Rivista Italiana di Paleontologia e Stratigrafia	volume 105	numero 3	tavole 1-2	pagine 455-464	Dicembre 1999

NOTA BREVE - *SHORT NOTE*

DITRUPA BREVIS N. SP., A NEW SERPULID FROM THE MEDITERRANEAN NEOGENE WITH COMMENTS ON THE ECOLOGY OF THE GENUS

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Received April 24, 1999; accepted October 24, 1999

Key words: Ditrupa, new species, Neogene, southern Italy, biometry, microstructure.

Riassunto. Viene descritta la nuova specie *Ditrupa brevis* (Polychaeta, Serpulidae) riscontrata in sedimenti siltosi del Pliocene medio di Tufara (Italia meridionale). *D. brevis* è stata anche segnalata per il Miocene superiore della Calabria. Il paleoambiente, in base alle faune associate, corrisponderebbe ad un fondale infralitorale o circalitorale superiore.

Rispetto a *D. arietina* la specie ha un tubo più piccolo, meno affusolato verso l'apice e presenta frequenti inspessimenti circolari della parete ("annuli") in prossimità dell'apertura.

Osservazioni al microscopio elettronico a scansione su fratture trasversali del tubo hanno evidenziato una microstruttura, comune anche al genere, caratterizzata dalla presenza di due strati: uno esterno trasparente con grossi cristalli isoorientati ortogonalmente al tubo, ed uno interno bianco opaco, più sottile, con cristalli prismatici di piccole dimensioni, a struttura incrociata.

I tubi di *Ditrupa* costituiscono il substrato per numerosi organismi epifaunali; la loro elevata densità in un fondale può influenzare composizione e diversità delle comunità di fondo mobile associate.

Sono ipotizzate differenti posizioni di vita di *Ditrupa* in rapporto al substrato, dovuti alla sua capacità di risposta alla dinamica del fondo mobile in cui vive.

Abstract. The new species *Ditrupa brevis* (Polychaeta, Serpulidae) is described from Middle Pliocene silts of southern Italy. It is also reported from Upper Miocene sediments of southern Italy. The associated faunas suggest an infralittoral or upper-circalittoral distribution.

A morphometrical and microstructural analysis of tube was carried out. *D. brevis* closely resembles *Ditrupa arietina* but several morphometrical differences allow to discriminate the two species.

The *Ditrupa* tubes provide a substrate for a diversified epifauna. Their high density greatly affects species composition and diversity of soft-bottom communities.

It is concluded that *Ditrupa* can live in various positions with respect to the sediment surface, depending on local sedimentation rate and dynamics.

Introduction.

Ditrupa Berkeley, 1835 is the only serpulid genus characterised by an unattached tusk-shaped tube. It has a long history of taxonomic confusion, early descriptions being poor, often based on empty tubes, which are rather featureless. This often led to misidentify *Ditrupa* as scaphopod molluscs and vice versa.

Ditrupa has been associated with many serpulid genera in identification keys (*Placostegus*, *Vermiliopsis* s.l., *Bonhourella*, *Sclerostyla*, *Dasynema* and *Marifugia*) but it really seems to set well apart systematically. In some cases, even the genus has been misinterpreted. In the palaeontological literature the taxonomic confusion has been greater: representatives of the genus *Ditrupa* often were placed erroneously with other serpulids and vice versa. An example is given by the serpulid *Serpula libera* Sars, 1835 later placed into the synonymy of *D. arietina*.

Ditrupa is known since the Tertiary: Paleocene-Eocene of Spain (Gaemers, 1978), Miocene of Taiwan and Australia (Cheng, 1974; ten Hove & Smith, 1990). It is common in Mediterranean Plio-Pleistocene sediments.

Ditrupa arietina O. F. Müller, 1776 occurs in the eastern Atlantic (from Iceland to Azores, Canary Islands and Senegal) and the Mediterranean. Ten Hove & Smith (1990) re-described a distinct species, *Ditrupa gracillima* Grube, 1878, from the Indo-Pacific and on this occasion gave a thorough review on *Ditrupa taxonomy*, morphology and ecology.

Here, a new species of *Ditrupa* from the Neogene of southern Italy is described.

Materials and methods.

The examined material of the new species *Ditrupa brevis* originates from Miocene and Pliocene silty deposits, in southern Italy:

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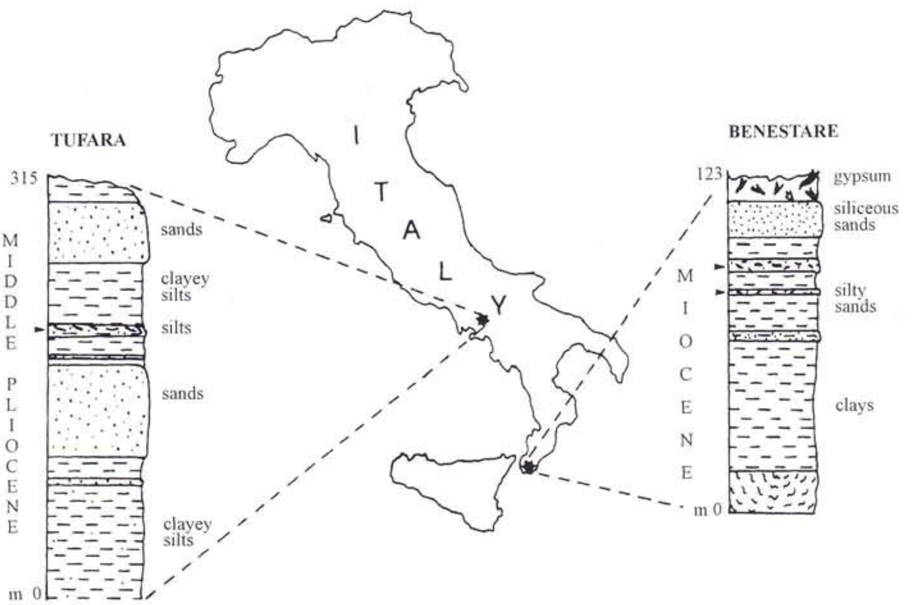


Fig. 1 - Location of Tufara and Benestare sections. Arrows point layers containing to *D. brevis*.

