig. 6), the spines are about 0.19 mm tall (as measured from the tip to the centre of the base).

A re-examination of the material from Madeira in the British Museum that Brook assumed to be Gray's type revealed five broken branches, presumably all from the same colony; one of which was 55 cm tall (fig. 5a), with a basal stem diameter of about 5 mm. This closely corresponds to the dimensions of the specimen described by Brook. The branches have the appearance of being sparsely sub-branched, however, because the specimen is dry, it is likely that many branches and pinnules were broken off over the years. The pinnules tend to be arranged bilaterally near the tips of the branchlets but become more pseudo-spirally arranged further away from the tip; with pinnules occurring on all sides of the branchlets (fig. 5c). The pinnules are mostly 2 cm long although they can be up to 4 cm



Fig. 5. Corallum, branches and pinnules of the type of *A. wollastoni* (Gray), BMNH.

in some places. Where they occur on all sides of the branchlets, there are 14 to 25 (mostly 16-19) per centimetre. The pinnules tend to be directed distally, with a distal angle of approximately 60° . A few of the pinnules have one, or rarely two, subpinnules which arise 1-3 mm from the base of the primary pinnule and are directed distally. In some cases the subpinnules may actually represent the earliest forming pinnules on an incipient branch.

The spines (fig. 6) on the pinnules are tall, conical, and are inclined and curved distally. They are taller on one side of the axis which very likely corresponds to the side of the axis on which the polyps are located. In the sample examined, the tallest pinnular spines measure 0.18 mm, and those on the opposite side of the stem from the tallest ones measure about 0.14 mm. The spines are arranged in longitudinal rows, with about six spines per millimeter in each row. The upper third to one-half of the surface of the spines, especially the

