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Otoliths from the Middle to Upper Miocene of the Gavdos Island (South Greece). Systematics - Paleoecology

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Abstract
This paper concerns the study of Otoliths of Teleostei Fishes, found in the Middle to Upper Miocene-compact blue marls of the sections : Aghios Ioannis and Potamos of the Gavdos Island.
Twelve identified species of the Otoliths belong to the following orders :
A) Myctophiformes : *Diaphus* sp. I, *Diaphus* sp. II, *Diaphus* cf. *problematicus* Parr, *Diaphus debilis* (Koken), *Diaphus dumerilli* (Bleeker), *Ceratoscopelus* aff. *maderensis* (Lowe), *Ceratoscopelus maderensis* (Lowe),
B) Perciformes : *Gobius* sp.
C) Gadiformes : *Gadus* sp.
Most of the studied Otoliths, belonging to juvenile individuals, allow us to accept – combined with the lithology – a marine paleoenvironment, shallow and warm water.
The studied Otoliths, in the Mediterranean, give important results on the biogeography and paleogeography.

Key words
Otoliths, Teleosts, Middle to Upper Miocene, Island Gavdos southern of Crete (South Greece), Systematics, Paleoecology.

1. INTRODUCTION

The studied Otoliths were found in the Neogene sediments of the villages Aghios Ioannis and Potamos of the Gavdos Island. The Neogene sediments extend to almost all the central and northern part of the island. The sampling positions are marked on the part of IGME geological map (Sheet Gavdos, Fig. 1, Vidakis, 1988). The Neogene sediments – compact blue marls – rotate in sand bed (Fig. 2) and settle unconformable in the alpine substratum.
The first steps – in the domain of the Regional Geology – about the studies on the Otoliths have been conducted by Gaemers & Schwarzhans (1973) concerning those of the Oligocene and the Neogene of the Northern Sea Basin and by Nolf (1978) regarding the Paleocene Otoliths of the Belgian and Parisian Basin.
Reports on the fossil Otoliths in Greece have been conducted abstractly within paleontologic and statigraphic studies.
A systematic paper has been recently published about the Otoliths from some localities of the village Prassies (Rethimnon, Crete Island) (Marcopoulou-Diacantoni & Kagiouzis, 2001).
The material of otoliths from Aghios Ioannis and Potamos of the Gavdos Island have been accompanied by the Foraminefers : *Neogloboquatrina acostaensis, Neogloboquatrina atlantica, Globigerinoides conglobatus, Globigerinoides obliquus, Globoquatrina altispira, Globoquatrina dehiscens, Paragloborotalia siakensis, Spiroplectammina carinata*. The stratigraphic expansions of the above mentioned Foraminifers allows us to define the age of the Middle-Upper Miocene for the studied sections.

2. PALAEONTOLOGICAL PART

2.1. General knowledge about Otoliths

The Otoliths – organs of teleosts fishes balance and acoustics – are located within the otic cranial sack, inside the membranous labyrinth (Fig. 3, 4) and consisted of aragonite and organic substance. Their small size fluctuates from 0.2 to 15 mm.
The Otoliths are the unique definable isolated Teleosts Fishes remaining at present and are located more frequently in the fossil record rather than the complete fish skeletons. Our awareness on fossil Otoliths lies still in the point of discovery and description – except for the Otoliths pre-mentioned from the Europe Tertiary. Their study is of great interest and contributes to the Biostratigraphy and Paleoecology.
Some researchers (Hecht & Hecht, 1977 ; Karrer, 1971 ;

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Fig. 1 : Geological map of the studied area with reef-forming Corals (VIDAKIS, M., sheet Gavdos 1 :50.000, IGME, 1988, simplified).

NOLF, 1974 ; SCHWARZHANS, 1972 ; STINTON, 1967 ; WEILER, 1968) recognize Otoliths possess conservative characteristics that allow foliate explanations at the levels of the species, the genus and the family. Their most significant feature is the acoustic furrow (sulcus acusticus).

2.2. Morphological features

At the species level the small differences in outline, in structure, the ratios L : H and L : W are the most essential features. At the gender and family level, other characters, such as the small differences in the sulcus acusticus border, generally in the outline, in the flexures as well as in other larger structures (in their external surface) are of bigger importance. Concerning the higher taxonomic units the most useful feature are the sulcus acusticus structure (the number of colliculi = colliculum, the opening of the sulcus acusticus, the general sulcus acusticus outline). We could generally mention that the way of fish life (epipelagic, mesopelagic, and bathypelagic) influences in a way the morphology of their Otoliths (SCHWARZHANS, 1972, 1980).

2.3. Ecological data

The depths, where fish with the particular Otoliths dwell are the following :

- The several *Diaphus* species (in general principle) from 200 to 700 m, but also from 0 to 1000 m.
- *Ceratoscopelus maderensis* (LOWE) from 200 to 700 m.
- The several *Gobius* species dwell mainly from 0 to 50 m (SCHWARZHANS, 1980, p. 47)

Most species of Myctophidae family are mesopelagic and of the Gadiidae family live in the pelagic zone.