Tufara. This section is ca. 300 m thick and crops out along the eastern edge of the Caudina Valley, SW of Benevento (Fig. 1). It consists of alternating clayey silts and sands Middle Pliocene in age (MPL5 Zone) (De Castro Coppa et al., 1969; Violanti, unpubl. data). Faunas testify an upper-circalittoral palaeoenvironment in the basal part of the section, evolving to infralittoral upwards (Barbera et al., 1995). Near the contact with the sandy levels, some silty layers with *Corbula gibba* and *Ditrupa brevis* occur, corresponding to the present-day Heterogeneous Communities. These layers contain species of different biocoenoses and are characterised by quasi-permanent instability of qualitative and quantitative faunal composition (Picard, 1965). The type material of the new species is from these silty beds. The tubes are often broken (more than 1,000 tube fragments).

Benestare. This section is located ca. 1 km NW of Benestare (Fig. 1). It is a classic locality, originally reported on by Seguenza (1879-80) Late Miocene and probably Tortonian in age. The sequence is made of clays, 100 m thick, with silty-sandy layers on its upper part and a fossiliferous level of siliceous sands and Messinian gypsum.

Ditrupa brevis comes from two silty layers (Benestare I and Benestare II) at the top of the clayey bed. Fragmented tubes largely prevail. Samples also contain abundant *Corbula gibba* and lunulitiform bryozoans, indicating Heterogeneous Communities (Di Geronimo et al., 1992).

Some populations of *Ditrupa arietina* from Pliocene, Pleistocene and Recent sediments, were also studied:

Diolo. Along the Stramonte River in Western Emilia, northern Italy. Material comes from a silty-sandy layer 2 m thick, within a clayey-silty sequence of Middle Pliocene age. It contains circalittoral faunas referable to a Coastal Detritic Assemblage (Di Geronimo et al., 1992). The presence of sedimentary instability indicators among molluscs and bryozoans, together with the dominance of *Corbula gibba* and *D. arietina*, suggests an incipient turbidity (see Di Geronimo & Robba, 1989).

Ionian Sea dredges. Gulf of Noto (off SE Sicily): Stn. PS/81 5B (- 47 m), 36°52.98' N, 15°10.48' E; Stn. PS/81 5C (- 34 m), 36°53.30' N, 15°09.82' E. Samples consist of biogenic sands containing faunas referable to the Coastal Detritic Assemblage.

Catania Gulf dredges. Stn. CT/11 (-110 m), 37°29.15'N, 15°09.05'E. Sandy gravels containing würmian faunas (Di Geronimo & Li Gioi, 1980) including several tubes of *D. arietina*; Acitrezza, Stn. AC/50 (- 50 m) dredged ca. 1 km off the coastline. Volcanic sands containing circalittoral faunas referable to a Coastal Detritic Assemblage swept by bottom currents.

Tyrrhenian Sea dredges. Off Patti, Stn. PD4 (- 50 m), 38°09.40'N, 15°02.19'E. Muddy sands with faunas belonging to the Coastal Detritic Assemblage subject to an incipient turbidity.

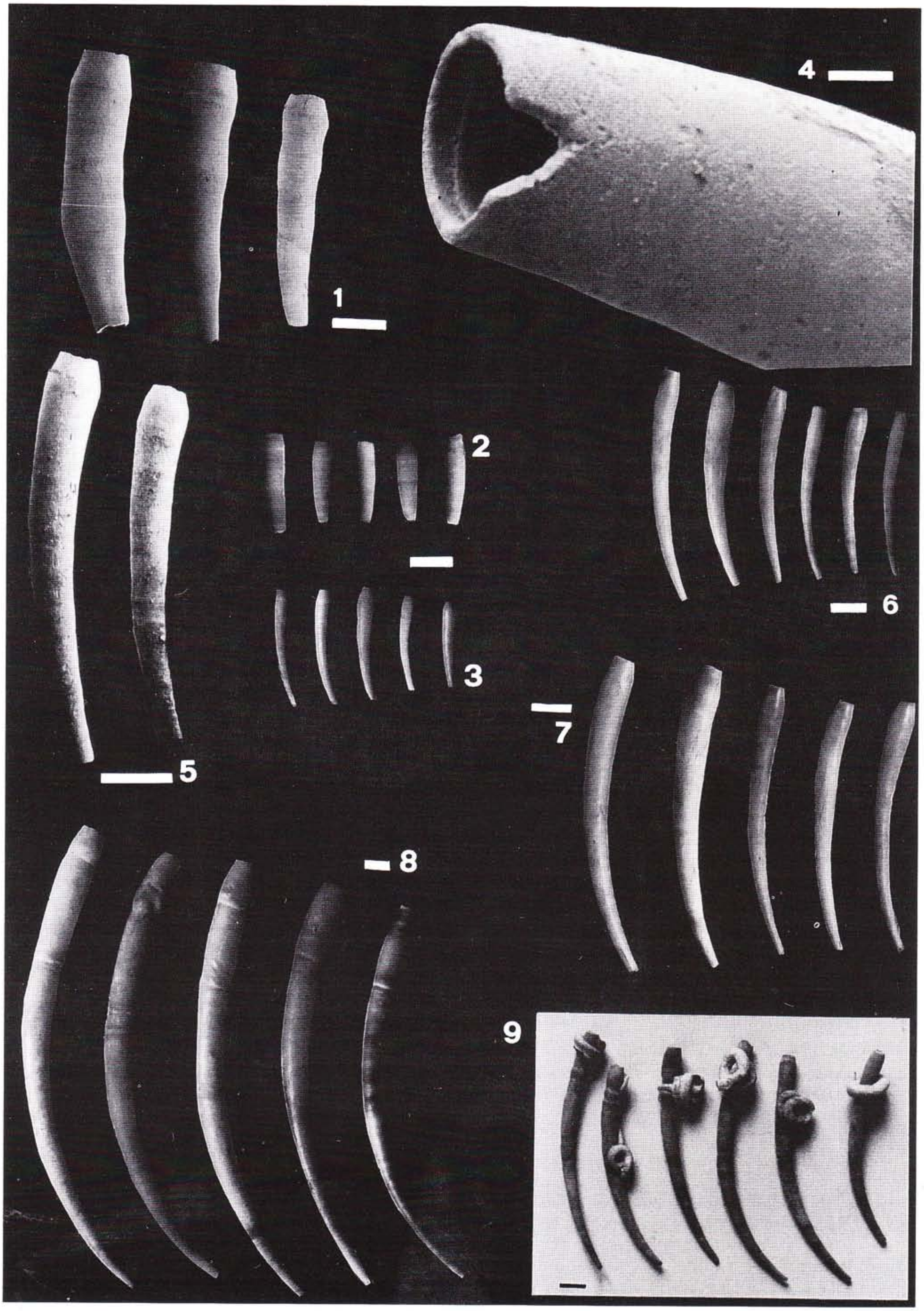
Measurements were taken from Recent and fossil specimens of *Ditrupa*, mainly following the method proposed by ten Hove & Smith (1990) (Fig. 2). Only whole tubes were measured.