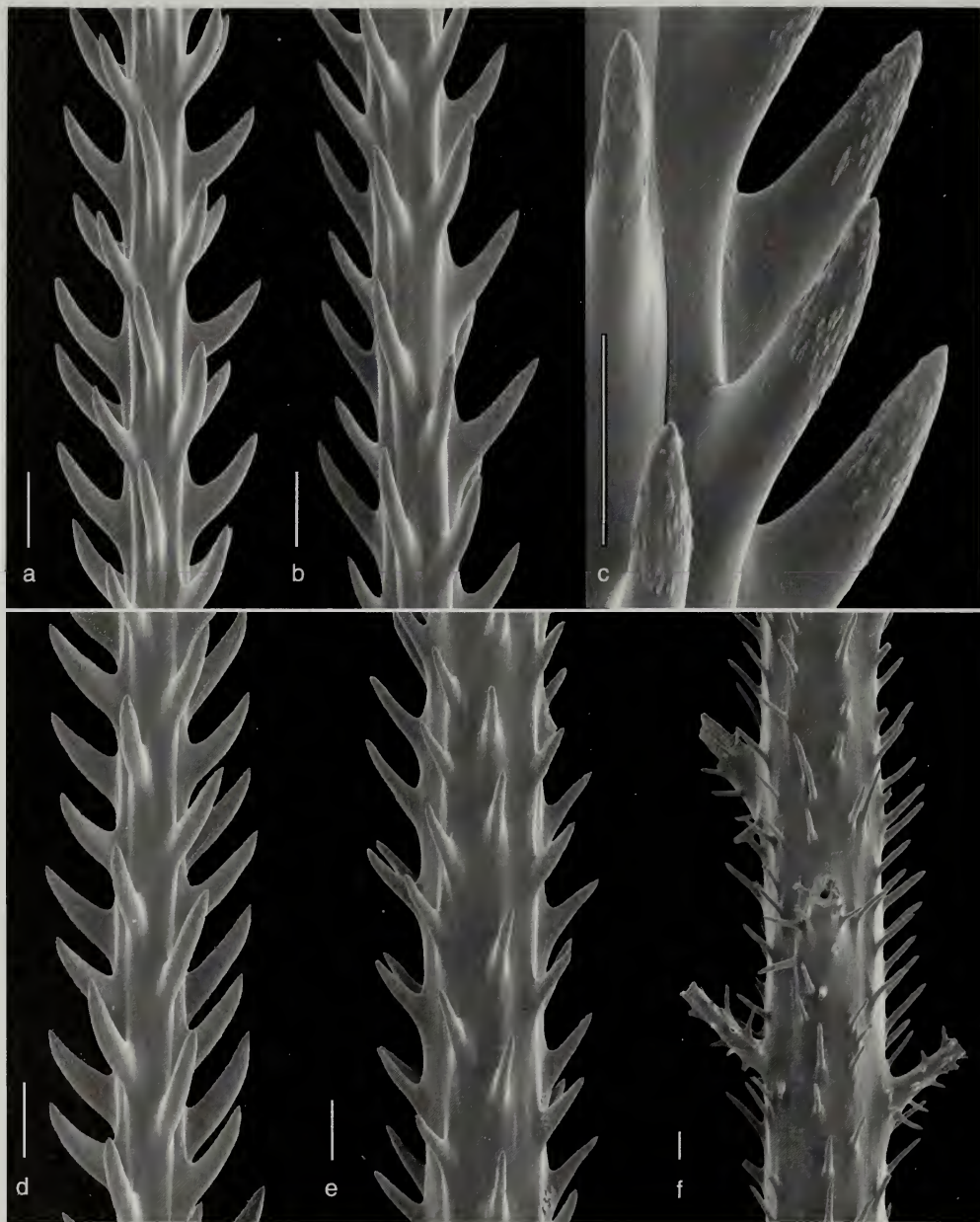


Fig. 6. Spines of the type of *A. wollastoni* (Gray), USNM 100357; scale bars 0.1 mm.

larger ones, is covered with very small, elongate tubercles (fig. 6c). On the larger branches and near the base of the corallum the spines become taller (up to 0.24 mm) and acicular (figs. 6e-f), but they do not show any evidence of antler-like branching at the apex.

The remains of polyps were found on the dry specimen, and these were estimated to be approximately 8-9 mm in transverse diameter. Due to their poor condition, the density of the polyps could not be determined.

4. DISCUSSION

4.1. Nomenclatural and taxonomic remarks

In a 1857 publication, Gray identified a specimen from Madeira as *Antipathes subpinnata* Ellis and Solander (1786). At the end of his short description of the specimen he states: "I had originally described it as distinct under the name *A. Wollastoni*". Gray published no other description of this specimen, nor did he refer to it in any later publications. In 1889, Brook found Gray's specimen in the British Museum and decided that it was a different species from *A. subpinnata*, which Brook had assigned to his new genus *Antipathella*. BROOK [4] identified the species as *Aphanipathes? Wollastoni* (Gray, MS). In 2001, *A. wollastoni* was transferred by OPRESKO [23] to the genus *Antipathella* in the family Myriopathidae (Opresko, 2001) which also contained the species *A. subpinnata*, *A. strigosa*, *A. aperta*, and *A. fiordensis*. Because Gray used the the specific name *wollastoni* in a publication, together with a valid description of a specimen which was later found in the British Museum, Gray is considered the original author, and the correct designation of the taxon is *Antipathella wollastoni* (Gray, 1857).

Gray's species *A. wollastoni* does resemble the original description of *A. subpinnata* given by ELLIS & SOLANDER [7] in 1786, but it differs from the description of *A. subpinnata* given by BROOK [4] in 1889. Unfortunately, Ellis & Solander's type material is lost, and when BROOK [4] redescribed *A. subpinnata*, he based his description on a specimen from the Bay of Naples. Brook's definition of the taxon was accepted by later workers, and when OPRESKO [23] established a neotype for this species, he used Brook's concept of the species because it had been in use for over 100 years. Significantly, the new material of *A. wollastoni* from Ceuta is the first record of the species from the Strait of Gibraltar, which is also the type locality reported by Ellis and Solander for their species *A. subpinnata*. Thus, there is the possibility that Gray's species and the specimen described by Ellis and Solander as *A. subpinnata* are the same taxon; however, nomenclaturally, the two taxa are now permanently fixed by their described type and neotype, respectively.