According to the bathymetry, the climatology and the biogeography SCHWARZHANS (1980, p. 46) classified the Otoliths as following (Table I) :

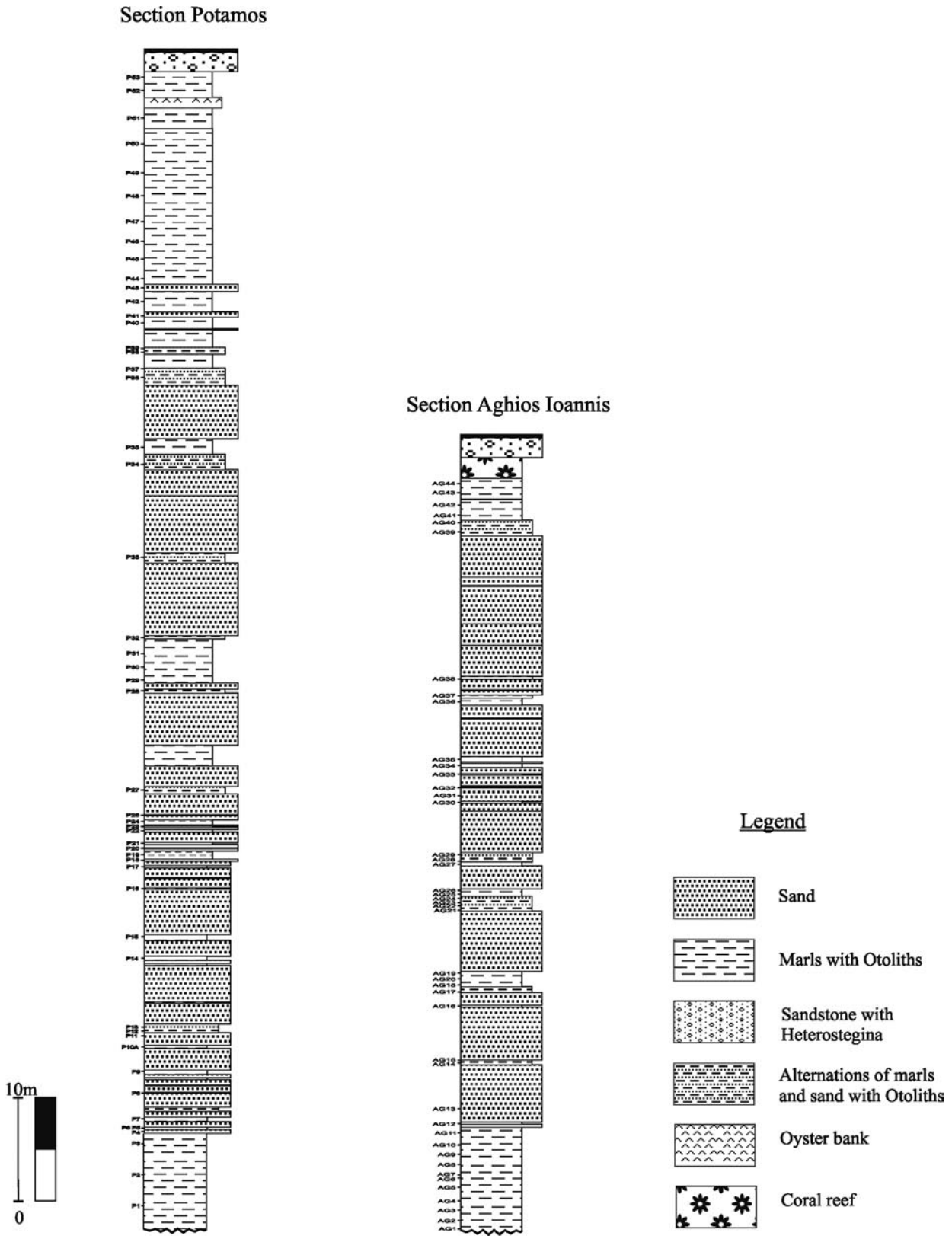


Fig. 2: Lithostratigraphical columns of the localities of the villages Potamos and Aghios Ioannis (Island Gavdos).

Table I: Taxonomy of the recent Otoliths according to the bathymetry, the climatology and the biogeography (SCHWARZHANS, 1980, p. 46).

