

<i>Bollettino della Società Paleontologica Italiana</i>	42 (1-2), 2003	ISSN 0375-7633	171-178	2 pls.	Modena, Giugno 2003
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Climatic response in the genus *Placostegus* Philippi, 1844 from Plio-Pleistocene to Recent Mediterranean, with description of a new species (Polychaeta, Serpulidae)⁽¹⁾

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KEY WORDS – *Polychaeta*, *Serpulidae*, *Placostegus*, *Systematics*, *Morphotypes*, *New species*, *Plio-Pleistocene*, *Recent*, *Mediterranean*.

ABSTRACT – The serpulid genus *Placostegus* Philippi, 1844 is represented in the Recent Mediterranean by two species: *P. tridentatus* (Fabricius, 1779), typical of deep circalittoral and bathyal bottoms, and *P. crystallinus sensu Zibrowius*, 1968 at shallower depths. *P. tridentatus* is well known from Arctic, Northern Atlantic and Mediterranean waters.

The tube of *P. tridentatus* is re-described using material from Icelandic waters, the Western and Central Mediterranean, as well as from Plio-Pleistocene sediments of Southern Italy.

An "Atlantic" and a "Mediterranean" morphotype of *P. tridentatus* are distinguished based on differences in size and morphological characters of the tubes. Some tubes from the Plio-Pleistocene are described as a new species, *Placostegus zibrowii*.

Stratigraphical, geographical and ecological distribution of these taxa are discussed.

RIASSUNTO – [Effetti climatici sul genere *Placostegus* Philippi, 1844 dal Plio-Pleistocene all'attuale Mediterraneo, con la descrizione di una nuova specie (Polychaeta, Serpulidae)] – Il genere *Placostegus* Philippi, 1844 è attualmente presente in Mediterraneo con due specie: *P. tridentatus* (Fabricius, 1779) tipico di fondi circalittorali profondi e batiali, e *P. crystallinus sensu Zibrowius*, 1968 che lo sostituisce a minore profondità. La distribuzione di *P. tridentatus* comprende le acque artiche, il Nord Atlantico e il Mediterraneo, dove, però, i popolamenti sono meno abbondanti.

Nella presente nota il tubo di *P. tridentatus* viene ridefinito, su materiale proveniente da fondi attuali dell'Islanda e del Mediterraneo, e da depositi Plio-Pleistocenici dell'Italia meridionale.

È stato osservato per *P. tridentatus* una variabilità intraspecifica, che ha permesso la distinzione di due morfotipi legati a fattori climatici e idrologici: un morfotipo "Atlantico", con un tubo di maggiori dimensioni, un lungo tratto distale eretto e spiralato, con peristomi trilobati; un morfotipo "Mediterraneo" con un tubo più piccolo, un tratto distale relativamente corto e non spiralato, privo di peristomi. Il morfotipo "Atlantico" è stato riscontrato in popolazioni attuali del NE Atlantico nonché in fondali würmiani e in depositi Plio-Pleistocenici di significato freddo del bacino mediterraneo. Il morfotipo "Mediterraneo" è stato trovato solo in fondali del Mediterraneo attuale.

Viene descritta, inoltre, una nuova specie, *Placostegus zibrowii*, su materiale del Plio-Pleistocene mediterraneo. Il tubo è caratterizzato da un tratto distale diritto e proporzionalmente lungo, con sezione triangolare isoscele, un profondo solco ventrale e tre carene fornite di spine equidistanti tra loro. La specie proviene da depositi riconducibili a biotopi di piattaforma esterna, caratterizzati da sedimenti grossolani e probabile elevato idrodinamismo.

Viene discussa la distribuzione geografica e stratigrafica dei due morfotipi, nonché di *Placostegus zibrowii*, che in base agli indizi climatici dei livelli di provenienza, sembra mostrare una affinità "temperato-calda".