In 1921, GRAVIER [11] described a specimen as *A. wollastoni* which reportedly had pinnules that were 8-9 cm in length at the base of the branches and were more spread out than in the typical form. The pinnules also appeared to be less crowded than in the type. The spines on the basal holdfast were reported to be piliform (i.e., antler-like), as in a variety that JOHNSON [19] described as *A. wollastoni* var. *pilosa* from Madeira. JOHNSON [19] also noted that the pinnules were more obtuse than those in the typical form. Johnson did not report on the density of the pinnules or the average and maximum length; however, based on the illustrations given by GRAVIER [11], it appears likely that the variety *pilosa* is a distinct species.

4.2. Comparison of the Ceuta specimen with the type of *A. wollastoni*

The specimen from Ceuta closely agrees with Gray's type of *A. wollastoni* in terms of the length and density of the pinnules, the presence of subpinnules, the size of the skeletal spines, and the size of the polyps. The Ceuta specimen also matches descriptions of the species based on specimens from Macaronesia (see BRITO [2]; BRITO & OCAÑA [3]). It should be noted, however, that in the latter publication the height of the spines was erroneously given as 0.35-0.60 mm. The correct size of the spines is 0.16-0.24 mm.

4.3. Distribution and ecology

Antipathella wollastoni is a common species throughout the Macaronesian Archipelagos. The type locality is Madeira, and BROOK [4] also reported the species from Iles Salvages. More detailed information about the ecology and the distribution can be found in BRITO & OCAÑA [3]. The species is now recorded from Ceuta where it was found growing on vertical wall at a depth of 35 meters (fig. 7). The colony was located in the *Astroides calycularis* community on circalittoral bottoms affected by strong currents (see OCAÑA [21]). The area is surrounded by strong tidal currents that extend their influence down to a depth of 40 and even 50 meters. The current stress is very high and the communities that are able to live under these conditions are typically encrusting benthonic organisms. As observed in specimens from Macaronesian waters, *A. wollastoni* is a good indicator of strong current conditions (see BRITO & OCAÑA [3]).

An examination of the contents of the coelenteron of polyps of the Ceuta specimen revealed the remains of small crustaceans, indicating that the polyps feed on zooplankton.



Fig. 7. Habitat of *Antipathella wollastoni* at Ceuta bottoms.

4.4. The estimated age of the colony of *A. wollastoni* at Ceuta

An estimate of the age of the colony of *A. wollastoni* found at Ceuta, would be useful in providing an indication of how long ago larval settlement might have taken place. Several studies on antipatharians have estimated the age of colonies from measurements of growth rate and colony size. Growth rate studies of commercially valuable species have been especially important in fishery management decisions (see GRIGG [13]. GRIGG [14] reported that in Hawaiian waters *Antipathes grandis* grew at a rate of 6.12 centimetres per

year, while another Hawaiian species (identified at the time as *A. dichotoma* Pallas, but now known to be a different species from the true *A. dichotoma* Pallas from the Mediterranean, see OPRESKO [24]), had a growth rate of about 6.42 centimetres per year. In studies conducted in the Caribbean, OAKLEY [22] found that the warm-water species *Plumapathes pennacea* had a growth rate of 5.7 centimetres per year. In contrast, GRANGE [10] studied the growth of *Antipathella fiordensis*, a cold-water species found in the fjords of New Zealand, and reported an annual linear increase in the size of the colonies of only 2.4 centimetres. In summarizing the available data, GRANGE [10] concluded that cold-water species very likely grew at much slower rates than warm-water species. Although there are no grow rate data for *Antipathella wollastoni*, it might be assumed that the species would exhibit a grow pattern more similar to warm-water species than to cold-water species. In this case, if we apply the minimum grow rate known for the Hawaiian black corals studied by GRIGG [14] to our colony, which measured 45 centimetres in height, we can estimate that our specimen should not be more than ten years old. This information may be of special interest in view of the changes in the Mediterranean fauna that are thought to have occurred over the past 30 years (see DULČIĆ & GRBEC [5], and discussion below).

