

The first fossil record of the codlet *Bregmaceros?* sp. (Thompson, 1840) (Gadiformes, Bregmacerotidae) from the Fırat Formation (Early Miocene-Aquitanian - Burdigalian) of Diyarbakır, Turkey

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In this paper, a fossil fish *Bregmaceros?* sp. (Thompson, 1840) (Gadiformes, Bregmacerotidae) is described from the Fırat Formation (Early Miocene: Aquitanian - Burdigalian) of Diyarbakır, Southeast Turkey. The fossil specimen is the first record from Turkey. It is discovered in the limestone layer in Sağlam village of Eğil district of Diyarbakır. The specimen is found in early Miocene sediments of Anatolia and may represent *B. albyi* (Sauvage, 1880) or *B. filamentosus* (Priem, 1908) which have been reported from the Miocene sediments of the Mediterranean Sea. Due to poor preservation, it is difficult to make an identification at the species level with certainty. Bregmacerotidae consists of 14 extant and 2 extinct (*B. albyi* and *B. filamentosus*) species and has only genus *Bregmaceros* distributed in subtropical and tropical waters all over the world. *Bregmaceros* sp. is a small-sized, pelagic species within the Gadiformes Order, and its fossils are often discovered as articulated skeletons or otoliths in Eocene-Miocene-Pliocene marine sediments. The present specimen is characterized by having an elongated body, 60 mm in length (head not fully visible). The traces of anal, dorsal, and pectoral rays are moderately visible. The vertebral column includes 44 vertebrae (there may be a few more since the skull part is not visible), 35 of which are post-abdominal (caudal). Although several studies related to their geographical and chronological distributions across the world have been published and well documented, there are no studies on their existence in the Anatolia region, Diyarbakır, South-eastern Turkey.

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INTRODUCTION

Bregmacerotids (codlets) are small elongated fish species having a maximum body length is about 120 mm. The fish of Bregmacerotidae (Gill, 1872) family is recognized by two prominent dorsal fins. The first one is with a long single ray at the back of the head and the second is on a long base with rudimentary rays in the middle part of the fin. The anal fin has a close resemblance to the second dorsal fin and is located just below it. The family consists of the only genus *Bregmaceros* (Thompson, 1840), which includes 14 extant and 2 known extinct fossil species. The extant species are *B. atlanticus* (Goode and Bean, 1886), *B. arabicus* (D'Ancona and Cavinato, 1965), *B. bathymaster* (Jordan and Bollman, 1890), *B. cayorum* (Nichols, 1952), *B. rarisquamosus* (Munro, 1950), *B. houdei* (Saksena and Richards, 1986), *B. japonicus* (Tanaka, 1908), *B. lanceolatus* (Shen, 1960), *B. mccllellandi* (Thompson, 1840), *B. nectabanus* (Whitley, 1941), *B. cantori* (Milliken and Houde, 1984), *B. neonectabanus* (Masuda, Ozawa and Tabeta, 1986), *B. pescadorus* (Shen, 1960), *B. pseudolanceolatus* (Torii,

Javonillo and Ozawa, 2004) and extinct species known only from fossils are *B. albyi* (Sauvage, 1880) (Miocene-Pliocene), *B. filamentosus* (Priem, 1908) (Eocene-Miocene) (Prikryl *et al.*, 2016).

Bregmacerotids are neritic and found in the subtropical to tropical oceans and seas. Their habitats are varied from mesopelagic to inshore and even estuaries (Prikryl *et al.*, 2016). It has been observed that the 14 identified *Bregmaceros* species are quite similar. Intra-species variations, making identification of the species even more complicated and sometimes overlapping with other species, have been reported. The use of conventional meristic and morphometric properties to distinguish species has been complemented by molecular research (Prikryl *et al.*, 2016), and data on chromatophores. The combined approach help in the classification of the genus (Torii *et al.*, 2003, 2004; Prikryl *et al.*, 2016). Unfortunately, the lack of soft tissue features makes it very difficult to identify fossil specimens. Despite small body size and the criticality of morphological distinction, *Bregmaceros* has been recognized based on isolated otoliths, skeletal specimens, and skeletal specimens preserving otoliths in situ from various marine regions of

Cenozoic. Fossil remains of *Bregmaceros* species are largely present in the Mediterranean, Paratethys, and nearby areas. However, determination of the osteological properties is very difficult due to small body sizes, insufficient preservation, crushed, broken, dismembered bodies, and poor preservation of bone surfaces. For these reasons, the taxonomy of *Bregmaceros* fossils is often unclear. So far, five *Bregmaceros* fossil species and one monotypic *Bregmacerina* have been designated based on articulated skeletons from West Asia, Europe, and North Africa (Prikryl *et al.*, 2016). More extensive otolith fossils show a greater number of species and a wider geographic distribution of *Bregmaceros* in Asia, Europe, Northern, Western Africa, Northern America, and New Zealand during the beginning of the Middle Eocene. Apart from their limited preservation within Europe during the Oligocene, it is believed that the *Bregmaceros* otoliths appeared in the Miocene in Australian records and show their global distribution in the Quaternary (Prikryl *et al.*, 2016).

The present paper reports a new occurrence of *Bregmaceros?* sp. from the Early Miocene sediments of the Eğil (Diyarbakır) region, Turkey. This is the first time that *Bregmaceros?* sp. have been found in Early Miocene (Aquitanian - Burdigalian) deposits in Anatolia. Besides, the comparisons were made with other Miocene *Bregmaceros* species found in the Mediterranean deposits, and then palaeobiogeographic implications are discussed.

