New species of *Hyalopomatus* Marenzeller, 1878 (Annelida, Polychaeta, Serpulidae) from Recent Mediterranean deep-water coral mounds and comments on some congeners

Rossana SANFILIPPO
Università degli Studi di Catania,
Dipartimento di Scienze Geologiche, Sezione di Oceanologia e Paleoecologia,
Corso Italia 55, I-95129 Catania (Italy)
sanfiros@unict.it

ABSTRACT

Calcareous tubes of the micro-serpulid *Hyalopomatus madreporae* n. sp. (Polychaeta, Serpulidae) are described from the central Mediterranean. Like congeners, the new *Hyalopomatus* species has a deep-water distribution (497 to 1146 m). Only empty tubes have been collected, from *Madrepora oculata* (Linnaeus, 1758) mounds and from muddy sediments associated to the coral framework. The species has been described considering characters of the tube which is small-sized, circular in cross-section and free on its distal end, with a smooth shiny surface. Tube is rather flexible owing to some disruptions and its parts are kept joined by the inner chitinous layer. Way of life of *H. madreporae* n. sp. is put in relation to such tube feature. Micromorphology of the outer surface and ultrastructure of the tube wall are also described. Morphological characters observed on more than 150 tubes of *H. madreporae* n. sp., permitted to keep *H. madreporae* n. sp. apart from the other known *Hyalopomatus* species. Tubes of *H. claparedii* Marenzeller, 1878 and *H. marenzelleri* Langerhans, 1884 from Icelandic waters have been compared with those of *H. madreporae* n. sp. X-ray microanalyses showed that the organic content in *H. madreporae* n. sp. is more abundant than in *H. claparedii* tubes. The discussion covers aspects of tube features used for taxonomy within the genus.

RÉSUMÉ

Une nouvelle espèce de Hyalopomatus *Marenzeller, 1878 (Annelida, Polychaeta, Serpulidae) récoltée dans des bioconstructions profondes actuelles de coraux de Méditerranée et remarques sur certains congénères.*

Les tubes calcaires du micro-serpulidé *Hyalopomatus madreporae* n. sp. (Polychaeta, Serpulidae) sont décrits de Méditerranée centrale. La nouvelle espèce, tout comme ses congénères, a une distribution bathyale, entre 497 et 1146 m de profondeur. Seuls des tubes vides ont été trouvés sur des bioconstructions de *Madrepora oculata* (Linnaeus, 1758) et dans les dépôts vaseux associés. La nouvelle espèce est décrite d'après les caractères morphologiques des tubes. Le tube est petit et fragile, circulaire en section transversale et libre dans sa partie distale ; la surface est lisse et brillante. Le tube calcaire est quelquefois interrompu et les portions sont jointes par la couche chitineuse intérieure ce qui le rend quelque peu flexible. La micromorphologie de la surface extérieure et l'ultrastructure du tube sont décrites. Des caractères morphologiques observés sur plus de 150 tubes de *H. madreporae* n. sp. permettent de distinguer nettement cette espèce des autres *Hyalopomatus* connus. En outre, le tube de la nouvelle espèce se distingue des autres par sa taille notablement plus petite. Les tubes de *H. claparedii* Marenzeller, 1878 et *H. marenzelleri* Langerhans, 1884 des eaux islandaises ont été comparés avec ceux de *H. madreporae* n. sp. Une micro-analyse aux rayons X a démontré que le contenu organique est plus important dans les tubes de *H. madreporae* n. sp. que dans ceux de *H. claparedii*. Les caractères des tubes utiles du point de vue taxonomique dans le genre sont discutés.

INTRODUCTION

Ten morphologically similar species are actually recognised in the genus *Hyalopomatus* Marenzeller, 1878, beside two still uncertain attributions (ten Hove 1975: 71; Ben Eliahu & Fiege 1996: 18). Five of them show high latitudinal distribution: *H. macintoshi* (Gravier, 1911) from southwestern coast of the Antarctic peninsula (400-500 m); *H. claparedii* Marenzeller, 1878 from Arctic Basin (142-3800 m); *H. jirkovi* Kupriyanova, 1993 (1050 m), *H. mironovi* Kupriyanova, 1993 (5020-5110 m) and *H. sikorskii* Kupriyanova, 1993 (4550 m) from northeastern Pacific (Kurile-Kamchatka). The species *H. variorugosus* Ben Eliahu & Fiege, 1996 and *H. marenzelleri* Langerhans, 1884 are essentially distributed at mid-latitudes: the former from Mediterranean (Tyrrhenian sea, Ionian sea, Levant Basin: 300-2009 m), eastern Atlantic and from Pleistocene sediments of southern Italy; the

latter (208-2800 m) from western Mediterranean (?), temperate northeastern and eastern Atlantic (Brittany to southern Portugal, Josephine Bank, Madeira, Azores). Lastly, the distributions of *H. cancerum* Knight-Jones, Knight-Jones, Oliver & Mackie, 1997 (685 m) from eastern Indian Ocean (Arabian sea), *H. biformis* (Hartman, 1960) (> 2000 m) (Hartman, 1960) from northeastern Pacific (southern California) and *H. langerhansi* Helers, 1887 (535-1573 m) from tropical west Atlantic (Cuba) are restricted to low latitudes.

A further species, collected from the central Mediterranean, northern Ionian sea (Fig. 1), is herein described.

Noteworthy, all these species have been recorded from bathyal and abyssal depths and exclusively from present day environments (Knox 1959; Zibrowius 1969, 1977; Kupriyanova 1993; Ben Eliahu & Fiege 1996; Knight-Jones *et al.* 1997; Sanfilippo 1998) except *H. variorugosus*, also known from Pleistocene

bathyal palaeoenvironments of the Mediterranean area (Sanfilippo 1998).

The genus is scarcely mentioned in literature owing to the small number of findings (with species descriptions often based on very few specimens) partly due to the relatively sparse surveys in bathyal and abyssal depths. In addition, *Hyalopomatus* species are quite small-sized thus often overlooked when using standard methods i.e. sieves > 1 mm.

Zibrowius (1969, 1977) carefully revised the genus outlining that the known species of *Hyalopomatus* are morphologically very similar and closely allied. More recently Kupryanova (1993) proposed a key for the genus to clarify differences among species, exclusively based on soft parts. Furthermore, as evidenced by Ben Eliahu & Fiege (1996) traditional methods based only on light microscopy observations, do not appear sufficiently adequate for a precise point by point comparison among *Hyalopomatus* species.