Values and standard deviation of each morphometric character have been compiled (Tab. 1). Pearson correlation coefficients between data were cluster analysed (Figs. 3, 4), using the average linkage method (Sokal & Sneath, 1963; Sneath & Sokal, 1973).

PLATE 1

Scale bar = Fig. 1-3: 0.6 mm; Fig. 4: 150 µm; Fig. 5, 7, 8: 1 mm; Fig. 6: 200 µm; Fig. 9: 3 mm.

Fig. 1) *Ditrupa brevis*, holotype (on the right) and paratypes. Tufara, Middle Pliocene. Fig. 2) *Ditrupa brevis*. Benestare, Miocene. Fig. 3) Small-sized *Ditrupa arietina*. PS/81 5B, Recent. Fig. 4) Apex of *D. brevis*. The rim consists only of the outer hyaline layer. Tufara, Middle Pliocene. Fig. 5) *D. arietina*. Diolo, Middle Pliocene. Fig. 6) *D. arietina*. PS/81 5C, Recent. Fig. 7) *D. arietina*. PD 4, Recent. Fig. 8) Large *D. arietina*. CT/11, Würmian. Fig. 9) *D. arietina* with *Hydroides norvegicus* coiling around the anterior ends of tubes. CT/11, Würmian.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	Chord (mm)	Height (mm)	mean D. (mm)	D. mouth (mm)	D. apex (mm)	Arcuation (%)
Ditrupa brevis						
Tufara 10	2.60-**3.16**-3.80 (SD = 0.38)	0.05-**0.11**-0.20 (SD = 0.05)	0.40-**0.55**-0.75 (SD = 0.09)	0.40-**0.49**-0.58 (SD = 0.05)	0.30-**0.36**-0.44 (SD = 0.03)	1.70-**3.26**-5.20 (SD = 1.15)
Benestare1 23	2.70-**4.68**-9.80 (SD = 1.63)	0-**0.22**-0.50 (SD = 0.13)	0.28-**0.64**-1.50 (SD = 0.18)	0.35-**0.53**-0.81 (SD = 0.12)	0.28-**0.38**-0.50 (SD = 0.07)	0-**4.48**-8 (SD = 1.8)
Benestare 2 30	2.01-**4.07**-7.50 (SD = 1.5)	0.02-**0.13**-0.50 (SD = 0.11)	0.29-**0.60**-0.95 (SD = 0.15)	0.34-**0.53**-0.75 (SD = 0.11)	0.28-**0.37**-0.56 (SD = 0.07)	1-**2.82**-7 (SD = 1.58)
Ditrupa arietina						
AC/50 143	3.30-**6.84**-12 (SD = 1.44)	0.2-**0.52**-1.10 (SD = 0.21)	0.55-**0.79**-1.10 (SD = 0.14)	0.45-**0.65**-0.85 (SD = 0.09)	0.2-**0.37**-0.55 (SD = 0.07)	4.17-**7.43**-12.31 (SD = 2.15)
PD 4 97	2.60-**9.61**-22 (SD = 4.28)	0.50-**1.08**-1.03 (SD = 0.63)	0.25-**0.79**-1.40 (SD = 0.28)	0.30-**0.71**-1.70 (SD = 0.24)	0.15-**0.32**-0.55 (SD = 0.09)	6-**11.04**-19.23 (SD = 2.49)
PS/81 5B 32	2.90-**4.80**-10.80 (SD = 1.7)	0.10-**0.32**-1.30 (SD = 0.23)	0.23-**0.47**-0.68 (SD = 0.1)	0.30-**0.70**-0.80 (SD = 0.16)	0.21-**0.34**-0.38 (SD = 0.05)	3.2-**4.21**-13 (SD = 2.35)
PS/81 5C 88	2.60-**8.05**-16 (SD = 0.28)	0.10-**0.51**-2.30 (SD = 0.16)	0.30-**0.73**-1.20 (SD = 0.19)	0.32-**0.63**-0.97 (SD = 0.11)	0.20-**0.36**-0.57 (SD = 0.1)	3-**6.01**-14 (SD = 0.71)
Diolo 2 72	2.70-**6.24**-21.10 (SD = 3.23)	0.27-**0.71**-3.10 (SD = 0.5)	0.30-**0.64**-1.50 (SD = 0.27)	0.30-**0.62**-1.30 (SD = 0.21)	0.20-**0.36**-0.70 (SD = 0.13)	10-**10.69**-15.13 (SD = 1.2)
CT/11 199	5.50-**24.01**-40 (SD = 7.19)	0.8-**3.73**-7 (SD = 1.46)	0.7-**1.73**-2.5 (SD = 0.42)	0.5-**1.59**-2 (SD = 0.38)	0.20-**0.70**-1 (SD = 0.21)	7.50-**15**-22.91 (SD = 2.83)

Tab. 1 - Morphometric parameters measured on tubes of *D. brevis* and *D. arietina* populations. For each sample maximum, minimum, mean values (bold) and standard deviation are reported. The total number of measured tubes for each sample is reported on the left.