Otoliths	Zone	Bathymetry	Climatology	Biogeography
Myctophus sp.	Pelagic	Epipelagic & mesopelagic	Tropical-Subtropical-Temperate-Polar	Mediterranean
Diaphus sp.	Pelagic	Epipelagic & mesopelagic	Tropical-Subtropical-Temperate-Polar	Mediterranean
Ceratoscopelus maderensis	Pelagic	Epipelagic & mesopelagic	Subtropical-Temperate	Mediterranean
Gobius sp.	Benthic	Coastal & subcoastal	Tropical-Subtropical-Temperate-Polar	Mediterranean

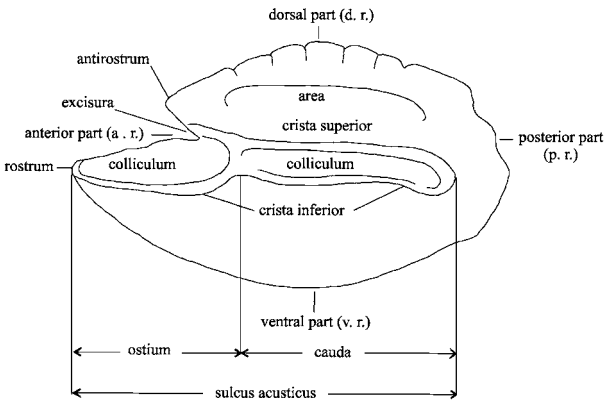


Fig. 3: Morphological nomenclature of the inner face of Otoliths (SCHWARZHANS, 1978 modified).

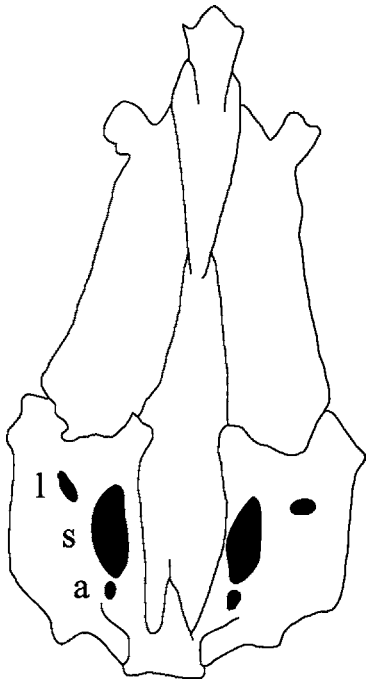


Fig. 4: Location of the Otoliths in the labyrinth (lateral to the brain of the Teleosts) (NOLF *et al.*, 1987). (a = asteriscus, s = sagitta, l = lapillus).

2.4. Systematic classification

The studied fossil Otoliths (Tabl. II) belong to the following orders:

1. **Myctophiformes:** *Diaphus* sp. I sensu SCHWARZHANS, *Diaphus* sp. II sensu SCHWARZHANS, *Diaphus* cf. *problematicus* PARR, *Diaphus debilis* (KOKEN), *Diaphus dumerili* (BLEEKER), *Ceratoscopelus* aff. *maderensis* (LOWE), *Ceratoscopelus maderensis* (LOWE), *Myctophidarum* erdwarsi (SAUVAGE), *Myctophidarum* sp., *Myctophum solendidum* (PROCHANZA).
2. **Gadiformes:** *Gadus* sp.
3. **Perciformes:** *Gobius* sp.

Class: Osteichthyes HUXLEY, 1880
Subclass: Actinopterygii, KLEIN, 1885.
Superorder: Teleostei, MUELLER, 1846.
Order: Myctophiformes
Suborder: Myctophoidei
Family: Myctophidae GILL, 1892

Genus: *Diaphus* EIGEMANN & EIGEMANN, 1890

***Diaphus* sp. I, *sensu* SCHWARZHANS, 1980**
Pl. II, fig. 4

1980. *Diaphus* sp. SCHWARZHANS, p. 8.

Number of specimens: 3 Otoliths of adults and 4 Otoliths of juveniles specimens.
Description: The Otoliths of the *Diaphus* sp. I are more elongated than those of *Diaphus* sp. II. The rostrum and

the antirostrum are of equal size. The ventral part (v. r.) carries 6 round projections.
Geographic and stratigraphic distribution:
Middle - Upper Miocene of the Gavdos Island, Greece.
Lower Pliocene of Sicily and Toscan, Italy.

Diaphus sp. II, *sensu* Schwarzhans, 1980
Pl. II, fig. 3

1973. *Diaphus* sp. Anfossi & Mosna, p.97, tav. XV (I), fig. 7a.b.
1978. *Diaphus* sp. Nolf, p. 521.
1978. *Diaphus* sp. Schwarzhans, p. 10, pl. 2, fig. 26.
1979. *Diaphus* sp. Schwarzhans, p. 10, pl. 2, fig. 26, pl. 11, fig. 128.
1980. *Diaphus* sp. Nolf & Martinell, p. 211, pl. 2, fig. 1-8.

Number of specimens: 3 Otoliths of adults and 6 Otoliths of juveniles specimens.