Recently some works stress the reliability of identifications by means of even more detailed tube characters, among which ultrastructure, that give adjunctive data to traditional descriptions based on soft parts (Bubel *et al.* 1983; ten Hove & Zibrowius 1986; ten Hove & Smith 1990; Nishi 1993; Pillai 1993; Sanfilippo 1993, 2001; Pillai & ten Hove 1994; Aliani *et al.* 1995; Sanfilippo & Mollica 2000). The analysis of tube characters is becoming an obligatory diagnostic tool when only dead or fossil material are under description (Zibrowius & ten Hove 1987; Weedon 1994; Sanfilippo 1996, 1998; Radwańska 2004; Vinn 2005; Jäger & Kočí 2007).

In the present instance, since living specimens were not found, the new species is described based exclusively on macroscopical characters of the empty tube and adjunctive observations by scanning electron microscopy. This approach revealed to be necessary for an univocal identification of the new species, being its tubes completely smooth and lacking in diagnostic ornamentations thus hardly distinguishable by traditional stereoscopy observations.

The aim of the present paper is to describe the new species based on tube morphology and ultrastructure, and to discuss its relationship with some previously established *Hyalopomatus* species.
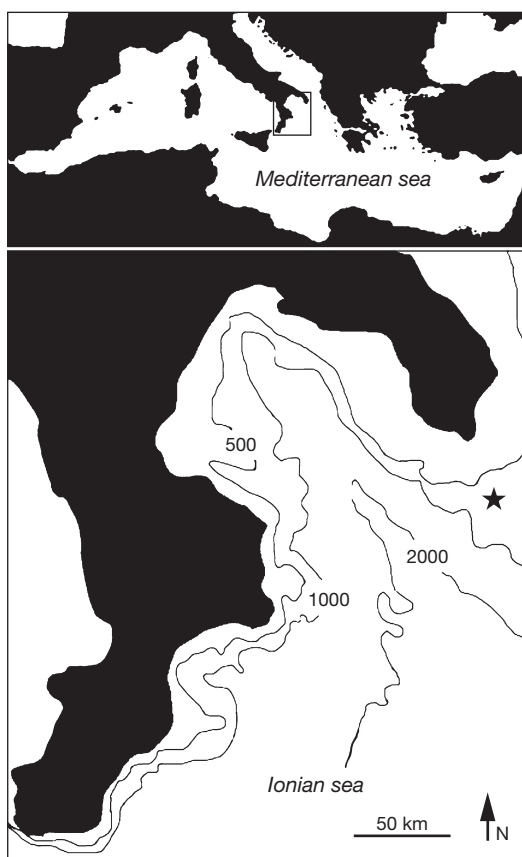

Fig. 1. — Location of sampled area (★).

Close inspection of the tubes allowed peculiar morpho-functional characters to be detected, which are shared with other *Hyalopomatus* species.

MATERIAL AND METHODS

Studied specimens were acquired during the oceanographic cruises APLABES (RV *Universitatis*, 2005, sample code AP-) and CORSARO (RV *Urania*, 2006, sample code CR-) performed on deep-water coral mounds off Santa Maria di Leuca (northern Ionian sea, central Mediterranean) (Fig. 1). Examined material was sampled in the depth range 497-1146 m by means of grab (60 litre Van Veen) and dredges (Table 1).

Cruise code	Date	Gear	Coordinates	Depth (m)	Remarks	Specimens of *Hyalopomatus madreporae* n. sp.
APLABES cruise						
AP01	29.IX.2005	Grab	39°34.84'N, 18°23.30'E	513	Mud with living and dead corals	Holotype: 1 entire tube on a *Madrepora oculata* colony. Paratypes: 2 tubes inside dead *M. oculata* calices; 1 tube on a chitinous epizoan on *M. oculata*; 3 proximal parts on *M. oculata* fragments; 1 tube on a bryozoan; 6 proximal parts on the serpulid *Filogranula annulata*; 102 distal parts and fragments from sediment
AP11	30.IX.2005	Grab	39°34.64'N, 18°23.00'E	528	Bioclastic mud	1 proximal part on a *M. oculata* fragment.
AP22	2.X.2005	Grab	39°36.72'N, 18°30.49'E	638	Slightly sandy mud	14 distal parts and tube fragments
AP29	3.X.2005	Sanders dredge	39°28.00'N, 18°24.20'E	765	Start	1 proximal part on a *M. oculata* fragment
			39°27.38'N, 18°24.46'E	790	End: bioclastic mud with coral and hard-ground fragments	
AP30	4.X.2005	Grab	39°28.09'N, 18°24.42'E	747	Bioclastic sandy mud with corals	5 proximal parts on *M. oculata* fragments; 10 distal ends from sediment
CORSARO cruise						
CR55	5.I.2006	Rectangular dredge	39°34.93'N, 18°23.37'E	501	Start	7 entire tubes on bryozoans and 3 proximal parts on hydrozoans epibionts on *M. oculata*
			39°35.35'N, 18°23.65'E	497	End: living coral banks	

The new species has been recorded on *Madrepora oculata* (Linnaeus, 1758) colonies and on some of its epibionts: calices, tissue-barren and dead branches of *Madrepora*, and on associated bryozoans and hydrozoans (Fig. 2A-C). Tube distal parts have been also delivered from mud entrapped between the coral framework, and from bottom sediments neighbouring the mounds (Fig. 2D, E). Sediments were treated for microfaunas studies, tubes picked from fractions major than 250 µm.

Serpulid association comprises eight living species and 22 taxa belonging to the thanatocoenosis. *Filogranula gracilis* Langerhans, 1884, *Metavermilia multicristata* (Philippi, 1844) and *Filograna implexa* Berkeley, 1827 prevail both in the community and thanatocoenosis. Serpulids are elsewhere quite abundant (Fig. 3A), constituting one of the most representative groups among epibionts (Sanfilippo 2007; Mastrototaro *et al.* in press; Rosso *et al.* in press). Photos

under a Zeiss Discovery V8 A stereomicroscope were performed by means the Axiocam MRC software.

Platinum coated material was observed under an Hitachi S.4000 scanning electronic microscope. Some tubes were treated with concentrated H_2O_2 to eliminate organic matter and others were broken to obtain natural longitudinal and cross-sections, in order to examine their structures. A Tescan Vega2 LMU equipped with an EDAX Sapphire Si(Li) detector working in the energy dispersive mode was used for microanalysis. Operating conditions were 20 kV accelerating voltage and 12 NA beam current. Quantitative analyses, expressed in weight percentages (wt%), were obtained following the standardless ZAF correction methods.