BIOSTRATIGRAPHY AND SEDIMENTOLOGY OF THE FIRAT FORMATION

3 different formations are noticed around the Dicle Town (Diyarbakır) District. In the South, the Early Miocene age the Firat Formation (Eğil town-Sağlam village: the study area); in the North, the Lice Formation of the Middle Miocene age, both belonging to the Silvan Group are exposed. The Lice Formation is overlain by the Şelmo Formation of the Late Miocene age (Yılmaz and Duran, 1997; Hüsing *et al.*, 2009). Outcrops of the Firat Formation are found in Dicle, Eğil, Hani, Çüngüş, Hazro and Çermik districts in Diyarbakır, along the right bank of Tigris River, in the valley of Zori Stream in Ergani district, Sason district in Batman province, Cizre (Şırnak), Pervari (Siirt), Şemdinli (Hakkari) and Kasrik Strait north of Cizre district (Yılmaz and Duran, 1997). This Formation consists of cream, beige, white, pinkish grey coloured soil, sometimes thin, or very thick rocks with red algae, bryozoans, corals, large benthic and echinoid fossils, and molluscs (mostly gastropods and bivalves) shells as well as reef/bench type limestone. The age of the Firat Formation is considered as Aquitanian-Burdigalian (Early Miocene) and its depositional environment has been determined as a shelf edge-bank/reef (Yılmaz and Duran, 1997). The Firat Formation is distinguished by the surrounding formations by its lighter colour, brittleness, a significant amount of macrofossils, and an excess of marl content.

The Firat Formation consists of four facies; (A) Grey-beige coloured conglomerate Facies (incorporating the pebbles and stones consisting of schist, marble, quartz, serpentinite, radiolarite, and limestones), (B) Limestone

Facies (including beige-yellow coloured, degraded, deformed and chalked limestone, referred to the marine environment), (C) Yellow-colored limestone Facies (Representing yellow-colored, hard limestone with clayey layers at intermediate levels), (D) Beige-white coloured marl Facies (thickest and the extensive extent of the Firat Formation with beige-white coloured marls and clays) (Fig. 1) (Duke *et al.*, 1991; Yeşilova and Helvaci, 2012a, 2012b; Güngör and Helvaci, 2013, 2017; Yeşilova *et al.*, 2018). Following fossil groups, genera and species have been documented from the Firat Formation (Yılmaz and Duran, 1997), Homotramatidae, Echinoidea, Acervulinidae, Ostracoda, Bryozoa, Pelecypoda, Bivalvia, Cnidaria, Gastropoda, Miliolidae, Rotaliidae, Textulariidae, Alveolinidae, Peneroplidae, *Heterostegina* sp., *Neovalveolina* sp., *Miyogypsina* sp., *Globigor spina*, *Miogypsinoides* sp., *Austrotrillina* sp., *Sphaerogypsina* sp., *Archaias* sp., *Peneroplis* sp., *Borelis* sp., *Elphidium* sp., *Rotalia* sp., *Cycloclypeus* sp., *Amphistegina* sp., *Lepidocyclina* sp. and *Nephrolepidina* sp.

MATERIALS AND METHODS

The lone fossil specimen has been found during fieldwork carried out in South-eastern Anatolia, Diyarbakır (Sağlam Village, 10 km far from Eğil Town) (Altitude: 885 m, Coordinate: 38° 15' .57" N/40° 08' .27" E) in March 2020. The sample was collected from the upper layer deposits of the Firat Formation. The fossil was cleaned and prepared by placing it in an alkaline solution to extract the clay material. With the help of palaeontologists, the classification and description of the sample at the genus level were made. Genus identification has been verified by comparison with Gadiformes morphology (Endo, 2002; Nelson *et al.*, 2016). The above features are suitable for comparison with living Gadiformes. Features such as the fin pattern of a single long ray behind the head, bilobed dorsal and anal fins, long, free pelvic rays, number of vertebrae, vertebral spines, pterygiophores, and number of caudal fins were taken into consideration in the fossilized specimen. The sizes of the sample were measured using a precision ruler and digital caliper. High-resolution photos of the sample were taken in the lab using a Nikon Coolpix P900 camera and 83x Zoom-NIKKOR ED Glass Lens. All dimensions of the samples are expressed in millimeters and shown with the scale bar on the photographs.

SYSTEMATICS

- Superclass Actinopterygii Klein, 1885
- Class Actinopteri Cope, 1972
- Infraclass Teleostei Müller, 1845
- Order Gadiformes Goodrich, 1909
- Family Bregmacerotidae Gill, 1872
- Genus *Bregmaceros* Thompson, 1840
(Figs. 3, 4.1, 4.2)