INTRODUCTION

The world-wide genus *Placostegus* Philippi, 1844 mainly comprises deep-water species. In the Recent Mediterranean fauna it is represented by *P. tridentatus* (Fabricius, 1779), typical of deep circalittoral and bathyal bottoms, and *P. crystallinus sensu Zibrowius*, 1968, cryptic at shallower depths, within circalittoral concretions and caves (Zibrowius, 1971).

P. tridentatus is well known from Arctic and North Atlantic waters and also from the Mediterranean Sea (both Recent and Pleistocene). Records from Japan (Imajima, 1979) still need verification.

In this note, which is part of a current research on the bathyal Mediterranean fauna, the tube of *P. tridentatus* is re-described based on newly collected specimens from deep-waters of the Icelandic Sea, the Western and Central Mediterranean, as well as from Plio-Pleistocene deposits in Southern Italy.

Using differences in size and tube morphology, two forms of *P. tridentatus* are distinguished as the "Atlantic" and the "Mediterranean" morphotypes.

⁽¹⁾ Nota presentata alle "Giornate di Paleontologia 2002", Bolca (VR) giugno 2002.

In addition, some tubes from the Plio-Pleistocene were found distinctive and are here referred to a new species, *Placostegus zibrowii*.

The geographical and stratigraphical distribution of the three forms is discussed and it is speculated that they are related to hydrology and climate.

SYSTEMATIC ACCOUNT

Family SERPULIDAE Johnston, 1865
Genus PLACOSTEGUS Philippi, 1844

Type species – *Serpula tridentata* Fabricius, 1779.

Diagnosis – Tube semi-transparent (opalescent) to transparent, triangular in cross section with a dorsal keel.

PLACOSTEGUS TRIDENTATUS (Fabricius, 1779)

Diagnosis – Tube as for genus, with one dorsal toothed or spiny keel. Proximal part encrusting, distal end free with three keels protruding into three teeth around its mouth. Tube wall thick and strong, consisting of elongate isoriented and closely packed prismatic crystals.

"Atlantic" morphotype
Pl. 1, figs. 1-5

Description – Tube opalescent and large-sized, up to 8 cm in length (outer mean diameter: 2.8 mm). Proximal part attached to substrate, usually coiled in a loosely inter-twined mass; triangular in cross section, with one dorsal toothed keel. Distal end free for a considerable part of the tube, often spirally twisted (Pl. 1, figs. 1-3). Triangular or sub-circular in cross section, with three longitudinal keels continuing into three strong teeth around its mouth (Pl. 1, fig. 4). Keels bearing rare irregularly spaced teeth. Trilobed peristomes (more numerous and pronounced in fossil specimens) may precede the opening (Pl. 1, figs. 4-5).

Examined material –

Fossil:

- Capo Milazzo (NE Sicily), late Pliocene. Top part of the Cala S. Antonino outcrop, bathyal marls with *Neovermilia falcigera* (Roule, 1898) and *Vitreotubus digeronimoi* Zibrowius, 1979. Several tubes.
- Salice (NE Sicily), Early Pleistocene. Deep-water silty sands with *Hydroides norvegicus* Gunnerus, 1768. Several tubes.
- Canale (Southern Calabria), Early Pleistocene. Bathyal muds with *Neovermilia falcigera* and *Vitreotubus digeronimoi*. Several tubes.
- Archi (Southern Calabria), Early to Middle Pleistocene. Bathyal marls with *Neovermilia falcigera* and *Filogranula stellata* (Southward, 1963). A few tube fragments.
- Lazzaro (Southern Calabria), Middle Pleistocene. Bathyal marls with embedded boulders colonised by *Neovermilia falcigera* and *Vitreotubus digeronimoi*. A few tubes encrusting on boulders and fragments within marls.
- "del Toro" Canyon, (SW Sardinia), dredged Würmian muds, 400 m. A few tube fragments.

EXPLANATION OF PLATE 1

Figs. 1-9 - *Placostegus tridentatus* (Fabricius, 1779).