Material belonging to the congeners *H. claparedii* (45 tubes with animals inside) and *H. marenzelleri* (75 tubes with animals inside) from Icelandic waters (BIOICE project, cruise May 1999; stations

2403, 2410, 2691, 2697) has been examined comparing tubes for morphology, micromorphology, ultrastructure and microanalysis.

Examined material is housed in the Palaeontological Museum of the Department of Geological Science, Catania University (PMC) and Muséum national d'Histoire naturelle, Paris (MNHN).

SYSTEMATICS

Since original description of the genus is based on soft bodied parts not mentioning the tube, an emended description is here proposed also including characters of mineralized parts which proved to be an invaluable tool for taxonomic distinction in dead and fossil material.

Genus *Hyalopomatus* Marenzeller, 1878
emended by Kupriyanova (1993)

Hyalopomatus Marenzeller, 1878: 393, 394.

Hyalopomatopsis Saint-Joseph, 1894: 224, 261.

Cystopomatus Gravier, 1911: 315, 316.

EMENDED DIAGNOSIS. — Six thoracic chaetigers, 5 with uncini. Collar chaetae with either uniform (undifferentiated) limbate blade or with a proximal fin more or less separated from distal limbate blade. No *Apomatus*-type chaetae. Thoracic and abdominal uncini rasp-shaped. Abdominal chaetae geniculate or recurved, not always present in anterior segments. Soft vesicular operculum, with or without a differentiated distal opercular cape borne on a thin apinnulate opercular peduncle, or, no operculum at all present. Thoracic membranes short. Tube white, small-sized (0.2 to 1.0 mm in width) sensibly isodiametric for most of its length. Proximal part weakly and discontinuously encrusting substrate, more or less curved, or roughly coiled and folding on itself, circular in cross-section, rarely semicircular or triangular. Distal part straight and rising from the substrate for a sizeable length, always circular in cross-section. Tube wall thin and brittle.

Hyalopomatus madreporae n. sp.
(Figs 2-4)

Hyalopomatus sp. 1 – Sanfilippo 2007: 387.

TYPE MATERIAL (see Table 1). — APLABES, stn AP01, 513 m, 1 complete tube on *M. oculata*, holotype (PMC.S4h.15.06.2007).
Paratypes: APLABES, stn AP01, 513 m, 5 tubes on *M. oculata*, 1 tube on a bryozoan, 4 tubes on the serpulid *F. annulata*, 94 distal parts and fragments from sediment (PMC.S4p.15.06.2007); 1 tube on a chitinous epizoan on *M. oculata* (MNHN TYPE 1494); 2 tubes on the serpulid *F. annulata* (MNHN TYPE 1495); 8 distal parts and fragments from sediment (MNHN TYPE 1496).

ETYMOLOGY. — Named after its preferred host, the colonial coral *Madrepora oculata*.

DIAGNOSIS. — Tube white with smooth shiny surface, circular in cross-section, extremely brittle. Diameter 310 (253-397) µm, length attaining 15 mm. Proximal part more or less curved only partially and feebly adhering to the substrate, suddenly upward bending at a right angle; distal part nearly straight, raised from the substrate at least ½ of its total length (Fig. 3B).
Tubes are segmented owing to some interruptions in calcium carbonate secretion (Fig. 3B-D). One interruption just next the angle between attached and distal erect parts (Fig. 3C). A chitinous inner layer, still preserved in some specimens, keeps joined the adjacent parts (Fig. 3D).
Very weak round thickenings are sporadically visible (Fig. 4A). Crystals and their arrangement are not visible, covered by a regular cryptocrystalline amorphous film (Figs 2E; 4B) which occurs also on the edges of tube disruptions (Fig. 4C-E). Outer surface is smooth, very thin and discontinuous growth lines being hardly seen under high SEM magnification (Fig. 4B).
Tube wall 15 µm thick (Fig. 4F, G) consisting of a unique layer with prismatic small calcium carbonate crystals (3-5 µm long) criss-cross arranged, with homogeneous microcrystalline ultrastructure (*sensu* Hall 1980), or fine complex crossed lamellar structure (*sensu* Carter *et al.* 1990). Major axes of crystals are visible only in cross-section (Fig. 4G) giving a layering whatever noticeable in longitudinal section (Fig. 4F).