Systematics.

Genus *Ditrupa* Berkeley, 1835

Ditrupa brevis sp. nov.

(Pl. 1, Figs. 1-9; Pl. 2, Figs. 1-5)

Derivatio nominis: from latin brevis (= short)

Type material deposited in the Palaeontological Museum of the Catania University, collections of the Department of Geological Science. Labelled PMC.S1.20-10-99.

Description.

Tube not encrusting, circular in cross-section, scarcely bent and small (mean length 4 mm, mean diameter 0.6 mm). Tube opened at both ends, slightly narrowing to apex (almost cylindrical). Mean diameter at mouth 0.5 mm, diameter of apex ranging from 0.3 to 0.5 mm. Just before mouth, tube narrows forming conical shoulder. Rim of both mouth and apex circular and smooth. Distal ends often with irregularly spaced annular thickenings ("annuli" sensu ten Hove & Smith, 1990) (Fig. 5; Pl. 1, Fig. 1). Outer tube surface smooth, except for occasional transversal lines and/or constrictions mainly near the mouth.

Holotype: (PMC.S1.20-10-1999) length 3.2 mm, diameter of apex 0.4 mm, diameter at mouth 0.5 mm.

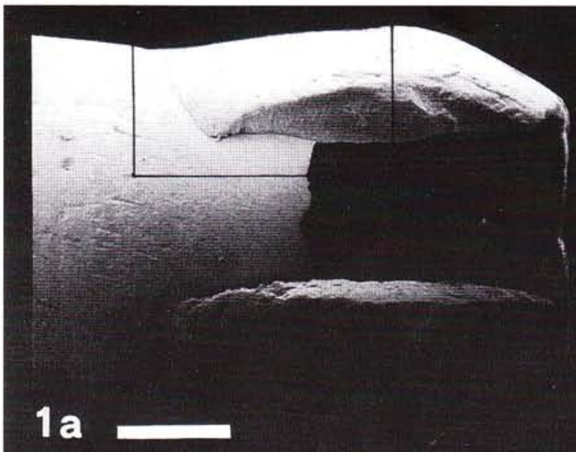
Microstructure.

Transverse fractures of the wall show two layers (Pl. 2, Fig. 3): an inner white one, thick ca. 1/4 of the entire wall and an outer somewhat transparent one thicker just before mouth, showing still some transparency despite fossilisation. Under SEM magnification the outer hyaline layer is composed of needle-like crystals arranged in lamellae, perpendicular to the tube surface. The inner opaque layer shows small prismatic crystals, crossly arranged. The apex is made only of the outer hyaline layer, the inner opaque layer starting at some distance from the apex (Pl. 1, Fig. 4). At higher magnifications, the outer surface does no longer appear smooth but is faintly dotted, due to the tips of crystals perpendicular to the surface (Pl. 2, Fig. 5). A discontinuous thin layer with an amorphous cryptocrystalline structure is randomly present on the outer surface.

PLATE 2

Scale bar = Fig. 1: 200 µm; Figs. 2, 4: 100 µm; Fig. 3: 40 µm; Fig. 5: 4 µm.