1-3) Tubes of the "Atlantic" morphotype. Proximal part loosely inter-wound, with a toothed dorsal keel; distal part free and spirally twisted, with three smooth or irregularly toothed keels. 1, 2) Iceland, sample BIOICE 2725; 3) Salice (Eastern Sicily), Early Pleistocene. Scale bars 3 mm. 4) "Atlantic" morphotype. Distal part of the tube showing the mouth surrounded by three strong teeth, peristomes and previous growth stages. Iceland, sample BIOICE 2725. Scale bar 3 mm. 5) "Atlantic" morphotype. Distal part of the tube with well-developed peristomes. Capo Milazzo (NE Sicily), top part of the Cala S. Antonino outcrop. Late Pliocene. Scale bar 2 mm. 6) "Mediterranean" morphotype. Tube of living specimen overgrowing a bryozoan colony. Proximal part U-shaped, with a dorsal spiny keel. Rare spines or keels in distal part. Ciclopi Islands (Ionian Sea), sample 2G. Scale bar 2 mm. 7) "Mediterranean" morphotype. Tube encrusting a bivalve shell. Proximal part longer than distal part, with a three-toothed mouth. Port Cros (NW Mediterranean). Scale bar 2 mm. 8) "Mediterranean" morphotype. Tube fragment (proximal part) with a spiny dorsal keel and two smooth lateral keels. Ciclopi Islands (Ionian Sea), sample 2G. Scale bar 3 mm. 9) "Mediterranean" morphotype. Distal end of tube, with three keels continued into three spines at its mouth. Ciclopi Islands (Ionian Sea), sample 2G. Scale bar 1 mm.



Recent:

- NE Atlantic (all around Iceland). BIOICE stations: 45 dredges from 86 to 1,410 m (alive). 139 living specimens + ca. 400 empty tubes (higher abundance from 300 to 400 m) associated with *Hydroides norvegicus* and *Ditropa arietina* (Müller, 1776).

"Mediterranean" morphotype
Pl. 1, figs. 6-9; Pl. 2, figs. 1-2

Description – Tube transparent and small-sized, up to 2.5 cm in length. Mean outer diameter 1.8 mm (Pl. 2, fig. 2). Proximal part encrusting, often folding on itself like an U-shape. It is triangular in cross section, with one dorsal spiny keel (Pl. 1, figs. 6-7); two lateral smaller and smooth keels are also present (Pl. 1, fig. 8; Pl. 2, fig. 1). Distal part about one half of the tube, free, not spirally coiled, triangular in cross-section, with three longitudinal keels continuing into three spines at its mouth (Pl. 1, figs. 7, 9). Keels usually smooth or with rare spines; peristomes absent (Pl. 1, fig. 6).

Examined material –

Recent:

- NW Mediterranean: Port Cros, 230 m (alive), Zibrowius collection.
- Tyrrhenian Sea: Pontine Islands, several stations from 73 to 97 m (one living specimen and a few empty tubes). Ustica, 80 m (68 empty tubes). Eolian Islands, 300 m (a few empty tubes). Basin of Gioia, 287 m (a few empty tubes). Ficarella Cave (Palermo), 20 m (one tube fragment).
- Ionian Sea: off Acitrezza, stations from 80 and 110 m (6 living specimens + 227 empty tubes). Ciclopi Islands, several stations from 85 to 107 m (2 living specimens + ca. 50 empty tubes). Gulf of Noto, 50 and 110 m (several tube fragments).
- Sicily Strait: Graham Bank. Post-Würmian deposits, 212 and 220 m (8 empty tubes).

Distribution – *Placostegus tridentatus* lives in lower circalittoral to bathyal bottoms. The record from a submerged cave in the Tyrrhenian Sea at a depth of 20 m (Di Geronimo *et al.*, 2001), here reported in chapter "Examined material", is attributable to an external incoming. Bellan (1964) considered the species as preferential of the White Corals Biocoenosis defined by Pérès & Picard (1964).