REMARKS
Description is presently based exclusively on empty tubes, living specimens being lacking. Since most tubes belong to recently dead specimens, which still contain their chitinous inner layer, it can be expected that further samplings will yield living material, to integrate species description.
The new species is quite different from *H. variorugosus*, easily recognisable thanks to its peculiar sculptured tube described in Ben Eliahu & Fiege (1996) and Sanfilippo (1998). It is by far distinguishable from *H. biformis* which possesses a
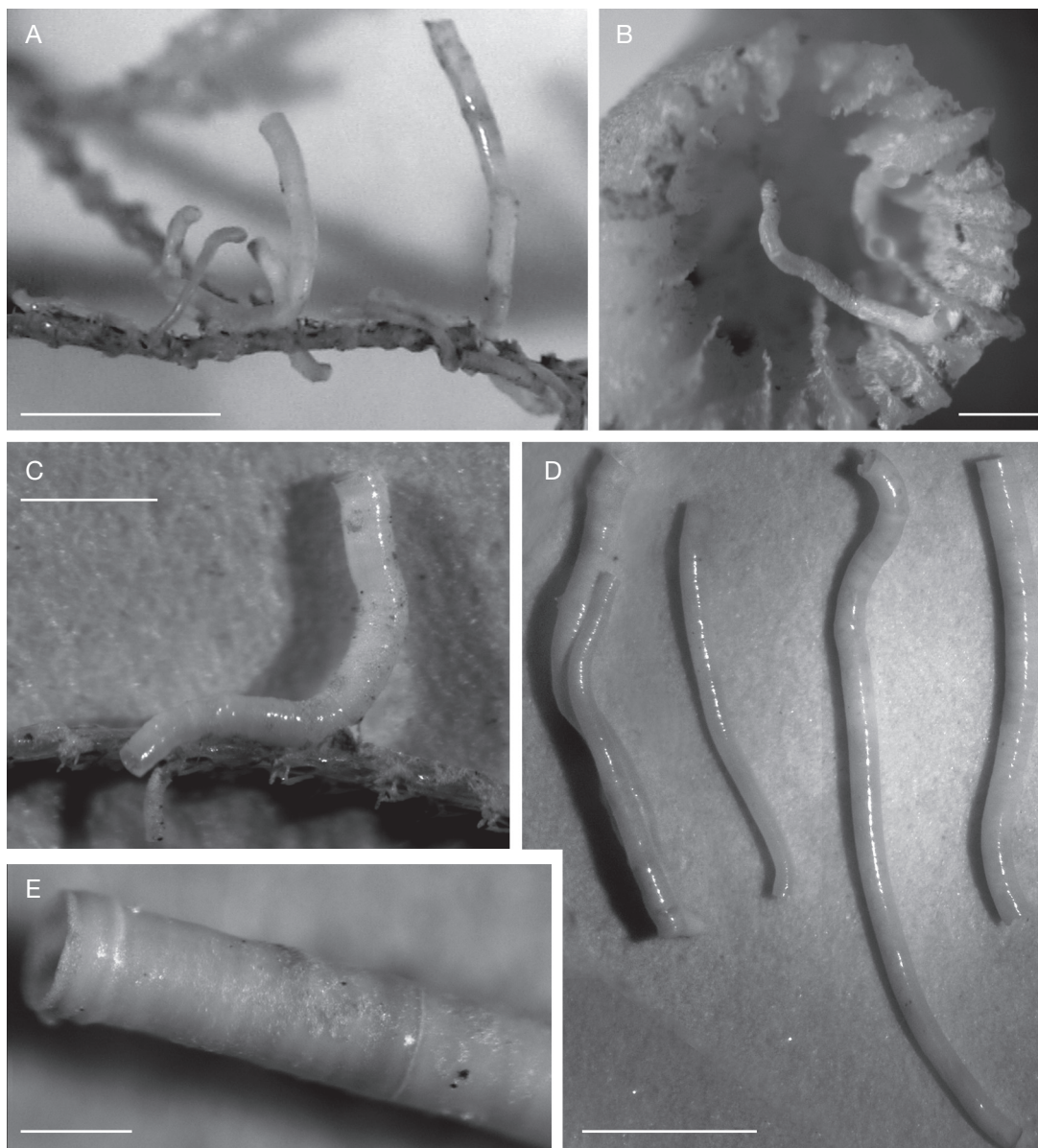
Fig. 2. — *Hyalopomatus madreporae* n. sp.: **A**, tubes encrusting an hydrozoan stalk (sample CR55); **B**, tubes inside a *Madrepora oculata* (Linnaeus, 1758) dead calice (sample AP01); **C**, an incomplete tube partially encrusting the erect flexible colony of the bryozoan *Scrupocellaria delilii* (Audouin, 1826) (sample AP01); **D**, tube distal parts delivered from muddy bottoms adjacent the coral bioconstructions (sample AP01); **E**, detail of the distal end showing weak round thickenings, the aperture is perfectly round and without peristomes (sample AP01). Scale bars: A, D, 1 mm; B, C, 500 µm; E, 200 µm.

triangular attached tube with a high dorsal keel (Hartmann 1960), and from *H. langerhansi* whose tube is flattened in its attached part, with slight lateral keels. Descriptions of other species point to less obvious tubes characters, allowing as before to distinguish their tubes from those of *H. madreporae*
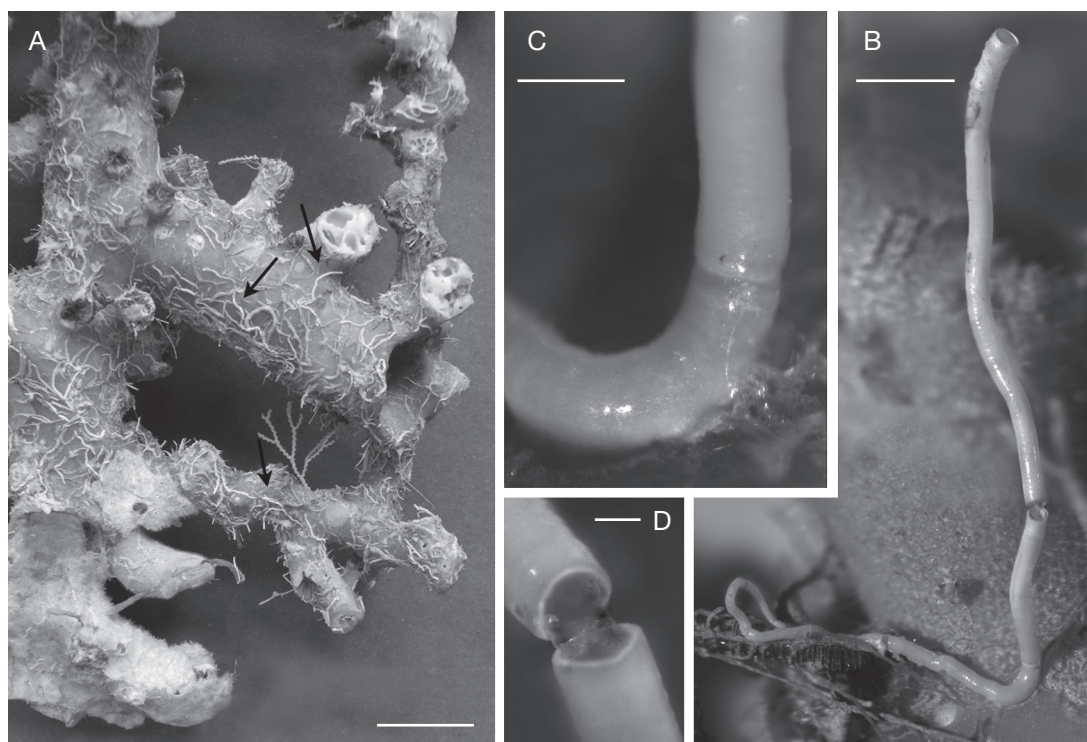
Fɪɢ. 3. — *Hyalopomatus madreporae* n. sp. (sample AP01): **A**, dead branch of the scleractinian *Madrepora oculata* (Linnaeus, 1758) heavily encrusted by epizoans among which *H. madreporae* n. sp. (arrows); **B**, holotype, a complete tube on a *M. oculata* branch; note the juvenile portion of the attached part of the tube partially encrusting an hydrozoan growing on the coral; **C**, holotype, close-up of the tube junction at the encrusting-erect parts boundary; **D**, holotype, slightly disjoined articulation to show the inner chitinous layer inside the tube. Scale bars: A, 1 cm; B, 1 mm; C, 300 µm; D, 100 µm.

n. sp.: tube of *H. cancerum* is attached for most of its length and shows a thickened base increasing area of attachment (Knight-Jones *et al.* 1997); tube of *H. mironovi* possesses weakly visible growth rings and round thickenings (Kupriyanova 1993); tube of *H. sikorskii* is circular or semicircular in cross-section and rough on its surface (Kupriyanova 1993).