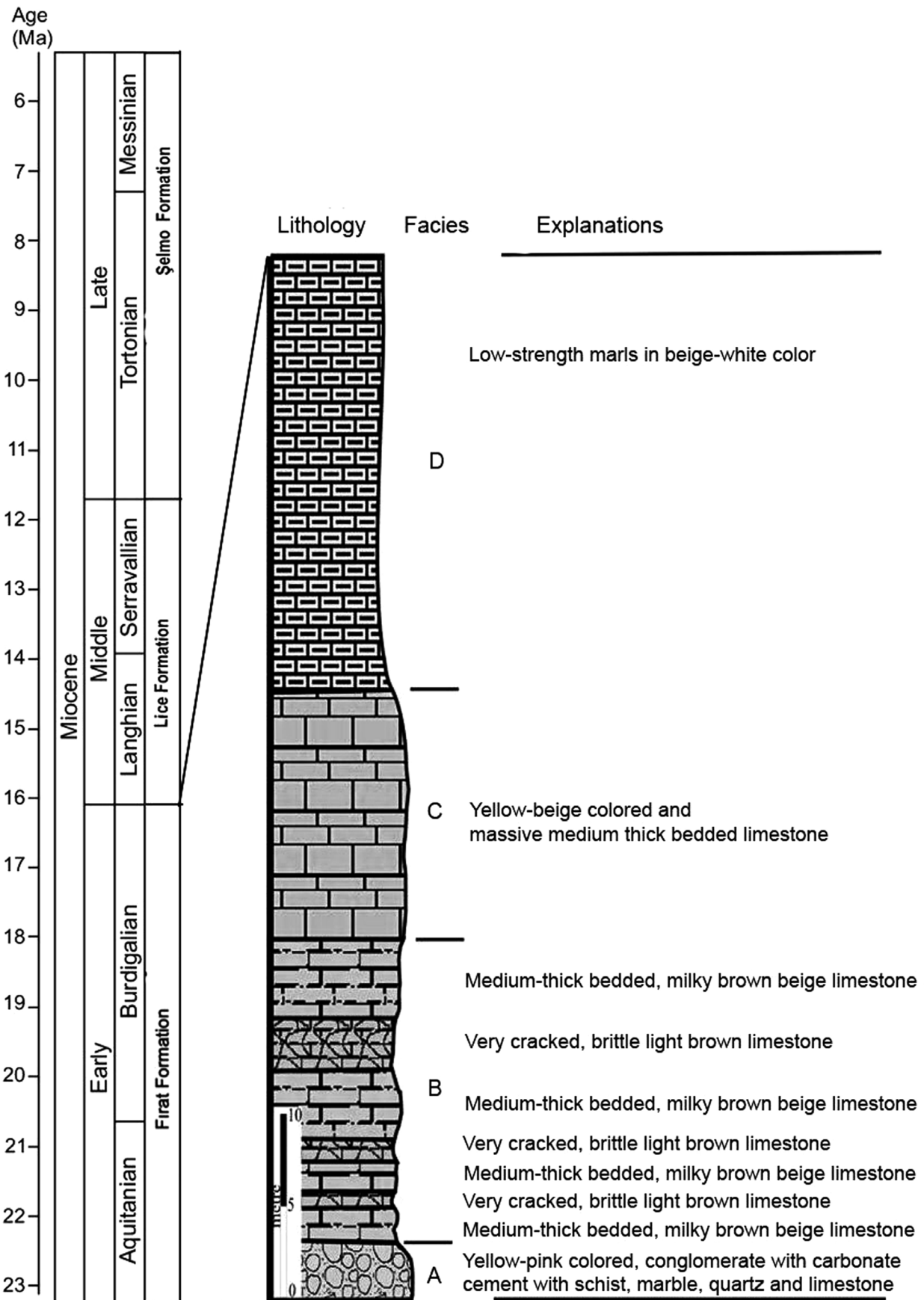


Fig. 1. Cross-section of the Firat Formation (Approximately 130m thick). The *Bregmaceros?* sp. specimen is found in D Facies (modified from Yeşilova and Helvacı 2012a).

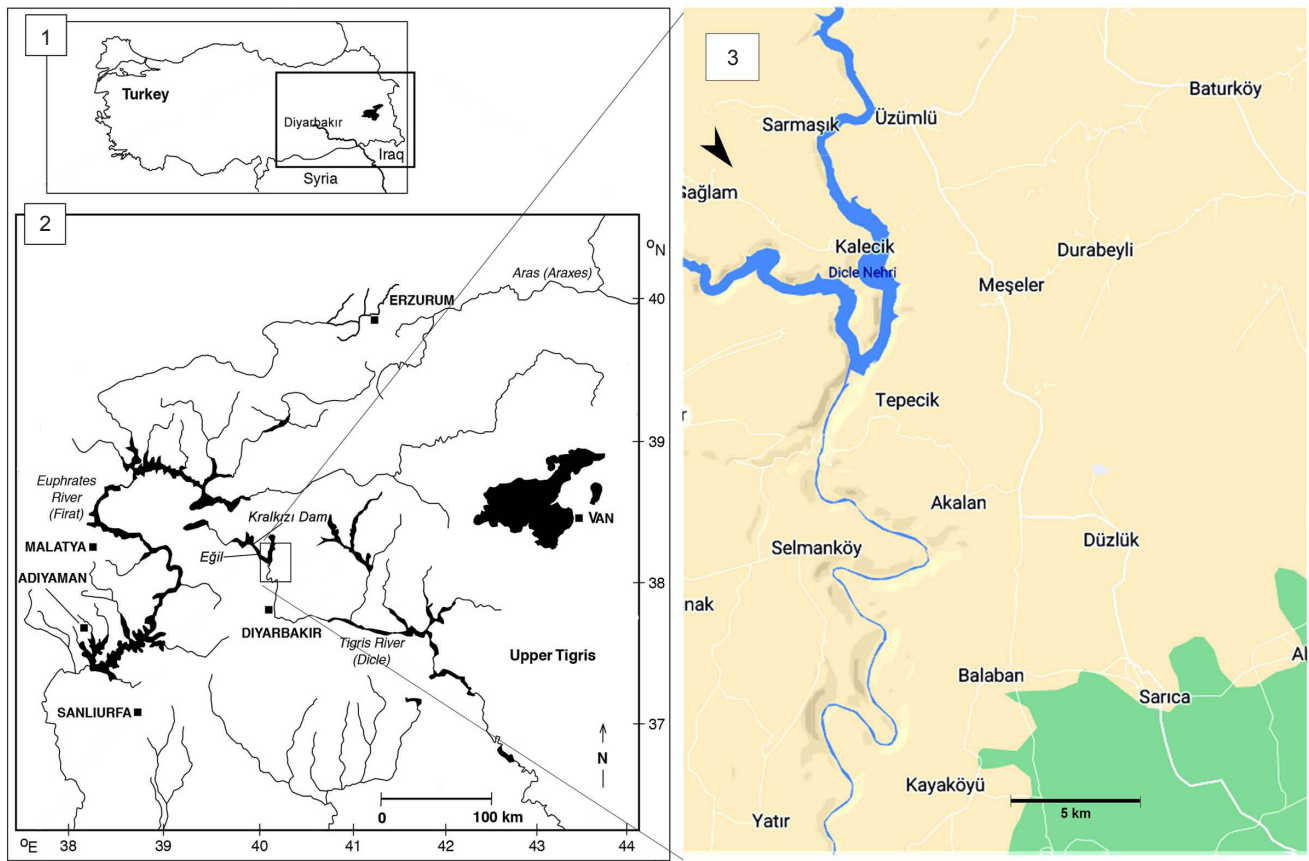


Fig. 2. 1. Map showing Turkey, 2. Diyarbakir city and collection locality of the *Bregmaceros?* sp. fossil sample, 3. the collection locality illustrated with a black arrow, Sağlam Village of Eğil Town, Diyarbakir.