Dimensions in mm*:	Length	Height	L: H
	3.1	2.8	1.11

*Average measurements of the 9 specimens
Description: Almost elongated Otoliths. The ventral part (v. r.) is typically crenate with 6 projections. The rostrum is a little larger than the antirostrum. The excisura is very small. Between the colliculums there is indistinct collum. We observe a false cauda colliculum (pseudocolliculum) in some Myctophiformes. The dorsal part (d. r.) presents a projection towards the posterior part (p. r.) and a hollow towards the rostrum.
Geographic and stratigraphic distribution:
Middle - Upper Miocene of the Gavdos island, Greece.
Lower Pliocene of S. Sicily and Toscan, Italy.

Diaphus debilis Koken, 1891
Pl. II, fig. 2

1977. *Diaphus taaningi* Norman, p. 332, fig. 30.
1979. *Diaphus debilis* (Koken) - Steurbaut, p. 62, pl. 3, fig. 9-16.

Number of specimens: 5 Otoliths of adults and 7 Otoliths of juveniles specimens.
Description: Almost elongated Otoliths. The ventral part (v. r.) is vigorously crenate. The rostrum is bigger than the antirostrum. The anterior ventral part (a. v. r.) has an angle very strenuous.
Geographic and stratigraphic distribution:
Pliocene of Spain (Catalonia)
Middle - Upper Miocene of the Gavdos island, Greece.
Miocene of Aquitaine (France).

Diaphus dumerili Bleeker, 1856
Pl. II, fig. 5

1976. *Diaphus dumerili* (Bleeker). – Nolf, p. 719, pl. III, fig. 8-14.
1979. *Diaphus dumerili* (Bleeker). – Steurbaut, p. 62, pl. 4, fig. 7-14

Number of specimens: 3 Otoliths of adults and 7 Otoliths of juveniles specimens.

Dimensions in mm*:	Length	Height	L: H
	1,6	1,3	1,23

*Average measurements of the 10 specimens
Description: Round otolith with strong development of angle that lies in the anterior dorsal part (a. d. r.). The excisura and the antirostrum are small. The rostrum is strong and longer than the antirostrum.
Geographic and stratigraphic distribution:
Lower Pliocene of Sicily and Toscan (Italy).
Familiar from the Trinidad Neogene.
Middle - Upper Miocene of the Gavdos island.

Diaphus cf. *problematicus* Parr, 1928
Pl. II, fig. 1

1928. *Diaphus problematicus* Parr, pl. 3, fig. 7-12.
1977. *Diaphus problematicus* Parr. – Nolf & Martinell, p. 211.

Number of specimens: 3
Description: Otolith with small rostrum and longer antirostrum. Excisura small, indistinct. In the ventral round part (v. r.) it bears 5 projections, while it presents hollow in the anterior dorsal part (a .d. r.). The center of the dorsal part (d. r.) is a little upturned. It presents a vague and extensive hollow in the posterior part (p. r.). The quite wide ostium takes up half of the colliculum, whereas the cauda is indistinct. The collum of the colliculum is distinct.
Geographic and stratigraphic distribution:
Middle - Upper Miocene of the Gavdos island, Greece.
According to Nolf and Martinell (1980) the *Diaphus problematicus* species appears relations with living species of the tropical Atlantic.

Genus: *Ceratoscopelus* Gunther, 1864.

Ceratoscopelus maderensis (Lowe, 1839)
Pl. I, fig. 5

1971. *Ceratoscopelus maderensis* (Lowe).– Weiler, p. 10, pl. 2, fig. 10.
1977. *Ceratoscopelus maderensis* (Lowe).– Nolf & Martinell, tab. 1, fig. 21.
1978. *Ceratoscopelus maderensis* (Lowe).– Schwarzhans, p. 12, pl. 3, fig. 33, 37.

Number of specimens: 3 Otoliths of adults and 3 Otoliths of juveniles specimens.

Dimensions in mm*:	Length	Height	L: H
	3,5	2,2	1,48

*Average measurements of the 6 specimens

Description: Elongated otolith with long tapering rostrum, antirostrum and indistinct excisura, spinal dorsal part (d. r.) with small inflations. Colliculums almost unified. No sign of collum.
Geographic and stratigraphic distribution :
Lower Pliocene of Sicily and Toscan (Italy),
Pliocene of Spain (Catalonia).
Middle - Upper Miocene of Gavdos island, Greece.
It dwells today in Adriatic.
It is referred as bathypelagic by WEILER (1971, p. 26).

Ceratoscopelus aff. *maderensis* LOWE, 1839
Pl. I, fig. 2

1980. *Ceratoscopelus* aff. *maderensis* (LOWE).– SCHWARZHANS, p. 12, pl. 3, fig. 32.

Number of specimens: 2 Otoliths of adults and 7 Otoliths of juveniles specimens.