Tubes of the two species *H. macintoshi* and *H. jirkovi* are merely described as smooth. Detailed observations on more than 150 tubes of *H. madreporae* n. sp., did not show any ornamentation, thus keeping *H. madreporae* n. sp. apart from most of the known *Hyalopomatus* species. Moreover, the tube of the new species is distinguishable from likewise smooth tubes of *H. macintoshi* and *H. jirkovi*, by its remarkably smaller size. In fact, the mean tube diameter in these two latter species is invariably

larger than 750-800 µm – as reported in literature descriptions or indirectly deduced from width of animals inside tubes, when any value is reported.

Only *H. variorugosus* exhibits a comparably sized tube but, as stressed above, this latter species is morphologically quite different from *H. madreporae* n. sp.

Finally, comparison of the *H. madreporae* n. sp. tube with those of *H. claparedii* (Fig. 5A-D) and *H. marenzelleri* (Fig. 5E-H) provides that tubes are reminiscent each other; they are always circular in cross-section not increasing in diameter, with proximal part scarcely encrusting substrate and distal part straight and rising from the substrate for a sizeable length. Under light microscopy magnification, tubes seem indistinctly smooth and can be discriminate only based on their sizes. The mean diameter measured for *H. claparedii* and *H. marenzelleri* is
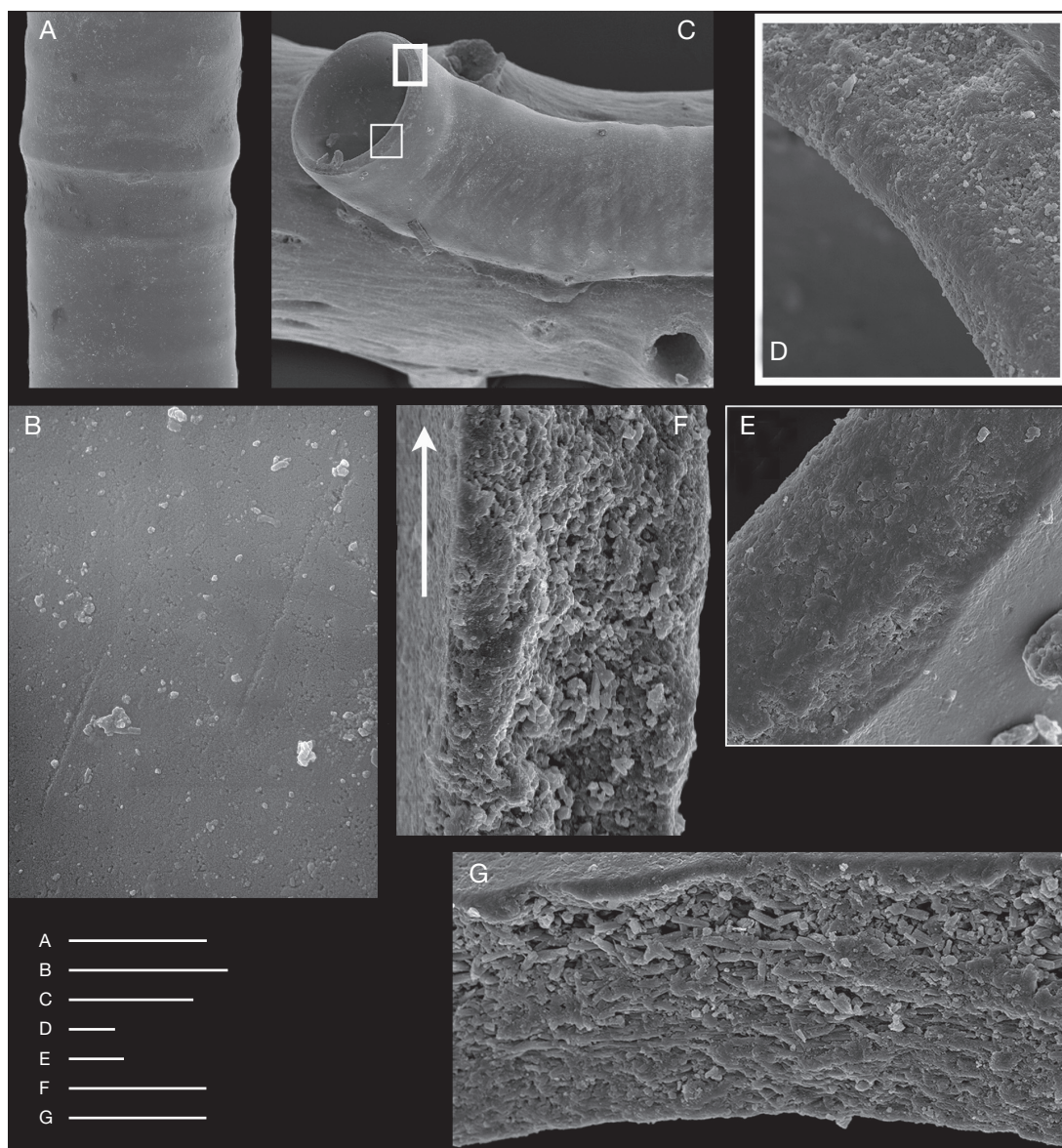
Fɪɢ. 4. — *Hyalopomatus madreporae* n. sp. (sample AP01): **A**, very weak round thickenings occurring on the distal part of the tube; **B**, micromorphology of the outer tube surface showing the cryptocrystalline amorphous covering and very weak lines of growth; **C**, proximal tube part attached on the bryozoan *Tessaradoma boreale* (Busk, 1860) with a disruption at the beginning of raised portion; **D**, **E**, close-up of the edge disruption showing no evidence of breakage as testified by the all over covering of the cryptocrystalline amorphous coat; **F**, longitudinal section of the tube wall displaying a unique layered tube wall; arrow indicates growth direction; **G**, cross-section of the tube wall with prismatic crystals criss-cross arranged; note the structure partially obliterated by an organic matter. Scale bars: A, 200 µm; B, D, E, 5 µm; C, 300 µm; F, G, 10 µm.

respectively 480 µm and 780 µm compared to 310 µm for *H. madreporae* n. sp. (compare Figures 3B and 5A, E).