Fig. 1) *Ditrupa brevis*; a) anterior end; b) detail of a transversal line corresponding to a beginning of the tube growth. Tufara, Middle Pliocene. Fig. 3) *Ditrupa brevis*, transverse section of the tube wall showing an inner opaque layer with criss-cross arranged crystals and an outer glossy layer, with needle-like crystals, perpendicular to the outer surface. Benestare, Miocene. Fig. 2) *D. arietina* with a cylindrical bore-hole by a muricid gastropod. Mecanical abrasion traces are visible on the outer surface. PS/81 5C, Recent. Fig. 4) Bore-hole due to a naticid gastropod with bevelled edge. *D. arietina*. PS/81 5C, Recent. Fig. 5) Detail of the outer surface of *D. brevis*, faintly dotted. Tufara, Middle Pliocene.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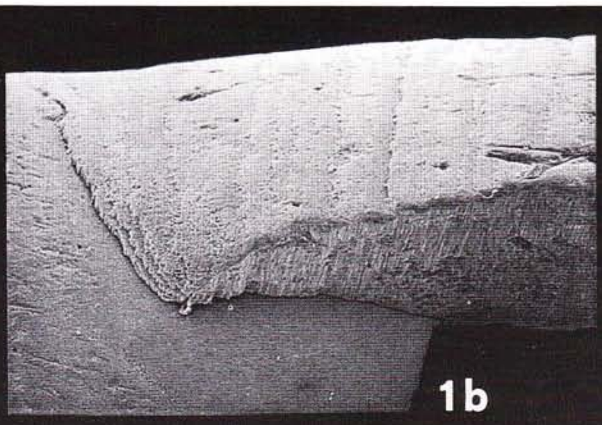
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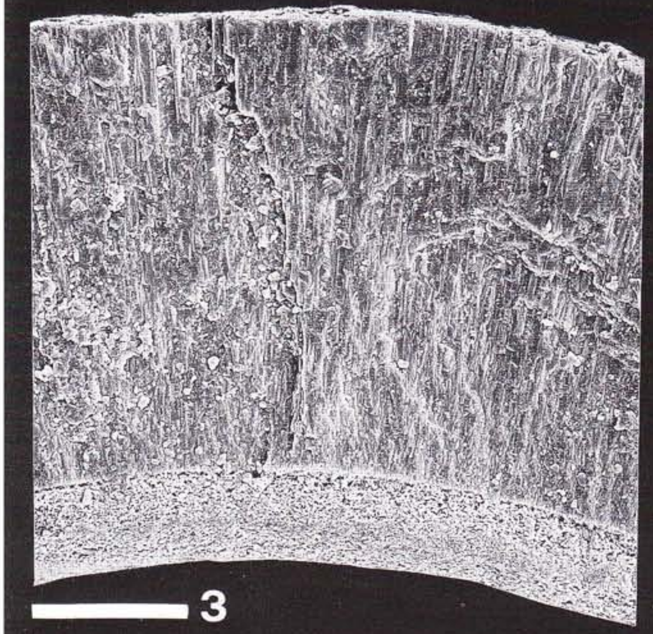
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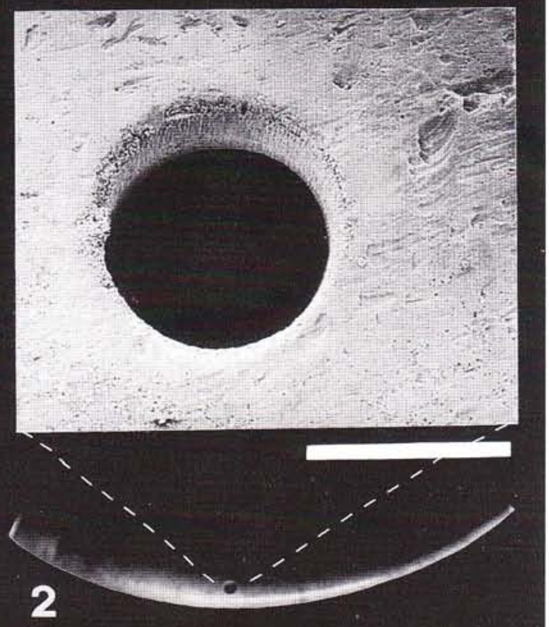
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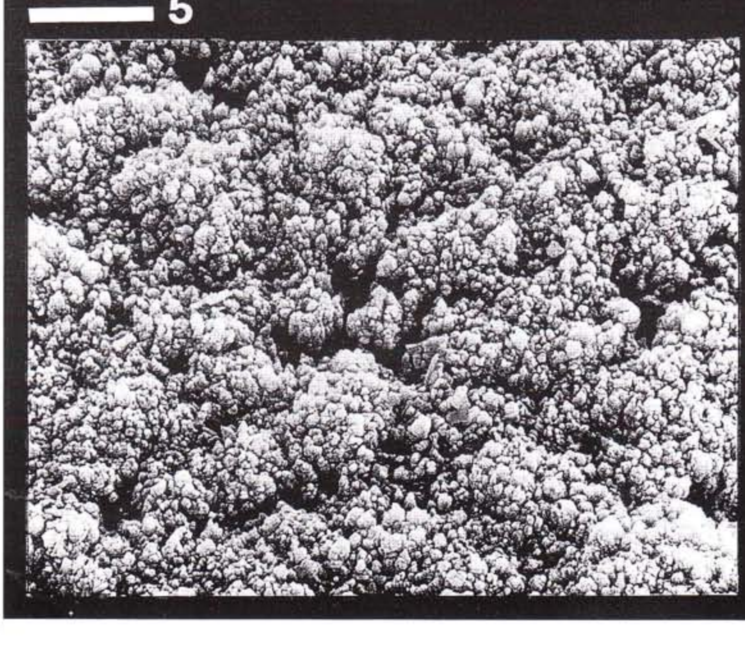
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Biometry.

The measured tubes of *Ditrupa* are easily classed in two groups (Tab. 1): in the first group (*D. brevis*: samples Tufara, Benestare I and Benestare II) tubes have notably low mean values of chord (3.16 - 4.68 mm) and height (0.11 - 0.22 mm); in the second group (*D. arietina:* samples AC/50, PD 4, PS/81 5B, PS/81 5C, Diolo 2, CT/11) tubes have mean values of chord of 4.80 - 24.01 mm and of height of 0.32 - 3.73 mm. In the first group apices show mean diameters (0.36 - 0.38 mm) similar to those of the second group, despite in the latter the tubes are generally much larger in size (Tab. 1). In both species the apex evidently remains unchanged from juvenile to adult stage (as showed also by the low values of SD). Even between specimens of *D. arietina* having different sizes, the apex diameter seems to be the only parameter morphometrically unchanged, tube accretion being possible only at the mouth.

The mean values of the arcuation index 2.82 - 4.48% also differ in the first group, versus 4.21 - 15% in the second group (Tab. 1).

Arcuation varies considerably within a population, ranging from almost straight (juveniles) to strongly curved (adults). It may also vary between populations from different sites. For instance, in the *D. arietina* population from the Gulf of Catania (Pl. 1, Figs. 8, 9) the arcuation index is greater than in other Recent populations here examined (PS/81 5B and 5C) (Pl. 1, Figs. 3, 5, 6, 7). The other examined size-shape parameters of *Ditrupa* also increase notably with growth and can vary considerably between different Recent and fossil populations.

The differences between the two species are also shown by cluster analysis (Fig. 3) where samples of *D. brevis* (Benestare I, Benestare II and Tufara) are grouped together. SD values (Tab. 1) of the two species are not markedly different.

Remarks.

D. brevis tube is much shorter than those of the other two *Ditrupa* species. Compared to *D. arietina* and *D. gracillima*, tube of the new species is also scarcely bent and almost cylindrical, slightly narrowing to the apex.