Dimensions in mm*:	Length	Height	L: H
Of an adult specimens	3,55	2,5	1,42
Of juveniles specimens	1,4-2,15	1,2-1,55	1,17-1,39

*Average measurements of the specimens
Description: It is different from the typical species in the outline. Otolith with long rostrum not round, antirostrum and indistinct excisura. The colliculum are almost unified. There is no sign of collum. Also the younger specimens are similar to the Upper Miocene species *Clupea bonii* ANFOSSI & MOSNA, 1971, from N. Italy according to SCHWARZHANS (1980).
Geographic and stratigraphic distribution:
Lower Pliocene of Sicily and Toscan (Italy),
Middle - Upper Miocene of Gavdos island, Greece.
It is referred as bathypelagic by WEILER (1971, p. 26).

Genus indet: ? *Myctophidarum*

Myctophidarum erdwarsi SAUVAGE, 1873
Pl. I, fig. 6

1929. *Myctophus (Lampanychtus) erdwarsi* (SAUVAGE).– D'ERASMO, p. 45, text-fig. 12, 13.
1980. *Myctophidarum erdwarsi* (SAUVAGE).– SCHWARZHANS, p. 16, fig. 46, pl. 12, fig. 137.
2001. *Myctophidarum erdwarsi* (SAUVAGE).– MARCOPOULOU-DIACANTONI & KAGIOUZIS, p. 581

Number of specimens: 2 Otoliths of adults and 1 Otoliths of juveniles specimens.

Dimensions in mm*:	Length	Height	L: H
	2,85	2,5	1,14

*Average measurements of the 3 specimens
Description: Otolith with almost cyclic outline. The dorsal part (d. r.) is almost flat. The ostium is bigger than the cauda and the collum distinct. The colliculum are quite distinct.
Geographic and stratigraphic distribution:
Skeletons by *Myctophidarum erdwarsi* have been found in the Messinian of Sicily. Otoliths are mentioned by the Lower Pliocene of Sicily and Italy.
Middle - Upper Miocene of Gavdos island, Greece.

Myctophidarum sp.
Pl. I, fig. 4

1979. *Myctophidarum* sp., STEURBAUT, p. 63, pl. 5, fig. 11.

Number of specimens: 2
Description: Otolith with almost cyclical outline but with bigger width than length. The ostium and the cauda are of equal size and the collum is distinct. The colliculum are quite distinct.
Geographic and stratigraphic distribution:
Miocene, France (Aquitaine).
Middle - Upper Miocene of Gavdos island, Greece.
It is mentioned as mesopelagic genus.

Genus: *Myctophum* RAFINESQUE, 1810

Myctophum splendidum (PROCHANZA, 1893)
Pl. I, fig. 3

1893. *Otolithus (Berycidarum) splendidus* PROCHANZA, p. 81, pl. 3, fig. 5a, b.
1906. *Scopelus splendidus* (PROCHANZA).– SCHUBERT, p. 633, pl. 17, fig. 17.
1918. *Scopelus splendidus* (PROCHANZA).– PIERAGNOLI, p. 35, pl. 1, fig. 25 a, b.
1931. *Scopelus splendidus* (PROCHANZA).– CHAINE & DUVERGIER, p. 39, pl. 1, fig. 21.
1950. *Myctophum splendidum* (PROCHANZA).–WEILER, p. 215, pl. 7, fig. 51, pl. 12, fig. 92.
1954. *Scopelus splendidus* (PROCHANZA).– BAUZA RULLAN, p. 64, pl. 11, fig. 10, 11.
1965. *Myctophum splendidum* (PROCHANZA).– BRZOBOHATY, p. 112, pl. 1, fig. 7-8.
1966. *Myctophum splendidum* (PROCHANZA).– SMIGIELSKA, p. 230, pl. 13, fig. 10.
1971. *Myctophum splendidum* (PROCHANZA).– WEILER, p. 7, pl. 1, fig. 2-3.
1985. *Myctophum splendidum* (PROCHANZA).– COLOM, p. 283, fig. 13, 15, 16.

According to SCHWARZHANS (1980, p. 8, pl. 2, fig. 16-18) the *Diaphus splendidus* (PROCHANZA) is synonym with the *Myctophum splendidum* (PROCHANZA) (WEILER, 1968 & 1971) and with the *Diaphus splendidus* (PROCHANZA) (GAEMERS & SCHWARZHANS, 1973, p. 7, Taf. 1, fig. 2-3) and not with the *Myctophum splendidum* (PROCHANZA) (ROBBA, 1970, 108-109, Taf. 8, fig. 7), that must be the *Myctophidarum* n. sp.
The *Myctophum* genus is mentioned by WEILER (1971, p. 28) as well as the *Myctophum splendidum* (p. 26) as bathypelagic.

Number of specimens: 12 (only two specimens are well conserved)

Dimensions in mm:	Length	Height	L: H
	1,2	1,5	1,3
	3,2	2,6	1,2

Description: Prolong otolith with long rostrum, antirostrum and small excisura, dorsal part (d. r.) with small projections. Both the colliculum and the collums are distinct. The ostium is longer than the cauda. Ventral part (v. r.) with 8-14 slightly spinous projections.