The Recent distribution of *P. tridentatus* comprises the Arctic and Boreal NE Atlantic and the entire Mediterranean, to the Levant Basin (Nelson-Smith, 1967; Zibrowius, 1971, 1973, 1979a; Bianchi, 1981; Ben Eliahu & Fiege, 1996; Kupriyanova & Jirkov, 1997; Kupriyanova & Badyaev, 1998), where its deepest record is from 943 m off Turkey.

Within that range the "Atlantic" morphotype is restricted to the NE Atlantic, whereas the present-day Mediterranean populations show the "Mediterranean" morphotype.

Conversely, fossil Mediterranean *P. tridentatus* is of the "Atlantic" form. It is common in Plio-Pleistocene beds of the Messina Strait area (Barrier *et al.*, 1989, 1996; Di Geronimo *et al.*, 1998), within deep circalittoral-bathyal assemblages. Samples here reported are from an inferred palaeo-depth of not less than 500-600 m for Lazzaro, Archi and Canale in Calabria, and of 100-500 m for the Salice beds in Sicily.

Remarks – *P. tridentatus* was originally described from the Norway by Fabricius (1779). A detailed re-description is that by Kupriyanova & Jirkov (1997). It is well recognisable by its transparent tube.

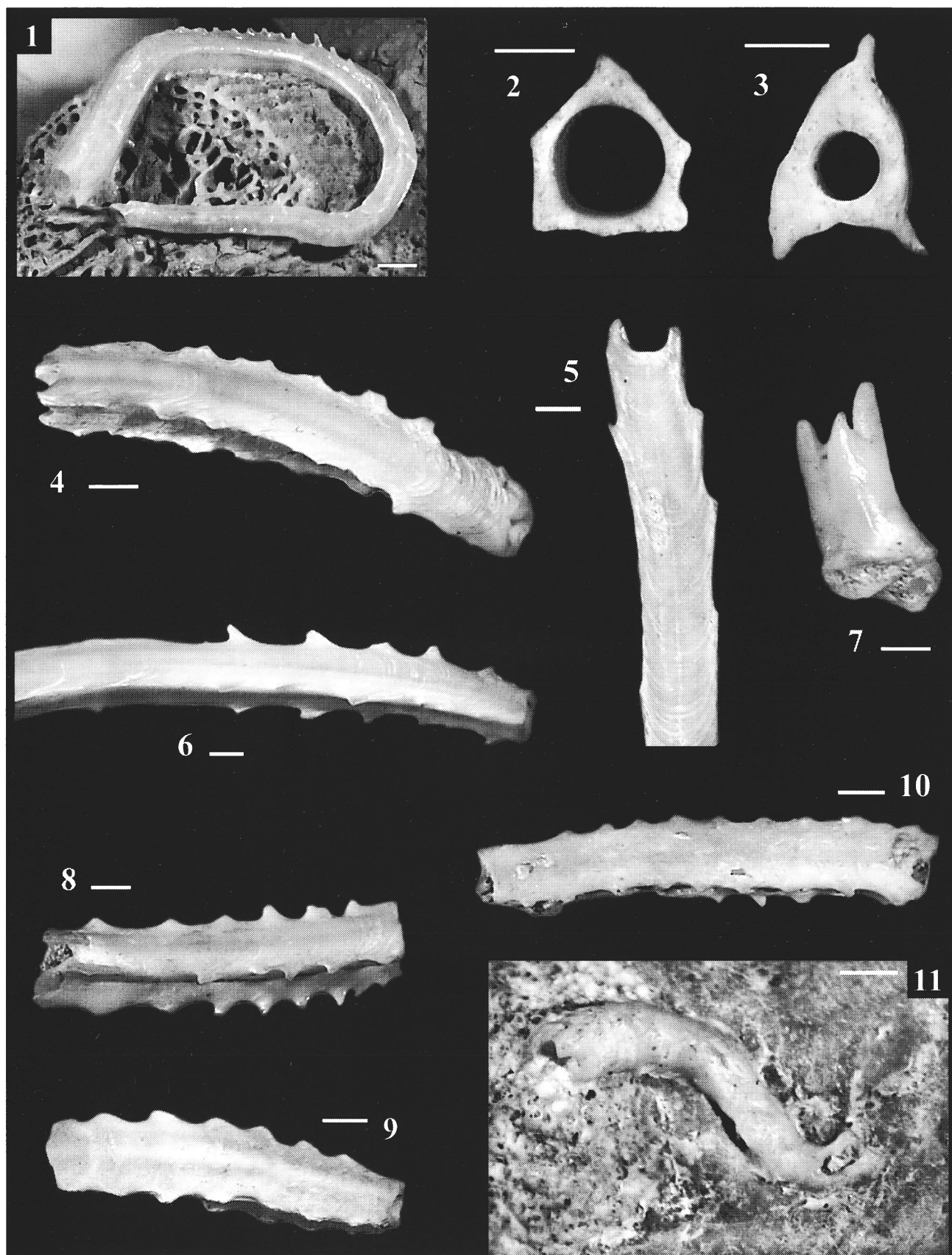
EXPLANATION OF PLATE 2

Figs. 1-2 - *Placostegus tridentatus* (Fabricius, 1779).

1) "Mediterranean" morphotype. Proximal part with a spiny dorsal keel and two smooth lateral keels. Graham Bank (Sicily Strait), sample CR8/90. Scale bar 1 mm. 2) "Mediterranean" morphotype. Triangular cross-section of the tube (proximal part). One dorsal keel and two small lateral keels. Ciclopi Islands (Ionian Sea), sample 2G. Scale bar 1 mm.

Figs. 3-11 - *Placostegus zibrowii* n.sp.