Further differences can be envisaged by SEM observations on micromorphology of the outer surfaces. In *H. claparedii* the cryptocrystalline
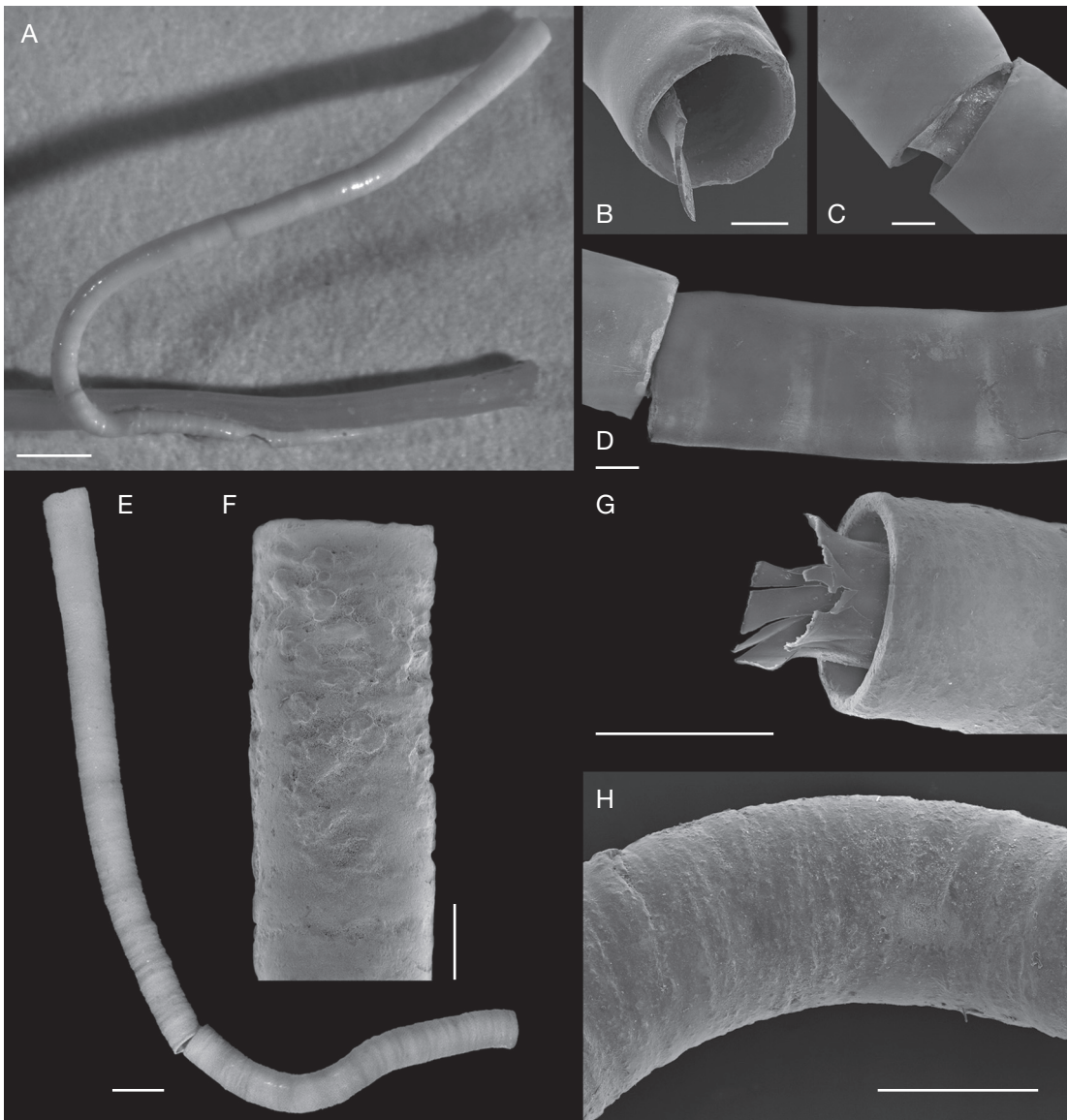
FIG. 5. — **A**-**D**, *Hyalopomatus claparedii* Marenzeller, 1878; **A**, an entire tube growing on *Isidella elongata* (Esper, 1788) (sample BIOICE 2403); **B**, detail of an interruption characterized by a regular unbroken edge (sample BIOICE 2410); **C**, close-up of a tube junction showing the inner chitinous layer (sample BIOICE 2410); **D**, completely smooth tube with weakly evident spaced circular areas corresponding to a less dense outer covering (sample BIOICE 2410); **E**-**H**, *Hyalopomatus marenzelleri* Langerhans, 1884; **E**, tube (sample BIOICE 2364); **F**, distal part of the tube showing an obvious rough surface (sample BIOICE 2697); **G**, strong growth ridges along the tube (sample BIOICE 2697); **H**, close-up of a tube interruption with a regular unbroken edge still preserving the inner chitinous layer (sample BIOICE 2697). Scale bars: A, E, 1 mm; B, C, 100 µm; D, 200 µm; F, 400 µm; G, 300 µm; H, 500 µm.

cover is less homogeneous than in *H. madreporae* n. sp., locally determining areas of loosely-patched crystals along the tube surface (Fig. 6A, B). These areas seem recurrent in accord with growth phases (Fig. 5D). Additionally, tube micromorphology in *H. marenzelleri* is even more different from that

described for *H. madreporae* n. sp., displaying an evident rough surface, especially on the distal part, and well visible traces of growth (Fig. 5F, G). At higher magnification such outer rough surface displays crystals, which are visible due to the absence of the cryptocrystalline film (Fig. 6C).

The interruptions along the tube have been observed in all specimens of the three compared species (Figs 3D; 5B, H). Though not mentioned in descriptions of other *Hyalopomatus* species, these structures probably occur in at least some species; they seem associated to lightly flaring collar rings and peristomes reported by some authors for *H. claparedii* (Kupriyanova & Jrkov 1997), *H. marenzelleri* (Zibrowius 1969) and *H. variorugosus* (Ben Eliahu & Fiege 1996; Sanfilippo 1998). Such thought is supported by Ben Eliahu & Fiege (1996: 16, fig. 6B), where high magnification displays an interruption immediately behind a peristome between the attached and raised tube parts, a position recurrent also in the new species and two congeners.

Tube wall structure that is built up of crystal layers is scarcely visible in *H. madreporae* n. sp. and *H. claparedii* in contrast to *H. marenzelleri*, which in longitudinal sections shows more obviously layers overlaying each other during growth (Fig. 6D-F).

The homogeneous microcrystalline structure of the wall in the new species (Fig. 4F, G) resembles that of *H. variorugosus* (Sanfilippo 1998) and *H. claparedii* (Fig. 6D, E), with crystals also having comparable sizes. Conversely, *H. marenzelleri* possesses more squat crystals (Fig. 6F).

Tube microanalysis

Serpulid tubes are composed of a mixture of calcium carbonate crystals and an organic matrix (Neff 1971). They are composed of magnesian calcite, aragonite or mixture of these two minerals (Bornhold & Milliman 1973). The magnesium carbonate content within serpulid tubes was documented by Bornhold & Milliman (1973) who discussed its concentration in relation with temperature and mineralogy.