Geographic and stratigraphic distribution:

A species from Miocene and Pliocene localities.

It is referred by the Tortonian of Rumania (Weiler, 1950), by the Middle Miocene of South Moravia (Brzobohaty, 1965) and by the Tortonian of South Poland (Smigielska, 1966).

It is also mentioned by the Pliocene of Italy, Sicily and of Spain (Pieragnoli, 1918; Chaine & Duvergier, 1931; Bauza Rullan, 1954).

Middle - Upper Miocene of Gavdos island, Greece.

From a phylogenetic point of view the Myctophiformes have been considered as a very important group for the origin of Acanthopterygii and the Paracanthopterygii (in Schwarzhans, 1978, p. 173).

From an ecologic point of view the species of Myctophidae include mesopelagic fish that rise in the surface during the night where there are sometimes "caught" by epipelagic thieves or are transferred close to shore by water currents (Nolf & Martinell, 1980, p. 213).

I. Order: Gadiformes
Suborder: Gadoidei
Family: Gadidae Rafinesque, 1810
Genus: *Gadus* sp.

***Gadus* sp.**

Number of specimens: 1

Observation: In Gadiformes the ostium and the cauda, which constitute the sulcus acusticus belong to type homosulcoid, that is, both sections are of equal size almost symmetrical and distinct. This characteristic appears to be a primitive character in all the Paracanthopterygians (in Schwarzhans, 1978, p.176). The same *Gadus* species mentioned here is mentioned as *Otolithus* by Koken (1891).

Geographic and stratigraphic distribution:

Middle - Upper Miocene of Gavdos island, Greece.

II. Order: Perciformes
Suborder: Gobioidei Jordan & Evermann, 1896
Family: Gobiidae Bonaparte, 1832
Genus: *Gobius* Linnaeus, 1758

***Gobius* sp.**
Pl. I, fig. 1

1891. *Otolithus (Gobius)* Koken.

Table II: The studied Otoliths from the localities Potamos (P) (Tabl.II a) and Aghios Ioannis (AG) (Tabl.II a) of the Gavdos Island.

Table II a

SPECIMENS	P 1	P 2	P 3	P 5	P 6	P 7	P 8	P 9	P 10	P 39	P 40	P 45	P 46	P 47	P 48	P 49	P 50	P 51
HEIGHT (m)	3,00	6,00	9,00	10,70	10,72	11,72	14,12	16,32	18,72	85,50	88,30	94,80	96,50	98,40	100,90	103,10	105,90	108,00
OTOLITHS																		
Ceratoscopelus sp.				*		*	*	*						*				
Ceratoscopelus cf. *maderensis*		*		*		*							*					
Diaphus debilis	*	*	*	*	*	*	*	*	*		*		*	*	*	*	*	*
Diaphus dumerilli	*	*	*	*	*	*	*	*	*			*	*	*	*	*	*	*
Diaphus sp. I	*	*	*			*							*	*	*	*		*
Diaphus sp. II	*	*				*					*			*	*	*		*
Diaphus cf. *problematicus*	*	*	*			*	*						*	*	*	*	*	*
Gadus sp.								*	*									
Gobius sp.	*		*	*			*		*								*	*
Myctophidarum sp.		*	*	*			*						*	*	*	*	*	*
Myctophidarum edwardsi	*	*	*			*									*	*	*	*
Myctophum splendidum		*	*	*		*	*						*					

Table II b

SPECIMENS	AG 1	AG 2	AG 3	AG 4	AG 5	AG 6	AG 7	AG 8	AG 10	AG 11	AG 12	AG 17	AG 18	AG 19	AG 42	AG 44
HEIGHT (m)	0,5	1,3	2,3	3,2	4	4,9	5,1	6,4	8,6	9,9	10,25	23,1	23,7	25	68,7	71
OTOLITHS																
Ceratoscopelus sp.	*	*	*	*	*	*										
Ceratoscopelus cf. *maderensis*				*			*									
Diaphus debilis	*	*	*	*		*				*						
Diaphus dumerilli	*	*	*	*	*	*	*									
Diaphus sp. I					*				*	*			*	*		
Diaphus sp. II					*					*						
Diaphus cf. *problematicus*					*				*	*						
Gadus sp.			*	*		*										
Gobius sp.	*	*	*	*	*	*										
Myctophidarum sp.	*	*		*		*		*								
Myctophidarum edwardsi									*	*						
Myctophum splendidum	*			*		*										

1971. *Gobius* sp., Weiler, p. 21.
1988. *Gobius* sp. Reichenbacher, p. 22, pl. 5.

Number of specimens : 3 Otoliths of adults and 6 Otoliths of juveniles specimens.