Description.—The total length (with invisible head part) of the *Bregmaceros?* sp. specimen is 65 mm in length. Head length represents about one-fifth of its body size. The shape of the head is not fully visible. Due to poor preservation, the morphology and description of the head of the fossil specimen are not possible and the same is true for the fins and rays. The traces of dorsal, anal, and pectoral rays of the specimen are slightly visible. The vertebral column includes about 44 vertebrae, 35 of which are post-abdominal (caudal), 9 of which are abdominal (precaudal vertebrae). The number of parapophyses is difficult to determine. Pterygiophores are extended forward over the abdominal wall. Caudal fin rays are moderately visible and approximately 12 and branched. Since the skull structure, pectoral and pelvic girdles in the studied specimen are not very well preserved, it cannot be compared with other known specimens of *Bregmaceros*. Osteology of poorly preserved fossil specimens is quite difficult.

Remarks.—Świdnicki (1991) conducted a skeletal study of the closest living relatives of the studied fossil. For example, in the study on *Bregmaceros* genus, osteology of four extant species of *Bregmaceros houdei*, *B. bathymaster*, *B. japonicus*, and *B. maccllellandi* were examined. Of the examined species, only *B. bathymaster* had a variable number of precaudal vertebrae (13-14). In *B. bathymaster*, the number of caudal vertebrae is (34-36) close to that found in *B. houdei* (35-36), as were the numbers of its parapophyses (10-11 pairs) and ribs (8-9 pairs). *B. japonicus* differs from

the other studied species in possessing the highest number of precaudal vertebrae (16), ribs (13 pairs), and parapophyses (14 pairs), and it had more caudal vertebrae (41) than *B. houdei* and *B. bathymaster*. *B. maccllellandi* was similar to the latter two species in the number of precaudal vertebrae (14), parapophyses (12 pairs), and ribs (11 pairs). Besides, *B. maccllellandi* had more caudal vertebrae (45) than other studied species (Świdnicki, 1991).

DISCUSSION AND CONCLUSIONS

In recent years, studies were carried out on the living species of *Bregmaceros* sp. in Turkish seas around the Aegean and Mediterranean. *Bregmaceros* sp. is rare, even its existence is sometimes difficult to prove and even its report is very significant. For example, it has been reported that extant species belonging to antenna codlet, *B. atlanticus*, is found in Iskenderun Bay (Turan *et al.*, 2011). *B. atlanticus* is distributed predominantly in circum-tropical regions and probably entered the Mediterranean Sea from the Atlantic Ocean through the Strait of Gibraltar and settled in the Levantine Sea, which has subtropical features. *B. atlanticus* species is reported from the eastern Mediterranean in Kusadasi Bay (Filiz *et al.*, 2007), Antalya Bay (Yilmaz *et*

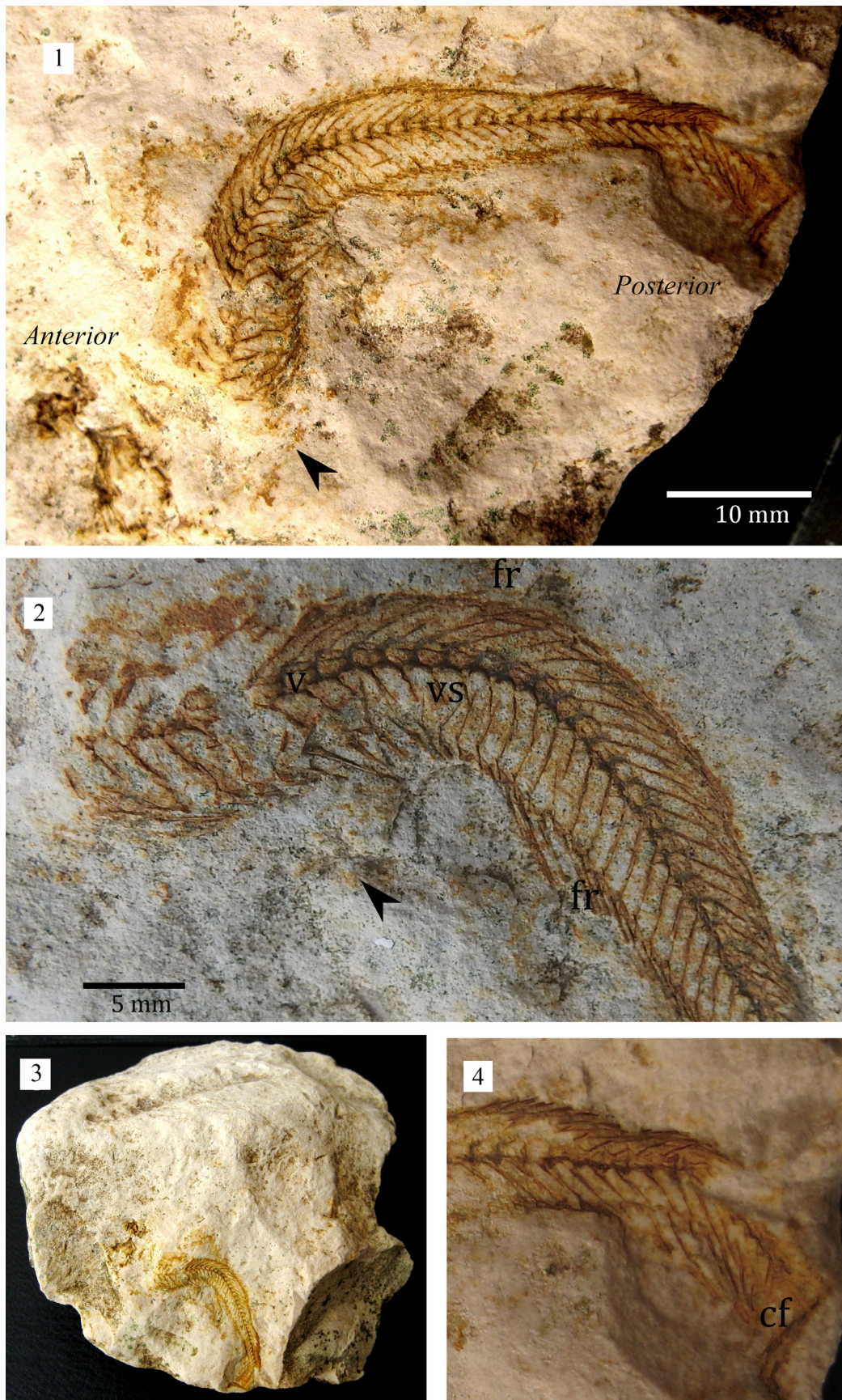


Fig. 3. 1. *Bregmaceros?* sp. (Thompson, 1840), rays 2. Details of vertebra (v), vertebral spines (vs), fin rays (fr), (The black arrows mark the pelvic fin ray trace) 3. Limestone fragment with the fossil specimen, 4. Close up of the tail part and caudal fin (cf)