On a local scale, grow rates of corals such as *A. wollastoni*, might also be affected by the availability of food. As noted above, we have found evidence that *A. wollastoni* feeds on zooplankton. Plankton productivity in a particular habitat may have a substantial impact on coral grow rates. In the Ceuta area where the *A. wollastoni* specimen was growing local upwelling occurs (see BALLESTER & ZAVATTI [1]) which very likely increases plankton productivity and may thereby result in higher than normal grow rates of planktotrophic benthic organisms. Thus, the Ceuta colony of *A. wollastoni* may be much younger than 10 years.

4.5. About the distribution of *A. wollastoni* and its possible relation with climatic fluctuation in the Mediterranean Sea

Despite the numerous marine biological surveys and expeditions that have been conducted over the past 150 years, the biodiversity of the oceans and seas has yet to be completely documented (DUARTE [6]). New discoveries are being made even today in locations that have been the subject of study from the beginning, including the European coastline of the Mediterranean and the Strait of Gibraltar. It is not surprising then that the various oceanographic expeditions that explored the Strait of Gibraltar never found, at least officially, the species *Antipathella wollastoni*, and it is possible that *A. wollastoni* is wide spread along the Mediterranean Sea, but was never collected before now. A second possibility is that the species was collected previously from the Mediterranean, but has gone unrecognized in museum collections due to the lack of taxonomic experts on the group. Indeed, in many museums and oceanographic institutions, there are many specimens that remain unidentified or are identified only as black coral or *Antipathes* sp. A third possibility, however, is that the discovery of *A. wollastoni* at Ceuta represents a totally new range extension of the species into the Mediterranean. At Ceuta on the African side of the Strait we have found the species at a depth of 35 meters, which is similar to its depth distribution in the Macaronesian archipelagos (see BRITO & OCAÑA [3]). Considering how shallow it is known to occur, one would have expected the species to have been detected in the Mediterranean long before now. Although its occurrence at Ceuta may only represent a random and sporadic dispersion from its normal geographic distribution, there is also the possibility that it represents a significant new range extension brought about by changes in the

environment which have made the Ceuta littoral more hospitable for the settlement and survival of the larvae. Several studies have documented the effect of climatic fluctuations on the distribution of the marine species. These studies have focused mainly on fish populations (see DULČIĆ & GRBEC [5]), but some information is also available for invertebrates. For example, the coral species *Astroides calycularis* has been shown to be a good indicator of climatic fluctuations in the Adriatic Sea (see GRUBELIC *et al.* [16]). This fact is not especially surprising in light of the natural history of the species through time. *Astroides calycularis* is an ancient Tethyan species related to the genus *Tabastrea* which is spreading through the Indo-Pacific (see OCAÑA [21]), so its response is similar to that of a warm water species.

Antipathella wollastoni is a typical Macaronesian faunal element with clear tropical affinities and, until now, it has never had been recorded outside Macaronesian waters (see BRITO & OCAÑA [3]). Accordingly, it can be postulated that the presence of *A. wollastoni* in the Mediterranean Sea at this time may be due to changes in environmental conditions brought about by fluctuations in the climate. If this is true, then in the future we should expect to find the species occurring in more and more locations along the Mediterranean coastline.

5. ACKNOWLEDGEMENTS

The same day we found the colony of *Antipathella wollastoni* we received the news of the death of our colleague and friend Amelia Ocaña. This paper is dedicated to her memory.

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