Both *D. arietina* and *D. brevis* show transversal lines and constrictions on the outer surface, mainly near the opening (Pl. 1, Fig. 8; Pl. 2, Fig. 1). These are due to a thinning of the external wall layer, as occurring at the mouth rim, and were interpreted by Gambi (1986) as markers of previous tube openings. Conversely, the so-called "annuli", described for *Ditrupa arietina* and *D. gracillima* by ten Hove & Smith (1990) as irregularities in the tube wall thickness, may occur in *D. brevis* (Pl. 1, Fig. 1). However, these "annuli" are more frequent and elevated than in *D. arietina* but less abrupt than in the "*monilifera*" form of *D. gracillima.*

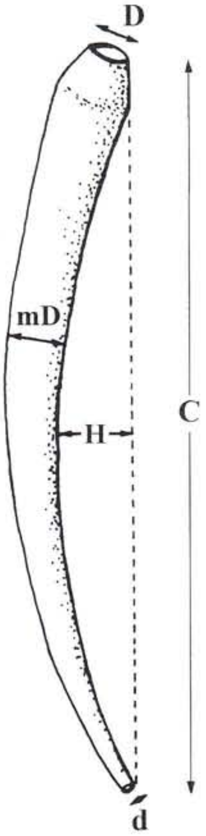

Fig. 2 - Morphometrics of *D. brevis* tube. D=diameter of tube mouth, d=diameter of apex, mD=mean width, c=chord (length measured in straight line between orifice to apex), h=height (widest perpendicular distance between inner curve of tube and chord).

A *Ditrupa* tube resembles a scaphopod shell, particularly the curved and smooth shell of *Gadila*. However, microstructural analysis reveals a distinctive two-layered pattern of *Ditrupa* tube (Pl. 2, Fig. 3): an outer layer somewhat transparent (which may become opaque by abrasion or fossilisation), and an inner bright white layer, of more randomly arranged crystals (ten Hove & Zibrowius, 1986; Zibrowius & ten Hove, 1987). The distinction between the two layers is generally evident, although in fossils the tube is entirely opaque, due to recrystallisation.

The outer tube surface is also peculiar. At higher magnification, the seemingly smooth surface can appear faintly dotted (Pl. 2, Fig. 5), similar to the fine honeycomb structure described by ten Hove & Smith (1990) for *D. gracillima*, but less pronounced.

Ecology and distribution.

Ditrupa lives with its tube free on muddy sediments on the continental shelf, in areas with high sedi-

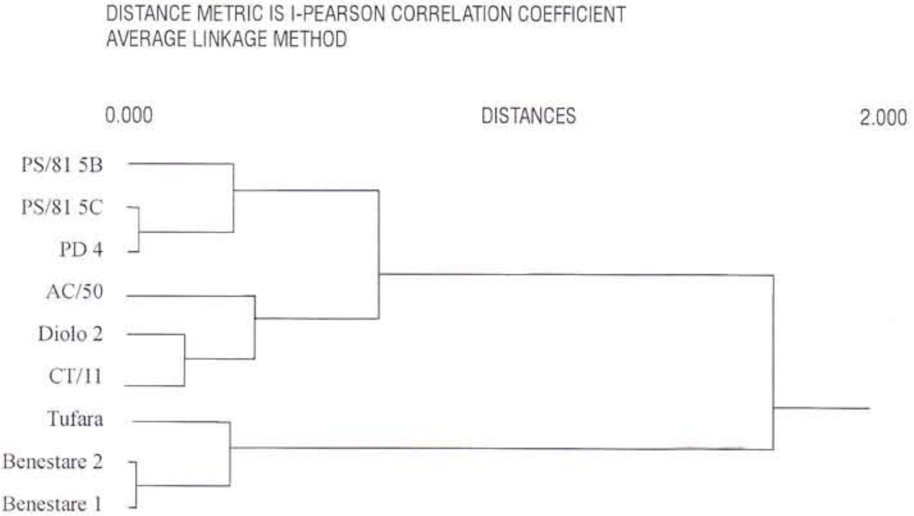

Fig. 3 - Dendrogram of samples of *Ditrupa* based on all five factors (C/H, C/Arc., max D of apex, max C, Arc.), expressing morphometric characters.

mentation rate and a quasi-permanent turbidity. In such environmental conditions, populations can be very dense (Di Geronimo et al., 1989) and tubes often constitute a conspicuous component (over 50%) of the biogenic carbonate sediments (Wilson, 1976). It also occurs in circalittoral detritic bottoms with scarce muddy component, although never abundant. Empty tubes, after the death of the animal, are easily preserved in the sediment.

Numerous dead tubes occur with the living animals and may constitute nearly 100% of the total number of tubes (Light, 1999). Forming dense assemblages of live and dead tubes, *Ditrupa* may control the sediment texture. It also provides a substrate for epibionts and rheophile taxa (Di Geronimo et al., 1989; Gambi, 1986; Gambi & Jerace, 1997; Light, 1999) and thereby affects species composition and diversity of soft-bottom communities. Observations on *D. arietina* assemblages from 60 to 300 m deep soft-bottoms of Iceland reveal that tubes can be densely colonised by brachiopods, solitary scleractinians, barnacles, serpulids, bryozoans, sponges, and foraminiferans. Opercula are often encrusted by foraminiferans, hydrozoans and erect flexible colonies of bryozoans. Most of dead specimens tubes are inhabited by sipunculids.

Ditrupa is common in Recent Mediterranean sediments. In fossil sediments, it can be abundant, often occurring in banks, due to the combined action of gregariousness and selective hydrodynamic transport (ten Hove & van den Hurk, 1993). It has been used as an indicator of sedimentary instability (Di Geronimo & Robba, 1989; Di Geronimo et al., 1989; 1992).

D. arietina from Pliocene and Pleistocene sediments is found together with *Hydroides norvegicus.* Although common in the Recent Mediterranean, both serpulid species are more abundant in Pleistocene deposits, where they usually are larger than in the Recent. A fine example is given by the Würmian CT/11 station, where *H. norvegicus* and even more *D. arietina* specimens have a markedly large size (Pl. 1, Figs. 8, 9). It seems that both species benefied of the lower water temperature.

For both localities with *Ditrupa* brevis an upper circalittoral palaeoenvironment can be hypothesised. Like other members of the genus, *D. brevis* can be considered as a species indicating an unstable environment with low diversity and be used to recognise Heterogeneous Communities. Comparing sediments containing *D. brevis* to Recent ones containing *D. arietina*, a similar ecological niche, at least from Miocene onwards, can be hypothesised.