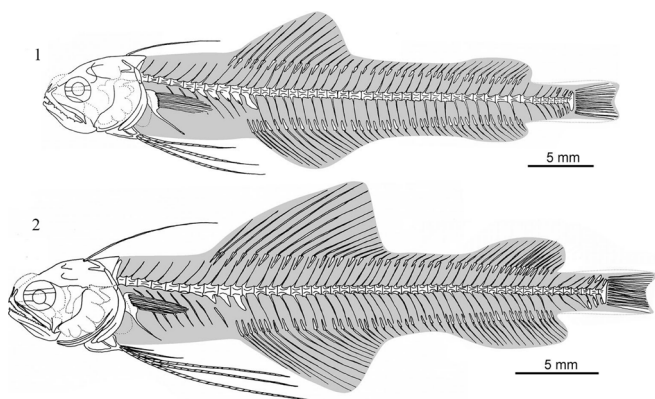


Fig. 4. Reconstructions of two fossil *Bregmaceros* species. 1. *B. filamentosus* (Priem, 1908); 2. *B. albyi* (Sauvage, 1880) (Priekryl et al., 2016).

al., 2004), the coast of Israel (Goren and Galil, 2006), the Bay of Iskenderun (Turan et al., 2011), the Izmir Bay (Aydin and Akyol, 2013), the Saronikos Gulf, Greece (Dogrammatzi and Karachle, 2015) and the Egyptian coast (Rizkalla and Akel, 2015). On the other hand, *B. nectabanus* was recorded in the Izmir Bay (□zgul and Akyol, 2017), the Patraikos, and Kerkyraikos Gulf, Greece (Ketsilis-Rinis and Dimitrou, 2018) and the Syrian coast (Othman and Galyia, 2019). In another study, it was reported that two individuals of *B. nectabanus* were collected from the Mediterranean, the Adriatic Sea, Italy (Dulčić et al., 2020). However, it was reported that all previously published records of *B. atlanticus* from the Mediterranean were based on misidentifications and those that could be confirmed were considered to be *B. nectabanus* (Harold and Golani, 2016). Among the features that help distinguish *B. nectabanus*, is its almost non-pigmented abdomen, a thin dorsolateral longitudinal stripe under the second dorsal fin, and a distally fimbriate opercular spine (Harold and Golani, 2016).

Bregmacerotidae fossils are generally known from the Cenozoic marine sediments and are represented by the otoliths, skeletons, and otolith-containing skeletons. Although many studies of *Bregmacerotidae* have been published and their geographical and chronological distributions are well documented, the morphological information of the species is not sufficiently documented. In a study, it was mentioned that 18 fossil species, belonging to the *Bregmacerotids*, were discovered. It has been reported that 17 fossils belonging to the Middle Eocene *Bregmaceros* genus and a Miocene *Bregmacerina antiqua* species have been found. On the other hand, *B. albyi*, a species of Miocene-Pliocene has been found in countries such as Italy, Austria, Greece, Cyprus, Malta, and Algeria. Additionally, it has been reported that *B. filamentosus*, a species of Eocene-Miocene, was detected in Russia, Egypt, Iran, Georgia, Czech, Romania and Poland (Priekryl et al., 2016). No fossil record of these species is mentioned in the Anatolia territories in the studies.

Bregmaceros sp. fossils are found in abundance from the Eocene to the Quaternary. As it is known from the Early Miocene, *B. albyi* (Fig. 4.2) was recorded from the Tethys Sea. There is a possibility that the sample examined in this study may have been either the extinct species *B. albyi* or *B. filamentosus* (Figs. 4.1, 4.2). Both the species lived during Miocene. However, since there is no information about the

skull bone, orbits, and otoliths of the fish, it is very difficult to state the fossil belongs to which species. In the study of Priekryl et al. (2016), it was mentioned, fossil records of *B. albyi* have been reported from the Miocene of Algeria (Arambourg, 1927; Gaudant, 2002), Italy (Leonardi, 1959; Bedini et al., 1986; Landini and Sorbini, 1992; Gaudant et al., 1996), Greece (Symeonidis, 1969; Symeonidis and Schultz, 1973; Gaudant et al., 1997, 2005; Gaudant, 2002), Malta (Pedley, 1978), Austria (Bachmayer and Weinfurter, 1965) and Spain (Gaudant, 1995, 2002) as well as from the Pliocene of Italy (Landini and Menesini, 1986; Sorbini, 1988; Landini and Sorbini, 1992, 1993). Additionally, *B. filamentosus* have been reported from the Oligocene of Poland (Kotlarczyk et al., 2006), Russia (Daniltshenko, 1960) and Romania (Jonet, 1958; Constantin, 1999) and from the middle Eocene (Bartonian) Dabachian Formation in the North Caucasus of Georgia (Daniltshenko, 1962; Bannikov, 1993; Bannikov and Parin, 1997). Poorly preserved skeletons of *B. cf. filamentosus* are reported from the lower Miocene and Oligocene-Miocene of Czech (Brzobohatý et al., 2003) and Miocene of Egypt (Gaudant and Rouchy, 1986). The species from Lebanon is identified as *B. filamentosus* and ranges from Middle Eocene to Early Oligocene and has been reported from the Mediterranean region and surrounding areas including Georgia (Middle-Late Eocene) and Iran (Middle Eocene) (Clark, 2020). The detailed otolith record for *Bregmaceros* sp. shows a wide geographic distribution including Northern America, Europe, New Zealand, Asia, Northern and Western Africa starting from the Middle Eocene. While it was confined to Europe during the Oligocene, otoliths of *Bregmaceros* sp. came to light in the Australian records, and it appears that they continued their global spread into the Miocene as well in younger Quaternary strata (Priekryl et al., 2016).