SEM-EDS microanalysis on *H. madreporae* n. sp. tubes confirmed calcium as a fundamental constituent (average 45 wt%) and magnesium in extremely subordinate percentage (average 0.2 wt%). The presence of slight strontium amounts (average 1.5 wt%) can be explained considering its tendency as vicariate of Ca.

X-ray microanalyses in *H. madreporae* n. sp. revealed that concentration of carbon was relatively high within the tube wall (average 22 wt%); it is even more higher along the outer and inner surfaces of the tube (average 26 wt%); here it is mixed with the cryptocrystalline carbonate coverings (Fig. 4B, E). The presence of abundant organic matrix is also noticeable in Figure 4G where crystals inside the tube wall are partially obliterate, embedded within the organic matrix.

The organic content in *H. madreporae* n. sp. resulted more abundant than in *H. claparedii* tubes. Microanalysis on this latter species gave mean weight percentages in carbon of 16wt% inside the tube wall and of 23 wt% along outer and inner surfaces. Strontium and magnesium have been also detected (average 1 wt% and 0.3 wt% respectively), values comparable to those of *H. madreporae* n. sp.

Distribution and ecology

Hyalopomatus madreporae n. sp. is a deep-water species found in the central Mediterranean (northern Ionian sea); the Santa Maria di Leuca finding is from 497 to 1146 m depth, and corresponds to bottom-water temperatures of 13.2-15.0°C, salinities of 38.66-38.89‰ and dissolved oxygen of 145-238 μM/l (Budillon *et al.* in press).

Hyalopomatus madreporae n. sp. lives attached to tissue-barren branches and calices of living or fresh looking *Madrepora oculata*, on mound rising from muddy bottoms (Mastrototaro *et al.* in press; Rosso *et al.* in press). It also colonises some coral epibionts, like branched bryozoans and hydroids which possess weakly calcified or not mineralised skeletons (Figs 2A, C; 3B) and small-sized serpulids (raised distal ends of *Filogranula annulata* (O. G. Costa, 1861)).

Except for several distal ends that have been recorded from bottom sediments around bioconstructions, presumably detached and fallen down from coral branches, the new species was neither found on bottom substrates (firm- and hard-grounds) nor on other coral species sampled in the same area (Rosso *et al.* in press). This suggests a possibly preferential
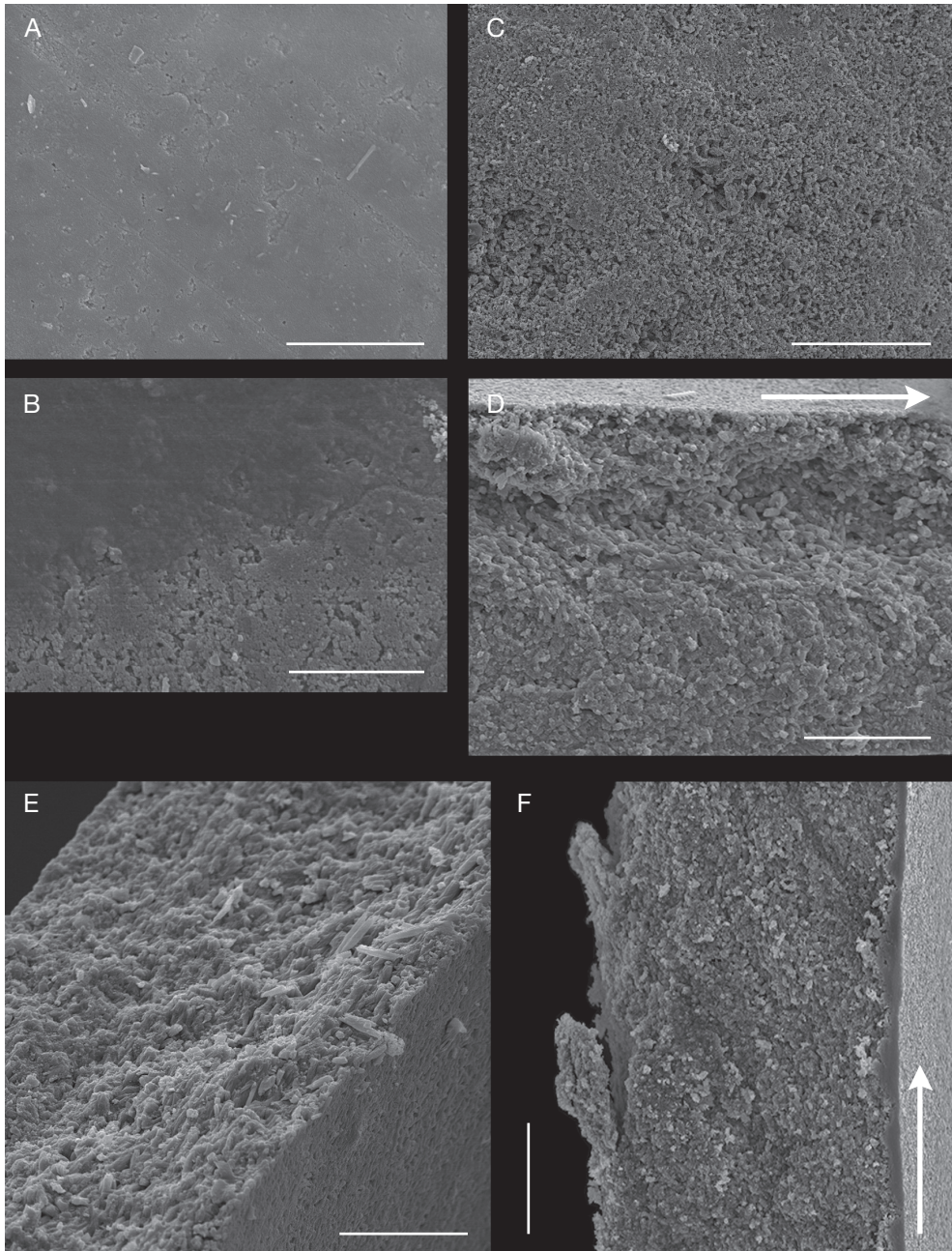
FIG. 6. — **A**, **B**, **D**, **E**, *Hyalopomatus claparedii* Marenzeller, 1878; **C**, **F**, *H. marenzelleri* Langerhans, 1884; **A**, **B**, micromorphology of outer surface consisting of a film of very small crystals forming an amorphous cryptocrystalline coat (**A**); locally (**B**) crystals are less densely packed, the inner crystals of the wall becoming partially evident (sample BIOICE 2410); **C**, micromorphology of the outer surface; crystals show a squat prismatic habitus, completely lacking in amorphous covering (sample BIOICE 2364); **D**, longitudinal section of the tube wall, arrow indicates growth direction (sample BIOICE 2364); **E**, transversal section of the tube wall, crystals of prismatic habitus are evident, arranged in a criss-cross homogeneous microcrystalline structure (sample BIOICE 2364); **F**, ultrastructure of the tube wall consisting of layers dipping towards the opening, arrow indicates growth direction. Scale bars: A, B, 5 µm; C, 40 µm; D, E, 10 µm; F, 20 µm.

selection for the scleractinian *Madrepora* and its associated small-sized epizoans. A similar ecological selectivity was also observed for *H. cancerum*, epizoic exclusively on the spider-crab *Encephaloides* (Knight-Jones *et al.* 1997).