3) Distal end of the tube in cross-section, isosceles triangular. Tube wall proportionally thick. Capo Milazzo (NE Sicily), sample 1(1999), Late Pliocene. Scale bar 1 mm. 4-6) Montalbano Jonico (Eastern Lucania), sample IQ2, Middle Pleistocene. 4) Holotype. Distal end of the tube with three spiny keels continued into three short teeth at its mouth; 5) Paratype. Distal end of tube; 6) Paratype. Distal fragment with spiny keels. Scale bars 1 mm. 7) Distal part of the tube showing the mouth surrounded by three short teeth. Serra San Biagio (NE Sicily), sample WVA7, Early Pleistocene. Scale bar 1 mm. 8) Distal fragment with three keels bearing regularly spaced spines. Serra San Biagio, eastern side of the hill, (NE Sicily), ? Late Pliocene. Scale bar 1 mm. 9) Distal fragment. Pavigliana (Southern Calabria), level 8, Late Pliocene. Scale bar 1 mm. 10) Distal end of the tube. Capo dell'Armi (Southern Calabria), Early Pleistocene. Scale bar 1 mm. 11) Tube encrusting on a pebble. Serra San Biagio (NE Sicily), sample WVA7, Early Pleistocene. Scale bar 1 mm.



The two morphotypes of *P. tridentatus* differ in size and morphological characters, as summarised in Tab. 1.

The "Atlantic" morphotype is most similar to specimens described and figured by Kupriyanova & Jirkov (1997) from the Arctic and Northern Atlantic. On the contrary, all the examined Recent Mediterranean specimens belong to the "Mediterranean" morphotype. Previous literature on *P. tridentatus* from Mediterranean areas is undetailed concerning the tubes.

PLACOSTEGUS ZIBROWII n. sp.

Pl. 2, figs. 3-11

Holotype – Distal end of a tube (Pl. 2, fig. 4).

Paratypes – 4 tube fragments.

Type locality – Montalbano Ionico, sample IQ2.

