



Quaternary climatic variability modulates *Bregmaceros* Mediterranean distribution range

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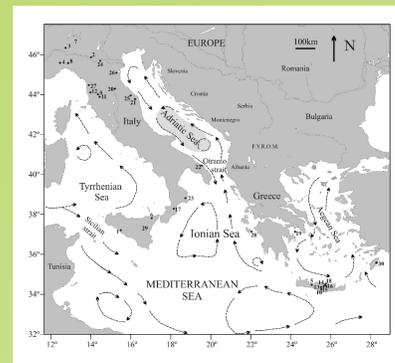
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Introduction and methodology

Bregmaceros THOMPSON 1840 (Gadiformes) is a small subtropical pelagic fish, with fourteen (14) worldwide distributed valid species(1). *Bregmaceros atlanticus* GOODE & BEAN 1886 is the only one truly circumglobal. In the modern Mediterranean Sea it is mostly considered an invasive species. *Bregmaceros* has been reported between 0 and 1260 meters depth, maintains an epipelagic life style and is most abundant in the upper 200 meters (2). Fossil remains of *Bregmaceros* are well recorded in the Mediterranean Neogene and Quaternary. Here, we review the Pliocene and Pleistocene Mediterranean record of *Bregmaceros*, based on the most recent data.

Palaeobiogeography

Landini & Menesini (3) were the first to address the distribution of *Bregmaceros* in the Neogene Mediterranean Sea. Two Miocene species, *Bregmaceros albyi* and *Bregmaceros catulus*, were considered valid, but no particular palaeoecologic significance was attributed to them. These authors suggested a genus extinction date from the Mediterranean by 2.2 Ma. More recent findings (4) extend its presence well into the Middle Pleistocene, at least until 0.7 Ma BP. The initial review (4) suggested that during the Pliocene, *Bregmaceros* was endemic to the eastern Mediterranean, a hypothesis that was thereafter disputed (5). Landini & Sorbini (6) also suggested that fish taxa with subtropical Indo-Pacific affinities may also survived other climatic crises in the Late Pliocene and the Quaternary. Records of *Bregmaceros* remains in sediments sampled across complete stratigraphic sections are very few. The *Bregmaceros* fauna, with few exceptions, is usually located in short geologic sections, where there is usually no continuous record of the fish assemblage evolution through time. In Gerakas section (4), the high abundance of *Bregmaceros* found in Gelasian stage sediments is interpreted as a palaeotemperature maximum, as well as an indication of increased oceanic input in the area of southern Zakynthos. The latest findings of *Bregmaceros atlanticus* in the Ionian stage sediments of Rhodes Island further the stratigraphic distribution of the genus in the Mediterranean waters at least until 0,28 Ma BP, indicating that its presence in the basin was not continuous. We hypothesize that, at least the Pleistocene *Bregmaceros* remains may indeed belong to the modern species *B. atlanticus*, which experienced geographic distribution shifts, similar to those occurring today, whenever climatic and local palaeoceanographic conditions were favorable.



The Pliocene - Pleistocene (5.33-0.28Ma) Mediterranean record of *Bregmaceros*.