The colonization of small-sized epizoans was also observed for *H. mironovi*, found on thin branches of the bryozoan *Striatodoma dorothea* Winston & Beaulieu, 1999 living in deep-water sponge stalk communities (Beaulieu 2001).

It is noteworthy the co-occurrence of *H. variorugosus* on the Santa Maria di Leuca coral frames, where it is generally cryptic (within calices); unlike *H. madreporae* n. sp., it also colonises shells and crevices of hard-grounds interspaced in the neighbouring bottoms from the same area (Ben Eliahu & Fiege 1996; Rosso *et al.* in press) and from other Mediterranean bathyal localities (Ben Eliahu & Fiege 1996; Sanfilippo 1998).

Furthermore, the numerous findings of *H. claparedii* and *H. marenzelleri*, during the BIOICE cruise, correspond to a depth range of 838-1215 m, with bottom-water temperatures of 3.7-5.5°C. These new records extend to the Icelandic waters the geographical distribution of both species.

DISCUSSION

Species of the genus *Hyalopomatus* are rarely recorded from deep waters. Descriptions, based on characters of soft parts, are from very few specimens and do not adequately treat tubes, which are often not figured. Except for some species exhibiting peculiar ornamentations (*H. variorugosus*), peristomes (*H. variorugosus*, *H. marenzelleri*), keels (*H. langerhansi*, *H. biformis*) or a triangular tube cross-section (*H. biformis*), tubes appear almost indistinguishable.

Taxonomic difficulties in identifying species were firstly highlighted by Zibrowius (1969) which outlines that the known species of *Hyalopomatus* are morphologically very similar and closely allied. More unlikely, based only on light microscopy, the merely tube descriptions prove to be not sufficiently detailed to discern species, as also stressed by Ben Eliahu & Fiege (1996).

Observations under SEM magnifications, permitted here to recognise some adjunctive characters usable for taxonomic distinction at specific level and for a precise point by point comparison between examined species. Such palaeontological approach permits to clearly distinguish and describe the new species based on empty tubes, the sole recorded in the area.

Furthermore, no morphological tube feature which could be considered diagnostic at a generic level, has been found for the genus *Hyalopomatus*. Thus, empty tubes could have been misidentified for *Protis* or *Filograna* species, both having similar generic tube characters. The numerous findings allowed here to emend the generic diagnosis. An adjunctive character which likely seems proper to the genus is the presence of the free distal end raising from the substratum; the descriptions of the sole two species *H. jirkovi* Kupriyanova, 1993 and *H. sirkoski* Kupriyanova, 1993 having entirely attached tubes (Kupriyanova 1993) are not liable, basing on a too little amount of material (one tube each). Further material is needed to corroborate such hypothesis. Likewise, interruptions along the calcareous tube layer would be an additional generic character. Presumably, peristomes reported in some *Hyalopomatus* descriptions could be interpreted as discontinuities if observed under SEM (see Remarks). If further material from different species could be analysed, this character could be confirmed as proper of the genus.

The numerous tube fragments and distal ends of *H. madreporae* n. sp. collected from muddy sediments near colonies may be overestimated owing to the disjoining of a unique tube in several parts, after breakage or decay of the inner organic layer.

Interruptions along the tube, both on its attached and distal part, ensure a relative flexibility, avoiding defiance of the extremely thin and fragile tube wall. It may be functional to colonise flexible and ephemeral substrates like lightly mineralised bryozoan colonies and chitinous hydrozoans on which *H. madreporae* n. sp. adheres.

A similar choice of substrates has been also observed for *H. marenzelleri* and *H. claparedii*, often encrusting on scrupocellariid and flustrid bryozoans (Rosso pers. comm., BIOICE material).

A fairly flexibility of the tube is only known for *Josephella marenzelleri* Caullery & Mesnil, 1896.

It has been attributed to a peculiar microstructure of the tube wall, also interpreted as an adaptation to colonise ephemeral substrates like flexible algal thalli (Sanfilippo 1996).

Ultrastructure of *H. madreporae* n. sp. tube, likewise *H. claparedii* and *H. marenzelleri*, displays a single crystal layer, as observed for about 75% of Recent serpulids (Vinn pers. comm.), where they are arranged in a complex crossed lamellar structure (*sensu* Carter *et al.* 1990), common in serpulids, too.

In all of the three examined species, crystals are not always similar in size showing an elongate or squat prismatic habitus. These observations confirm that the use of some ultrastructural characters like the shape and size of the tube wall crystals is still not enough for generic nor for specific determination. These characters are not related to the size or to the phylogenetic position of the worms (Nishi 1993). Moreover, they seem to depend on environmental factors like temperature, which also influences mineralogy (Bornhold & Milliman 1973).

Nevertheless, other ultrastructural characters like the distribution pattern of crystals within the wall may be constant and thus useable as adjunctive taxonomic feature. As stressed in recent studies, especially when using SEM techniques, a considerable diversity in the tube wall ultrastructure occurs among different genera. Small serpulids such as *Filogranula* Langerhans, 1884, *Filograna* Berkeley, 1827, *Protis* Helers, 1887 and *Josephella* Caullery & Mesnil, 1896 possess single layered tubes with thin walls, as here observed for *H. madreporae* n. sp. Nevertheless, other genera like *Serpula* Linnaeus, 1758 show variable tube characters within the genus.

The opaque appearance of the tube is due to the randomly arranged small crystals, as reported also for other serpulids (ten Hove & Zibrowius 1986; Zibrowius & ten Hove 1987). In contrast, the shiny surface observed in *H. claparedii* and *H. madreporae* n. sp. may be due to the very uniform criptocrystalline cover of the tube surface.

Acknowledgements

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