It has been claimed that only two fossil species (*B. filamentosus* and *B. albyi*) (Figs. 4.1, 4.2) are identifiable (Priekryl et al., 2016). The fossils of *B. filamentosus* and *B. albyi* are both known from skeletons whose otoliths are in situ, and *B. albyi* has a large record of isolated otoliths dating back to the Pliocene. However, up to the present, 12 nominal *Bregmaceros* fossil species have been identified based on isolated otoliths from the middle Eocene to the middle Miocene, such as *B. antiquus* (Late Eocene-Kaiatan); *B. felkeri* (Middle Eocene-Lutetian); *B. minimus* (Middle Eocene-Bartonian) and (late Eocene); *B. luellingensis* (Early Miocene and Middle Miocene - Reinbekian); *B. troelli* (Middle Eocene); *B. brihandensis* (Late Eocene-Priabonian); *B. deklaszi* (Oligocene-Aquitaine), (Early-Miocene - late Burdigalian) and (middle-late Miocene); *B. catulus* (Lower Oligocene - Rupelian) *B. oblongus* (Early Oligocene-Lattorfian); *B. prosoponos* (Early Miocene-Altonian); *B. hybridus* (Miocene); *B. minutus* (Middle Miocene) (Priekryl et al., 2016). Skeletal fossils of these species have not been found. Identifications of the species were made only based on otolith records. Skeletal fossil records indicated *B. filamentosus* was spreading across Southern Tethys and the Paratethys oceans from the middle Eocene into the Early Miocene, and then the species shows a post-Eocene shift towards western areas. The Miocene spreading of *B. albyi* follows the early trend with further southwest shifts and delimiting this form to the Mediterranean region. *B. albyi* dispersal widens from the Early Miocene (Burdigalian) to the Middle Pliocene, with existing in the Mediterranean (Priekryl et al., 2016). As the

geographical distributions of the *Bregmaceros* species are established owing to their skeletal remains, Bregmacerotid fossils are moderately common, however, preservation of the fossil specimens is frequently insufficient and for this reason, providing adequate information becomes difficult. Due to this limitation and the absence of preservable soft features, it becomes very difficult to identify, describe and interpret fossil Bregmacerotids.

So far, there is no study regarding the fossil record of *B. albyi* or *B. filamentosus* in Turkish territories. In the study of Prikryl *et al.* (2016), which explains *Bregmaceros* species in detail, there is no description or data about *B. albyi* or *B. filamentosus* from the Anatolian territory. In the current study, the first record of *Bregmaceros?* sp. (Fig. 3) (Gadiformes, Bregmacerotidae) is reported from the Firat Formation of Diyarbakır, South-eastern Turkey. Palaeobiogeographic implications are discussed by comparing with other Miocene *Bregmaceros* species in deposits of the same age and different ages. Although it is known that the extinct *B. albyi*

species belongs to the Miocene-Pliocene and the extinct *B. filamentosus* species belongs to the Eocene-Miocene, due to poor preservation it cannot be determined whether the fossil reported here represents *B. albyi*, *B. filamentosus* or a new species. However, the region where the fossil is located certainly belongs to the Early Miocene (Aquitanian-Burdigalian). We hope that future collection efforts and further studies of new samples will yield clearer taxonomic results.