D. brevis seems to have been replaced by *D. arietina* during the Pliocene.

In both studied localities, *D. brevis* co-occurs with warm water taxa, particularly some bryozoan species extinct in the present-day Mediterranean, but still living in tropical Atlantic and Pacific regions (Di Geronimo et al., 1992; Rosso, pers. comm.).

According to the present data, *D. brevis* is restricted to the Neogene. Conversely, *D. arietina* continues all through the Pleistocene till the Recent and was especially abundant during cold Quaternary phases of the Mediterranean.

Behaviour.

Many tubes of *D. brevis* and *D. arietina* show a circular hole bored by gastropod predators. Two types can be distinguished: distinctive countersunk holes with bevelled edges due to naticids, and smaller holes with nearly straight edges, made by muricids (Pl. 2, Figs. 2, 4).

Records of borer-attachs upon serpuloidean tubes (due to nudibranch, muricid and thaidid gastropods) are frequent (ten Hove, 1994).

In the examined material, drillings mainly occur near the mid point of the tubes, most commonly on its concave side. Similarly, the solitary coral *Caryophyllia smithi* encrusting *D. arietina* (Wilson, 1976) mainly occurs on the concave side, between the mid point and the anterior end of the tube. These data suggest that the *Ditrupa* tube lies horizontally on the sediment. This is in agreement with ten Hove & Smith (1990) observations that *D. arietina*, when placed on the sediment surface, is

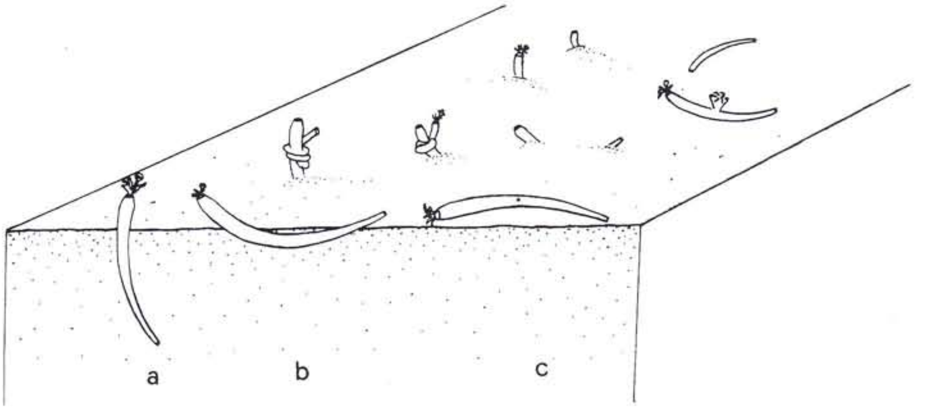

Fig. 4 - Different positions of Ditrupa on the soft bottom. a) tube with only the anterior end exposed; b) tube horizontally buried with the two ends exposed; c) tube lying horizontally above the sediment.

able to turn over its tube from lying on the right or left sides to lying on the convex side. Thus, only the concave side is always available for colonisators and/or predators. Notwithstanding this, the same authors also observed that *Ditrupa* can be partially buried, with the two tube ends emerging from the sediment.

Conversely, Gambi (1986) assumed that *Ditrupa* lives vertically buried in the sediment, with only the anterior end of its tube protruding above the surface. Wilson (1976) observed that tubes had the apex slight buried and the convex side turned upwards.

These latter models do not explain that on live *Ditrupa* the corals are attached, generally, near the mid point of the tube (settling on the concave side) and that bore-hole by muricids (preying only on epifauna, Reyment, 1966; Taylor, 1970) occur in the same position.

The presence of *Hydroides norvegicus*, mainly coiled around the anterior end of the tube, suggests that the posterior end of the tube was buried within the sediment (obliquely or almost horizontally).

Observations in aquarium reveal that *Ditrupa* is a filter-feeder (ten Hove & Smith, 1975) although observed life position have implied that deposit-feeding might occur (Hong, 1984). The worm is able to burrow in fine sediments using the branchial crown, thus varying its posture (Light, 1999).

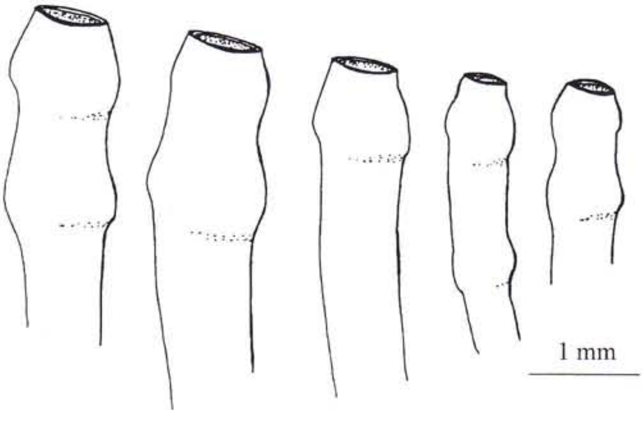

Fig. 5 - *D. brevis*: tube fragments of distal ends with "annuli".

To summarise, it can be assumed that *Ditrupa* can live in different postures: tube with only the anterior end exposed, at more or less steep angle (Fig. 4a); tube buried horizontally in the sediment, with the two ends above the surface (Fig. 4b); tube lying horizontally above the sediment (Fig. 4c).

The actual position probably reflects the sedimentation rate, suggesting the *Ditrupa*'s capability of reacting to sediment dynamics.

Acknowledgements.

I am indebted to C. Barbera (Dipartimento di Paleontologia, Napoli) for loaning topotypic material. I also thank H.A. ten Hove (Instituut voor Taxonomische Zoologie, Amsterdam) and H. Zibrowius (Station Marine d'Endoume, Marseilles) for useful suggestions. C.N. Bianchi who critically reviewed the manuscript. R. La Perna for effort in statistical elaboration. O. Torrisi (Istituto Internazionale di Vulcanologia, Catania) supplied assistance in SEM observations.

This paper is financially supported by 40% and 60% (Di Geronimo) M.U.R.S.T. grants.