Dimensions in mm* :	Length	Height	L : H
	0,6-1, 5	0,5-1,2	1,1-1,2

*Average measurements of the 9 specimens

Description : Otolith with long rostrum, antirostrum and indistinct excisura, dorsal part (d. r.) either almost smooth or it presents a small amount of inflations. Posterior dorsal angle (p. d. r.) which is weak or absent most of the times. Anterior part (a. r.) is sharp.

Geographic and stratigraphic expansion :
Lower Pliocene of Germany in the Bithynia layers.
In the boundaries of Pliocene/ Sarmatian of Sicily.
Middle - Upper Miocene of Gavdos island, Greece.

The *Gobius* species dwell today in a coastal environment in hot waters, some species have been found in fresh water or brackish water. The sagitta according Reichenbacher (1988, p. 22) is small on the right and its shape is defined between 0,8-1,4 mm. In younger forms it varies (Nolf, 1985, p. 99) while it is quite restricted in brackish forms. *Gobius* species which originated from Pontium are coastal (Weiler, 1971, p. 26).
According to the above mentioned some endemism has been observed in our material especially in several *Gobius* species coming from Gavdos island.

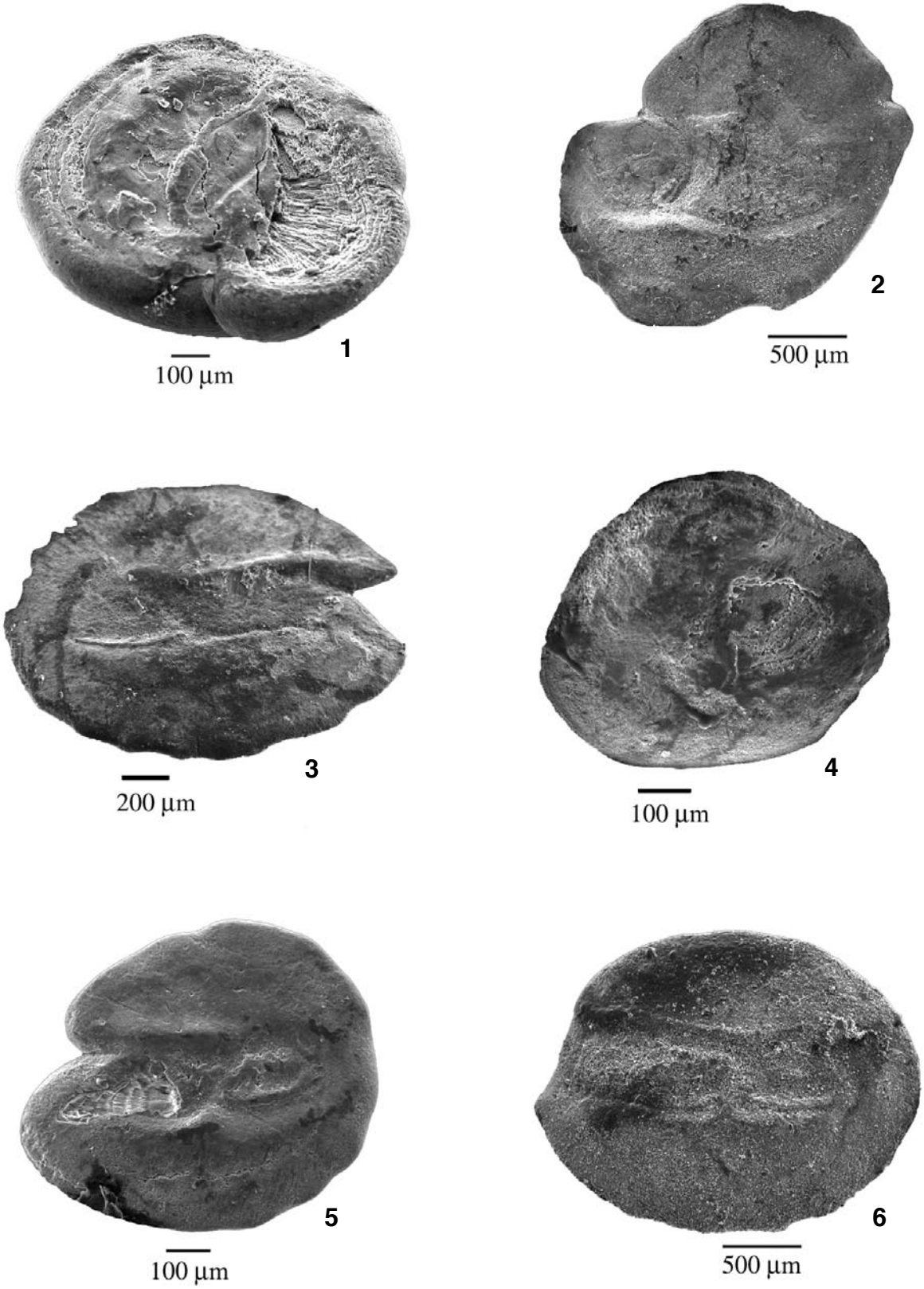
3. CONCLUSIONS

The study of otoliths – originated from the Neogene sediments of sections Aghios Ioannis and Potamos of Gavdos island – allow us to the following conclusions :