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REFERENCES

- Arambourg, C. 1927. Les poissons fossiles d'Oran. Matériaux Pour la Carte Géologique de l'Algérie, 1er Série-Paléontologie, 6: 1-218. (in French)
- Aydın, I., and Akyol, O. 2013. New record of the antenna codlet, *Bregmaceros atlanticus* Goode and Bean, 1886 (Gadiformes: Bregmacerotidae), from the northern Aegean Sea (Izmir Bay, Turkey). *Journal of Applied Ichthyology*, 29: 245-246. <https://doi.org/10.1111/jai.12009>
- Bachmayer, F., and Weinfurter, E. 1965. Bregmaceros-Skelette (Pisces) mit in situ gehaltenen Otolithen aus den tortonischen Ablagerungen von Walbersdorf, Oesterreich. *Senckenbergiana Lethaea*, 46a: 19-33 (in German).
- Bannikov, A.F. 1993. The succession of the Tethys fish assemblages exemplified by the Eocene localities of the Southern part of the former USSR. *Kaupia*, 2: 241-246.
- Bannikov, A.F., and Parin, N.N. 1997. The list of marine fishes from Cenozoic (Upper Paleocene-Middle Miocene) localities in southern European Russia and adjacent countries. *Journal of Ichthyology*, 37(2): 133-146.
- Bedini, E., and Landini, W. 1986. L'ittiofauna fossile del T. samoggia (Bologna): Nota preliminare. *Bollettino del Museo Regionale di Scienze Naturali di Torino*, 4(1): 217-242. (in Italian)
- Berg, L.S. 1958. System der rezenten und fossilen Fischartigen und Fische. VEB Verlag der Wissenschaften, Berlin. (in German)
- Brzobohatý, R., Reichenbacher, B., and Gregorová, R. 2003. Teleostei (otoliths, skeletons with otoliths in situ) from the Karpatian of the Central Paratethys. In R. Brzobohatý, I. Cicha, M. Kováč, F. Rögl (Eds), *The Karpatian. A lower Miocene stage of the Central Paratethys* (pp. 265-279). Brno: Masaryk University.
- Clark, G.N., and Boudagher-Fadel, M. 2020. Insights into the Cenozoic geology of North Beirut (harbour area): biostratigraphy, sedimentology and structural history. *UCL Open: Environment*, 1: 01. <https://dx.doi.org/10.14324/111.444/ucloe.000004>
- Constantin, P. 1999. Oligocene-lowermost Miocene fossil fish-fauna (Teleostei) from Romanian Eastern Carpathians. *Geo-Eco-Marina*, 4: 119-134.
- Daniiltschenko, P.G. 1960. Kostistiye ryby maikopskich othlozeniy Kavkaza. *Trudy Paleontologicheskogo Instituta*, 78: 1-208. (In Russian).
- Daniiltschenko, P.G. 1962. Ryby Dabakhanskoy svity Gruzii. *Paleontologicheskii Zhurnal*, 1: 111-126. (In Russian).
- Dogrammatzi, A., and Karachle, P.K. 2015. First record of the antenna codlet *Bregmaceros atlanticus* Goode & Bean, 1886 in Greek waters. In: Zenetos *et al.*, *New Mediterranean Biodiversity Records* (April 2015). *Mediterranean Marine Science* 16: 266-284. <https://doi.org/10.12681/mms.1292>
- Duke, W.L., Arnott, R.C., and Chell, R.J. 1991. Shelf sandstones and hummocky cross-stratification; New insights on a stormy debate. *Geology*, 19: 625-628.
- Dulčić, J., Bello, G., and Dragičević, B. 2020. *Bregmaceros nectabanus* Whitley, 1941 (Teleostei: Bregmacerotidae), a new Lessepsian migrant in the Adriatic Sea. *BioInvasions Records*, 9 (4): 808-813. <https://doi.org/10.3391/bir.2020.9.4.14>
- Endo, H., 2002. Phylogeny of the order Gadiformes (Teleostei, Paracanthopterygii): *Memoirs of the Graduate School of Fisheries Sciences, Hokkaido University*, v. 49, p. 75-149.
- Filiz, H., Akçınar, S.C., Ulutürk, E., Bayhan, B., Taşkavak, E., Sever, T.M., Bilge, G., and Irmak, E. 2007. New records of *Bregmaceros atlanticus* (Bregmacerotidae), *Echiodon dentatus* (Carapidae), and *Nemichthys scolopaceus* (Nemichthyidae) from the Aegean Sea. *Acta Ichthyologica et Piscatoria*, 37: 107-112. <https://doi.org/10.3750/AIP2007.37.2.07>
- Gaudant, J., Caulet, J.P., Di Gerónimo, I., Di Stephano, A., Fournanier, E., Romeo, M., and Venec-Peyre, M.T. 1996. Analyse séquentielle d'un nouveau gisement de poissons fossiles du Messinien marin diatomitique: Masseria il Salto près de Caltagirone (province de Catane, Sicile). *Géologie Méditerranéenne*, 23(2): 117-153. (in French)
- Gaudant, J. 1995. Nouvelles additions à l'ichthyofaune messinienne de la Sierra de Columbares (Province de Murcia, Espagne). *Comptes Rendus de l'Académie des Sciences. Série II. Sciences de la Terre et des Planètes*, 320: 439-446. (in French)
- Gaudant, J. 2002. La crise messinienne et ses effets sur l'ichthyofaune néogène de la Méditerranée: le témoignage des squelettes en connexion de poissons téléostéens. *Geodiversitas*, 24(3): 691-710. (in French)
- Gaudant, J., Fournanier, E., Lauriat-Rage, A., Tsagaris, S., Venec-Peyre, M.T., and Zorn, I. 1997. Découverte d'une ichthyofaune marine dans le Messinien préévaporitique de la Messara (Crète centrale, Grèce): Interprétation paléocéologique. *Géologie Méditerranéenne*, 24(3-4): 175-195. (in French)
- Gaudant, J., and Rouchy, J.M. 1986. Ras Dib: Un nouveau gisement de Poissons fossiles du Miocène moyen du Gebel Zeit (Golfe de Suez, Egypte). *Bulletin du Muséum National d'Histoire Naturelle, Paris*, 4e Série, 8(4): 463-481. (in French)
- Gaudant, J., Tsaparas, N., Antonarakou, A., Drinia, H., and Dermitzakis, M.D. 2005. The Tortonian fish fauna of Gavdos Island (Greece). *Comptes Rendus Palevol*, 4(8): 687-695.
- Goren, M., and Galil, B.S. 2006. Additional records of *Bregmaceros atlanticus* in the eastern Mediterranean - an invasion through the Suez Canal or in ballast water? *Marine Biodiversity Records*, 1:e42. <https://doi.org/10.1017/S1755267206004593>