Figure ref.	Site/Section	Identification	Material	Age	Reference
1	Girgenti	<i>Bregmaceros</i> sp.	Otoliths	Zanclean	Weiler 1971
2	Lugagnano	<i>Bregmaceros albyi</i>	Otoliths	Zanclean	Anfossi & Mosna 1979
3	Monteu Roero	<i>Bregmaceros albyi</i>	Otoliths	Zanclean	Anfossi & Mosna 1979
4	Alba	<i>Bregmaceros</i> sp.	Otoliths	Zanclean	Nolf & Cavallo 1995
5	Prassias	<i>Bregmaceros</i> sp.	Otoliths	Zanclean	Markopoulou & Kagiouzis 2001 - revised
6	Monte Bauso	<i>Bregmaceros albyi</i>	skeletal	Pliocene	Landini & Sorbini 2005b
7	Taino	<i>Bregmaceros albyi</i>	skeletal	Pliocene	Anfossi et al 1982
8	Val d'Arda	<i>Bregmaceros albyi</i>	skeletal	Pliocene	Anfossi & Mosna 1972
9	Castelfiorentino	<i>Bregmaceros albyi</i>	skeletal	Pliocene	Landini et al 1990
10	Roufais	<i>Bregmaceros albyi</i>	skeletal	Pliocene	Gaudant 2001
11	Poggibonsi	<i>Bregmaceros albyi</i>	skeletal	Pliocene	Landini & Sorbini 2005b
12	Orciano Pisano	<i>Bregmaceros albyi</i>	skeletal	Pliocene	Landini & Sorbini 2005b
13	Voutes	<i>B. albyi</i> <i>Bregmaceros</i> sp.	skeletal otoliths	Pliocene	Gaudant 2001 Agiadi et al. 2009
14	Gourmes	<i>B. albyi</i> <i>Bregmaceros</i> sp.	skeletal otoliths	Pliocene	Gaudant et al 1994 Agiadi et al. 2009
15	Stavromenos	<i>B. cf. albyi</i>	skeletal	Pliocene	Gaudant et al 1994
16	Prassias	<i>Bregmaceros albyi</i>	skeletal	Pliocene	Gaudant et al 1994
17	Singa	<i>Bregmaceros albyi</i>	skeletal	Pliocene	Sorbini & Landini 2003
18	Amissos	<i>B. cf. albyi</i>	skeletal otoliths	Piacenzian	Gaudant 2001 Agiadi et al. 2009
19	Agios Thomas	<i>Bregmaceros albyi</i>	skeletal	Piacenzian	Argyriou & Theodorou 2011
20	Marecchia River	<i>Bregmaceros albyi</i>	skeletal	Piacenzian	Sorbini 1988
21	Sforzacosta	<i>Bregmaceros albyi</i>	skeletal	Piacenzian	Sorbini 1988
22	Sant' Andrea	<i>Bregmaceros albyi</i>	otoliths	Piacenzian	Bossio et al 1986
23	Stuni	<i>Bregmaceros albyi</i>	skeletal otoliths	Piacenzian	Landini & Menesini 1985
24	Samoggia Stream	<i>Bregmaceros albyi</i>	Skeletal otoliths	Piacenzian	Bedini & Landini 1986 Landini & Sorbini 1993
25	Metauro River	<i>Bregmaceros albyi</i>	Skeletal	Piacenzian	Sorbini 1988
26	Rio Merli	<i>Bregmaceros</i> sp.	Otoliths	Piacenzian	Girone 2007
27	Morrone	<i>Bregmaceros</i> sp.	Otoliths	Gelasian - Calabrian	Nolf & Girone 2000
28	Gerakas	<i>Bregmaceros</i> sp.	Otoliths	Gelasian - Ionian	Agiadi et al. 2010
29	Fiamefreddo	<i>Bregmaceros</i> sp.	Otoliths	Calabrian - Ionian	Girone et al 2006
30	Tsampika Bay	<i>Bregmaceros atlanticus</i>	Skeletal Otoliths	Ionian	Agiadi et al 2012



Bregmaceros atlanticus

Taphonomy

A combination of palaeoecologic and taphonomic conditions determine fish remains preservation. Landini and Sorbini (6) as well as Girone et al (7) noted significant ecological and facies differences between fish assemblages preserved inside the Mediterranean Miocene sediments, either as skeletal or as otolith material. Articulated fish skeletons are preserved under very specific sedimentologic and palaeoceanographic conditions, usually inside laminated clays and diatomites, indicating anoxic/dysoxic or hypersaline waters. On the contrary normal marine clays and silts contain large numbers of otoliths, but do not allow for the preservation of articulated skeletal parts (4). Specifically, In fact, Mediterranean Pliocene - Pleistocene diatomites, diatomitic marls and laminated marls commonly preserve articulated skeletons of the *Bregmaceros* fauna, with pelagic and mesopelagic taxa, lacking benthic-benthopelagic species. On the contrary, normal marine marls containing a large number of otoliths, may contain *Bregmaceros* sp. (4) and its accompanying fauna, but also include a significant benthic portion. Consequently, it appears that during anoxic/dysoxic episodes, benthic and benthopelagic fish shift their distribution ranges to more favorable localities on the NW Mediterranean. When sea floor oxygenation rises to normal levels again, the benthic fauna returns to these areas, and can be discovered as otoliths.

Conclusions

Sampling methodologies and strategies in previous years have separated the fish skeletal record from the otolith database. Here we integrate these with regard to the genus *Bregmaceros*. During anoxic events it seems that *Bregmaceros* along with other high pelagic and mesopelagic taxa are favored and become extremely abundant in the sediments. The latest findings indicate that, *Bregmaceros* sp. coped with the intense Pliocene and Pleistocene climatic and oceanographic variability, through the contraction and expansion of its Mediterranean distribution, at least until 0.28 Ma. Its presence today in the central - eastern Mediterranean is one more effort to inhabit favorable waters, showing exactly how flexible and adaptable *B. atlanticus* can be.

References

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Co-financed by Greece and the European Union