REFERENCES

Barbera C., Robba E., Sanfilippo R., Violanti D. (1995) - The Middle Pliocene Tufara section (Benevento, south Italy). In Cherchi A. (Ed.) *Proceedings VI Palaeobenthos International Symposium*, 28-30 october 1995, pp. 129-131, Alghero.

Cheng Y.M. (1974) - Paleocurrent direction of the Taliao Formation (Lower Miocene) indicated by *Ditrupa* sp. (Serpulidae) shells. *Acta geol. Taiw.*, v. 17, pp. 13-22, Taipei.

De Castro Coppa M.G., Moncharmont Zei M., Pescatore T., Sgrosso I., Torre M. (1969) - Depositi miocenici e pliocenici ad est del Partenio e del Taburno (Campania). *Atti Acc. Gioenia Sc. nat.*, s.7, v. 1, *Suppl. Sc. Geol.*, pp. 479-512, Catania.

Di Geronimo I. & Li Gioi R. (1980) - Sur un gisement wurmien sous-marin du Golf de Catane. *Rapp. Comm. Int. Mer Médit.*, v. 25/26(4), pp. 137-139, Monaco.

Di Geronimo I. & Robba E. (1989) - The structure of benthic communities in relation to basin instability. *Mem. Acc. Lincei*, v. 80, pp. 341-352, Roma.

Di Geronimo I., Raffi S., Rosso A. (1989) - Dominanza di specie opportuniste nei "Popolamenti Eterogenei" del Pleistocene inferiore di Mazzarino, Sicilia centrale. *Boll. Acc. Gioenia Sc. nat.*, v. 20, n. 331, pp. 129-166, Catania.

Di Geronimo I ., Rosso A., Sanfilippo R. (1992) - Bryozoans as sedimentary instability indicators. *Riv. it. Paleont. Strat.*, v. 98, n. 2, pp. 229-242, Milano.

Gaemers P.A.M. (1978) - Biostratigraphy, palaeoecology and palaeogeography of the mainly marine Ager formation (Upper Paleocene-Lower Eocene) in the Tremp Basin, Central-south Pyrenees, Spain. *Leidse geol. Meded.*, v. 51, pp. 151-231, Lleida.

Gambi M.C. (1986) - Ecological implications in tube morphology and epibiota of a population of *Ditrupa arietina* (Polychaeta, Serpulidae). *Rapp. Comm. int. Mer Médit.*, v. 30, n. 2, p. 19, Monaco.

Gambi M.C. & Jerace S. (1997)- Epibiosis on the tubes of the polychaete *Ditrupa arietina* (Serpulidae) in some populations of the soft bottoms of the southern Tyrrhenian Sea. *Biol. Mar. Medit.*, v. 4, n. 1, pp. 380-383.

Hove H.A. ten (1994) - The dualistic relation between molluscs and serpulid tube-worms. Pp. 65-70. In Coomans-Eustatia M., Moolembeek R., Los W. & Prins P. (Eds.), De horen en zijn echo. Stichting Libri Antilliani, Zoologisch Museum Amsterdam, V. of 279 pp., Amsterdam.

Hove H.A. ten & Hurk P. van den (1993) - A review of Recent and fossil serpulid "reefs"; actuopalaeontology and the "Upper Malm" serpulid limestones in NW Germany. *Geol. en Mijnb.*, v. 72, pp. 23-67, Amsterdam.

Hove H.A. ten & Smith R.S. (1990) - A re-description of *Ditrupa gracillima* Grube, 1878 (Polychaeta, Serpulidae) from the Indo-Pacific, with a discussion of the genus. *Rec. Austr. Mus.*, v. 42, n. 1, pp. 101-118, Sydney.

Hove H.A. ten & Zibrowius H. (1986) - *Laminatubus alvini* gen. et sp. n. and *Protis hydrothermica* sp. n. (Polychaeta, Serpulidae) from the bathyal hydrothermal vent communities in the eastern Pacific. *Zool. Scripta*, v. 15, n. 1, pp. 21-31, Göteborg.

Hong J.S. (1984) - On two polychaetous serpulids new to Korean waters with notes on the ecological aspects. *Korean J. Zool.*, v. 12, n. 1, pp. 34-48.

Light J. (1999) - The free-living serpulid, *Ditrupa arietina*, on the outer continental shelf. Newsletter Porcup. *Mar. Nat. Hist. Soc.*, v. 2, pp. 40-42, London.

Picard J. (1965) - Recherches qualitatives sur les biocoenoses marines des substrats meubles dragables de la région marseillaise. *Rec. Trav. Stat. Mar. Endoume*, v. 52, n. 36, pp.1-160, Marseille.

Reyment R.A. (1966) - Preliminary observations on gastropod predation in the western Niger delta. Palaeogeogr. *Palaeoclim. Palaeoecol.*, v. 2, n. 2, pp. 81-102, Amsterdam.

Seguenza G. (1879-80) - Le formazioni terziarie di Reggio (Calabria). *Mem. Rend. Acc. Lincei, Cl. Sc. Fis. Mat. e Nat.*, s. 3, v. 6, pp. 1-446, Roma.

Sneath P.H.A. & Sokal R.R. (1973) - Numerical taxonomy: the Principles and Practice of Numerical Classification. V. of 573 pp, Freeman Libr., San Francisco.

Taylor (1970) - Feeding habits of predatory gastropods in a Tertiary (Eocene) molluscan assemblage from the Paris basin. *Palaeontology*, v. 13, n. 2, pp. 254-260, London.

Wilson J.B. (1976) - Attachment of the coral *Caryophyllia smithii* S. & B. to tubes of the polychaete *Ditrupa arietina* (Muller) and other substrates. *J. mar. biol. Ass. U.K.*, v. 56, pp. 291-303, London.

Zibrowius H. & Hove H.A. ten (1987) - *Neovermilia falcigera* (Roule, 1898) a deep- and cold- water serpulid polychaete common in the Mediterranean Plio-Pleistocene. *Bull. biol. Soc. Wash.*, v. 7, pp. 259-271, Washington.