Plate I

Fig. 1 : *Gobius* sp.
Fig. 2 : *Ceratoscopelus* aff. *maderensis* (Lowe)
Fig. 3 : *Myctophum splendidum* (Prochanza)
Fig. 4 : *Myctophidarum* sp.
Fig. 5 : *Ceratoscopelus maderensis* (Lowe)
Fig. 6 : *Myctophidarum erdwarsi* (Sauvage)

Plate I



- The 12 studied Otoliths species belong to the following taxa:
  a) Myctophiformes: *Diaphus* sp. I sensu SCHWARZHANS, *Diaphus* sp. II sensu SCHWARZHANS, *Diaphus* cf. *problematicus* PARR, *Diaphus debilis* (KOKEN), *Diaphus dumerili* (BLEEKER), *Ceratoscopelus* aff. *maderensis* (LOWE), *Ceratoscopelus madarensis* (LOWE), *Myctophidarum erdwarsi* (SAUVAGE), *Myctophidarum* sp., *Myctophum splendidum* (PROCHANZA),
  b) Gadiformes: *Gadus* sp., and
  c) Perciformes: *Gobius* sp.
- From the stratigraphic expansion of the accompanied fauna of Foraminifera (*Neogloboquatrina acostaensis, Neogloboquatrina atlantica, Globoquatrina dehiscens, Globoquatrina altispira, Paragloborotalia siakensis, Spiroplectammina carinata, Globigerinoides conglobatus, Globigerinoides obliquus*) we can define the age of the Middle - Upper Miocene for the studied sections.
- The majority of the fish, which carry the specific otoliths must have lived in the boundaries of the neritic zone (*Gadus* sp., and *Gobius* sp.) with the continental slope (*Diaphus, Ceratoscopelus*) possibly in depth less than 50 m. The last are mesopelagic and do vertical immigrations during the night and day (NOLF *et al.*, 1987). Therefore the otolith concentration in its majority illustrates a coastal environment. (e.g. numerous Gobiidae) where many mesopelagic elements are also concentrated. *(*Myctophidae, among which are almost many *Diaphus*). Perhaps one possibility would be if the above otoliths concentration were in a more remote environment from the mesopelagic, where there would be an important transportation in bathypelagic elements and mostly mesopelagic elements coming from the excreta of "thieves" that fish in deep or epipelagic waters. We notice that the Myctophidae, which are mesopelagic fishes, rise in the surface during night, when they are conceived many times by epipelagic "thieves" or are drifted in coastal waters from marine currents.
- Among the studied species we noticed the presence of several species of *Diaphus* genus and species of the *Gobiidae* family. Their definition in level of species is left open based on the fact that the majority of the found Otoliths belongs to juveniles specimens.
- The Otoliths study helps to the expansion of our knowledge on their biogeographic and paleobiogeographic distribution also on the SE Mediterranean unfamiliar to the Greek region, up to today.

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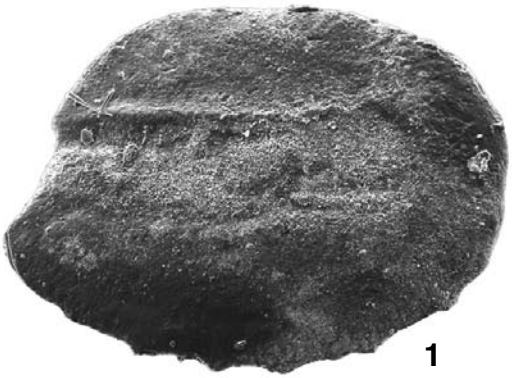
Plate II

Fig. 1: *Diaphus* cf. *problematicus* PARR
Fig. 2: *Diaphus debilis* (KOKEN)
Fig. 3: *Diaphus* sp. II, sensu SCHWARZHANS
Fig. 4: *Diaphus* sp. I, sensu SCHWARZHANS
Fig. 5: *Diaphus dumerili* (BLEEKER)

Plate II



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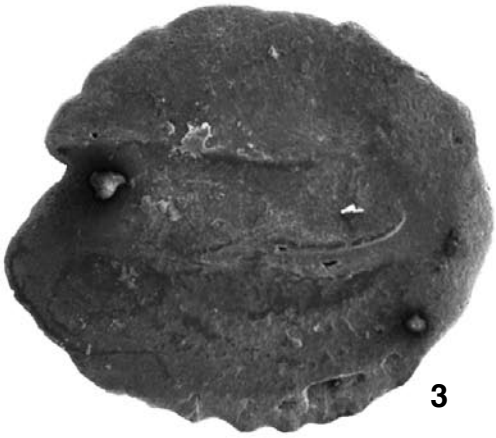
200 µm



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