- Güngör, Y.P., and Helvacı, C. 2013. Kurtalan sahası (GB Siirt) Germik formasyonu oligosen evaporitlerinin diyajenezi ve paleoçografik gelişimi, Türkiye. *Yerbilimleri Dergisi*, 34(1): 1-22. (in Turkish)
- Güngör, Y.P., and Helvacı, C. 2017. Petrographic study and geochemical investigation of the evaporites associated with the Germik Formation (Siirt Basin, Turkey). *Carbonates and Evaporites*, 32: 177-194.
- Harold A.S., and Golani D. 2016. Occurrence of the Smallscale Codlet, *Bregmaceros nectabanus* in the Mediterranean Sea, previously misidentified as *B. atlanticus* in this region. *Marine Biodiversity Records*, 9: 71, <https://doi.org/10.1186/s41200-016-0071-0>
- Hüsing, S.K., Zachariasse, W.J., Van Hinsbergen, D.J.J., Krijgsman, W., Inceöz, M., Harzhauser, M., Mandic, O., and Kroh, A. 2009. Oligocene-Miocene basin evolution in SE Anatolia, Turkey, Constraints on the closure of the eastern Tethys gateway. *Geological Society London Special Publications*, 311: 107-132.
- Jonet, S. 1958. Contributions à l'étude des schistes disordyiques Oligocènes de Roumanie. La fauna ichthyologique de Homorâciu District de Prahova. Lisboa: Sociedade Tipografica. (in French)
- Ketsilis-Rinis, V., and Dimitrou, N. 2018. First record of smallscale codlet *Bregmaceros nectabanus* Whitley, 1941 in the Ionian Sea. In: Chartosia *et al.*, *New Mediterranean Biodiversity Records* (July 2018). *Mediterranean Marine Science* 19: 398-415. <https://doi.org/10.12681/mms.18099>
- Kotlarczyk, J., Jermanska, A., Świdnicka, E., and Wiszniowska, T. 2006. A framework of ichthyofaunal ecostratigraphy of the Oligocene-Early Miocene strata of the Polish Outer Carpathian basin. *Annales Societatis Geologorum Poloniae*, 76: 1-111.
- Landini, W., and Menesini, E. 1986. L'ittiofauna della sez. di Stuni e suoi rapporti con l'ittiofauna plioleistocenica della Vrica (Crotone, Calabria). *Bollettino della Società Paleontologica Italiana*, 25(1): 41-63. (in Italian)
- Landini, W., and Sorbini, L. 1992. Données récentes sur les Téléostéens du Miocène et du Pliocène d'Italie. *Geobios*, 25(1): 151-157. (in French)
- Landini, W., and Sorbini, L. 1993. Biogeographic and palaeoclimatic relationships of the Middle Pliocene ichthyofauna of the Samoggia Torrent (Bologna, Italy). *Ciências da Terra (UNL)*, 12: 83-89.
- Leonardi, A. 1959. L'ittiofauna del 'Tripoli' del Miocene superiore di Bessima (Enna). *Palaeontographia Italica*, 54: 115-173. (in Italian).
- Nelson, J.S., Grande, T.C., and Wilson, M.V.H. 2016. *Fishes of the World*: Hoboken, John Wiley & Sons, 752 p.
- Othman, R.M., and Galyia, M. 2019. The appearance of Smallscale Codlet, *Bregmaceros nectabanus* Whitley, 1941 (Bregmacerotidae) in Syrian marine waters. In: N. Stern *et al.*, *New Mediterranean Biodiversity Records 2019*. *Mediterranean Marine Science*, 20: 409-426, <https://doi.org/10.12681/mms.20602>
- Ozgul, A., and Akyol, O. 2017. On the occurrence of the smallscale codlet, *Bregmaceros nectabanus* (Bregmacerotidae), off the Urla Coast in Izmir Bay (Aegean Sea, Eastern Mediterranean). *Annales, Series Historia Naturalis*, 27(1): 69-74.
- Pedley, H.M. 1978. A new fish horizon from the Maltese Miocene and its palaeoecological significance. *Palaeogeography, Palaeoclimatology, Palaeoecology*, 24(1): 73-83.
- Prikryl, T., Brzobohaty, R., and Gregorova, R. 2016. Diversity and distribution of fossil codlets (Teleostei, Gadiformes, Bregmacerotidae): Review and commentary. *Palaeobiodiversity and Palaeoenvironments*, 96: 13-39. <https://doi.org/10.1007/s12549-015-0222-z>
- Rizkalla, S.I., and Akel, E.H.K.H. 2015. New records of Indo-Pacific and Atlantic species in Egyptian Mediterranean waters. In: Zenetos *et al.*, *New Mediterranean Biodiversity Records* (April 2015). *Mediterranean Marine Science*, 16: 266-284. <https://doi.org/10.12681/mms.1292>
- Sorbini, L. 1988. Biogeography and climatology of Pliocene and Messinian fossil fish of eastern-central Italy. *Bollettino del Museo Civico di Storia Naturale di Verona*, 14: 1-85.
- Symeonidis, N. 1969. Fossile Fische aus der Gegend von Ierapetra (Kreta). *Annales Géologiques des Pays Helléniques*, 21: 501-530. (in French)
- Symeonidis, N.K., and Schultz, O. 1973. Bemerkungen zur neogenen Fischfauna Kretas und Beschreibung zweier Fundstellen mit miozänen Mollusken, Echiniiden etc., Insel Kreta, Griechenland. *Annalen des Naturhistorischen Museums in Wien*, 77: 141-147. (in German)
- Świdnicki, J. 1991. New data on the osteology of some species of *Bregmaceros* (Teleostei, Gadiformes). *Journal of Morphology*. 208: 129 - 160. <https://doi.org/10.1002/jmor.1052080202>
- Torii, A., Harold, A.S., and Ozawa, T. 2003. Redescription of type specimens of three *Bregmaceros* species (Gadiformes: Bregmacerotidae): *B. bathymaster*, *B. rarisquamosus*, and *B. cayorum*. *Memoirs of the Faculty of Fisheries, Kagoshima University*, 52: 23-32.
- Torii, A., Javonillo, R., and Ozawa, T. 2004. Re-examination of *Bregmaceros lanceolatus* Shen, 1960 with description of a new species *Bregmaceros pseudolanceolatus* (Gadiformes: Bregmacerotidae). *Ichthyological Research*, 51(2): 106-112.
- Turan, C., Yağlıoğlu, D., Gürlek, M., and Ergüden, D. 2011. A new record of antenna codlet *Bregmaceros atlanticus* Goode and Bean, 1886 (Bregmacerotidae: Gadiformes) from the Northeastern Mediterranean coast of Turkey. *Journal of the Black Sea/Mediterranean Environment*, 17(2): 186-192.
- Yeşilova, Ç., Carrillo, Alvarez, E., and Helvacı, C. 2018. Evaporitic sedimentation in the Southeastern Anatolian Foreland Basin, New insights on the Neotethys closure. *Sedimentary Geology*, 369: 13-27.
- Yeşilova, Ç., and Helvacı, C. 2012a. Batman-Siirt kuzeyi stratigrafisi ve sedimantolojisi, Türkiye. *Türkiye Petrol Jeologları Dergisi* 23(2): 7-49. (in Turkish)
- Yeşilova, Ç., and Helvacı, C. 2012b. Lice Formasyonu evaporitleri ve killerin ekonomik önemi, Baykan-Kurtalan-Şirvan Bölgesi (Siirt). *Yüzüncü Yıl Üniversitesi Fen Bilimleri Dergisi*, 17(2): 77-83. (in Turkish)
- Yılmaz, E., and Duran, O. 1997. Güneydoğu Anadolu bölgesi otokton ve allohton birimler stratigrafisi adlı sözlüğü (Lexicon). TPAO Araştırma Merkezi Grubu Başkanlığı Eğitim Yayınları, 31: 460. (in Turkish)
- Yılmaz, R., Bilecenoğlu, M., and Hoşsucu, B. 2004. First record of the Antenna Codlet, *Bregmaceros atlanticus* Goode & Bean, 1886 (Osteichthyes: Bregmacerotidae), from the eastern Mediterranean Sea. *Zoology in the Middle East*, 31: 111-112. <https://doi.org/10.1080/09397140.2004.10638031>