Repository – Paleontological Museum, Catania University, Department of Geological Science, PMC.S3.12.04.02.

Etimology – Named for Helmut Zibrowius, specialist in serpulids.

Description – Tube opalescent and small-sized, with a relatively thick wall. Outer mean diameter: 2 mm; inner mean diameter: 0.8 mm (Pl. 2, fig. 3). Cross-section of distal part isosceles triangular, the ventral side shorter (Pl. 2, fig. 3). Proximal encrusted part triangular in cross section, with one dorsal spiny keel (Pl. 2, fig. 11). Distal part straight and erect, with three longitudinal keels bearing regularly spaced spines (Pl. 2, figs. 4-6, 8-10) with a groove along its ventral side. Each keel terminating into a short tooth, surrounding the mouth. Peristomes absent (Pl. 2, fig. 7).

Examined material –

- Serra San Biagio (Eastern Sicily), eastern side of the hill. ? Late Pliocene. Deep-water sandy silts with lunulitiform bryozoans and *Ditrupa gracillima* (Grube, 1878). One distal end.
- Capo Milazzo (NE Sicily), basal part of the Cala S. Antonino outcrop, sample 1(1999). Late Pliocene (MPL5). Deep-water coarse sandy marls. One abraded distal end.
- Pavigliana (Southern Calabria), mid part of the outcrop (level 8). Late Pliocene. Current-swept deep-sea coarse sands. 3 distal ends.
- Serra San Biagio (Eastern Sicily), quarry (sample WA7). Early Pleistocene. Deep-water silts. 23 distal ends and 2 attached parts.
- Capo dell'Armi (Southern Calabria), Early Pleistocene. Deep-water cliff, together with *Dendrophyllia cornigera* (Lamorous). One abraded fragment.
- Montalbano Jonico (Eastern Lucania), upper part of Early Pleistocene to Middle Pleistocene. Samples IQ2, VbQ2. Deep circalittoral silty-clays. One distal part (holotype) and 4 specimens (paratypes) from sample IQ2 (Middle Pleistocene); 3 distal ends from sample VbQ2 and further 6 fragments from the same outcrop.

Distribution – Presently, *P. zibrowii* n.sp. is known only from Upper Pliocene to Middle Pleistocene deposits of Southern Italy, recent sightings being absent. This suggests a present-day disappearance for this species, which could be considered as a Mediterranean palaeoendemic.

It seems to have lived at about the same depth as *P. tridentatus*: the studied material originates from layers referred to deep-circalittoral and bathyal depositional environments. At the type locality specimens were found with-

"Atlantic" form	"Mediterranean" form
Large-sized tube	Small-sized tube
Proximal part usually coiled	Proximal part usually folding on itself
Distal end free for a long part	Distal end proportionally short
Distal part triangular to sub-circular in cross section	Distal part triangular in cross-section
One dorsal toothed keel; lateral keels absent	One dorsal spiny keel and two lateral smooth keels
Three-toothed mouth	Three-spiny mouth
Trilobed peristomes	Peristomes absent

Tab. 1 - Differences in morphological characters of the tube in the two forms of *P. tridentatus*.

in a pelitic sequence cropping out in the Montalbano Jonico area (Ciaranfi *et al.*, 2001). Sample IQ2 (including the holotype) dates from the Middle Pleistocene (*Pseudoemiliana lacunosa* Zone), falling within the Isotopic Stage 19. The depositional environment is referred to a deep-circalittoral biotope, as testified by faunistic (benthic invertebrates, otoliths) and taphonomic data (Ciaranfi *et al.*, 2001). Palaeo-depths of 100-120 m and 300-500 m are respectively inferred for beds from Pavigliana (Barrier *et al.*, 1987) and Serra San Biagio. The assemblage from Capo Milazzo and Capo dell'Armi point to deeper biotopes, but they are probably reworked (two abraded tube fragments). In most localities, *P. zibrowii* comes from layers where sedimentological features (cross-bedding structures and coarse sediments) testify deep facies marked by bottom currents.

In the Serra San Biagio Pliocene layer the co-occurring lunulitiform bryozoans and *Ditrupa gracillima* suggest some "warmer" episode. Likewise, the Montalbano Jonico Middle Pleistocene does not coincide with coldest glacial peaks, as corroborated by isotopic and faunistic data (Ciaranfi *et al.*, 2001). Fish fossils from the type locality (sample IQ2) also point to a "warmer" episode, with the record of *Bonapartia pedaliota* Goode & Bean, 1896, now having a sub-tropical distribution (Girone & Varola, 2001) in the Atlantic.

Remarks – *Placostegus zibrowii* n.sp. is similar to *P. tridentatus*, particularly to its "Mediterranean" morphotype, in tube size and shape. However, it is characterised by its distal part being straight and long, isosceles in cross-section, marked by a ventral groove, and having spines regularly spaced along the three keels.

These characters seem to differentiate *P. zibrowii* from all congeners in the Mediterranean and Atlantic: *P. assimilis* McIntosh, 1885 has fine transverse wavy ridges on the tube, up into the distal part (Zibrowius, pers. comm.); *P. langerhansii* Marenzeller, 1893 has its proximal tube part typically coiled-up into a cone.

CONCLUSIONS

P. tridentatus is a frequent component of the Recent Arctic, NE Atlantic and Mediterranean deep-bottom serpulid assemblages. In Würmian Mediterranean sediments and in bathyal cold Plio-Pleistocene deposits of Southern Italy it is present as well. In the Plio-Pleistocene deposits, *P. tridentatus* shows the "Atlantic" morphotype which in the Recent lives in the NE Atlantic, but not in the Mediterranean. Its disappearance from the Mediterranean (no longer present in post-Würmian palaeocommunities, Di Geronimo *et al.*, 1993) could be related to the warming of Mediterranean deep waters during Late Quaternary. At this time, variations in climate and hydrology caused drastic changes in the deep benthos, including the extinction of various taxa (Di Geronimo *et al.*, 1996; Di Geronimo & La Perna, 1997; Rosso & Di Geronimo, 1998).

Palaeoecological and palaeoclimatical extrapolations from fossil assemblages comprising the "Atlantic" morphotype of *P. tridentatus* point to cold phases characterised by marked "oceanic" conditions (Barrier *et al.*, 1989; Di Geronimo *et al.*, 1996), with near bottom temperatures below 8-10° C. This is the environment required in the NE Atlantic by the cold stenothermal serpulids *Neovermilia falcigera* and *Vitreotubus digeronimoi* (Zibrowius, 1979b; Zibrowius & Ten Hove, 1987). Profound changes in hydrology and the establishment of deep-water homothermy, reduced the number of cold-water species, like *P. tridentatus* ("Atlantic morphotype"). Present Mediterranean populations of *P. tridentatus* have smaller-sized tubes than their Atlantic counterparts. Decrease in size was observed by Zibrowius (1973) also within the Atlantic, where *P. tridentatus* becomes smaller within lower latitudes (Madera).

Placostegus zibrowii n.sp. was found in outer-shelf palaeoenvironments frequently characterised by sand-grained sediments and reophilic conditions. In the Late Pliocene and the Early and Middle Pleistocene these records seem to correspond to "temperate-warm" episodes. The species later disappeared from the Mediterranean basin, with the accentuation of glacial phases.

ACKNOWLEDGEMENTS

The author is grateful to: Dr G. Vidir Helgason (Institute of Biology, University of Reykjavik) for giving access to Icelandic material; Prof. T. D'Alessandro (Bari University) for providing material from Lucania; Dr H. Zibrowius (Station Marine d'Endoume, Marseilles) for providing specimens from the NW Mediterranean.

Paper financially supported by 60% grants (Rosso).

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(manuscript accepted November 18, 2002)

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