

# First fossil record of the family Euryalidae (Echinodermata: Ophiuroidea) from the Middle Miocene of the Central Mediterranean

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**ABSTRACT:** Recent sampling of the Langhian (Middle Miocene) Xwieni Conglomerate Bed at the base of the Upper *Globigerina* Limestone in the Maltese Islands has yielded abundant disarticulated ophiuroid vertebrae. Attribution to the family Euryalidae is beyond doubt, being based on vertebral shape, streptospondylous articulation, presence of branching vertebrae, and a “bridge-like” structure closing the ventral furrow. While some of these features are found in other groups too, this combination of features is found in the family Euryalidae only. This is the first fossil record of this family, extending its range back to the Miocene. It also widens the spatial distribution of the Euryalidae, which at present are confined to the Indo-Pacific region, suggesting that the family was more widespread in the Cenozoic than it is today.

## 1 INTRODUCTION

The skeleton of euryaline ophiuroids is composed of numerous large, sturdy ossicles. They are widespread members of Recent shallow- and deeper-water habitats (Döderlein 1927, Mortensen 1933, Baker 1980). Smith et al. (1995) suggested an Early Mesozoic origin for this group based on a combined morphological and molecular phylogenetic analysis. In spite of this, however, the fossil record of this group is rather poor.

The family Gorgonocephalidae is documented by disarticulated material from the Middle Miocene of Central Europe (Kroh 2003), the Pliocene of Northern Africa (Pomel 1885) and northwest Europe (Kroh & Jagt 2004). The families Asteroschematidae, Asteronychidae and Euryalidae, however, lack a fossil record to date. Although the last-named group is mentioned in several papers, these records are not convincing. An early report of *Euryale? liasica* Quenstedt, 1876 has subsequently been shown to comprise resting traces of indeterminate brittle stars with unbranched arms, with the impression of branched arms having been produced by multiple traces of moving arm tips (Seilacher 1953). Records of *Trichaster? ornatus* (Rasmussen 1950) and *Trichaster? sp.* from the Campanian and Maastrichtian of the SE Netherlands and NE Belgium (Jagt 2000, pp. 8, 9; pl. 1, figs 5-10) and from the Maastrichtian of Rügen (Germany) and Møn (Denmark; see Jagt & Kutscher 1998, Kutscher & Jagt 2000, pp. 51-53; pl. 32, figs 1-7) comprise dissociated streptospondylous vertebrae with an open

ventral groove. Rasmussen (1950, 1972) tentatively referred these ossicles to *Asteronyx*. Although these vertebrae are very similar to those of *Trichaster*, their attribution to the Euryalidae and in particular to this genus is questionable. In all extant euryalids, the ventral furrow is closed by a “bridge-like” structure in distal arm portions (Mortensen 1933, pp. 3, 4). In many Recent euryalid species only a few proximal vertebrae have open grooves, e.g. in *Asteroceras pergamenum* Lyman, 1879 only the first and second vertebrae. In addition, neither Jagt (2000) nor Kutscher & Jagt (2000) recorded any branching vertebrae, while in extant *Trichaster* arms branch up to ten times. The euryalid vertebrae reported in the present study from the Langhian (Middle Miocene) of Malta thus represent the first unquestionable fossil record of this family.

## 2 STUDY AREA

The studied samples were obtained from the Qolla I-Bajda section at Xwieni Bay, Gozo, Maltese Islands, Central Mediterranean. This section exposes the uppermost part of the Lower *Globigerina* Limestone, i.e. the hardground below the Qammieh Conglomerate Bed (Rose et al. 1992) (= C<sub>1</sub> Phosphate Conglomerate of Pedley et al. 1976), the complete Middle *Globigerina* Limestone, and the lower half of the Upper *Globigerina* Limestone. The samples which have yielded the ophiuroid vertebrae studied come from the basal part of the Upper *Globigerina* Limestone, namely the Xwieni Conglomerate Bed (= C<sub>2</sub> Phosphate Conglomerate

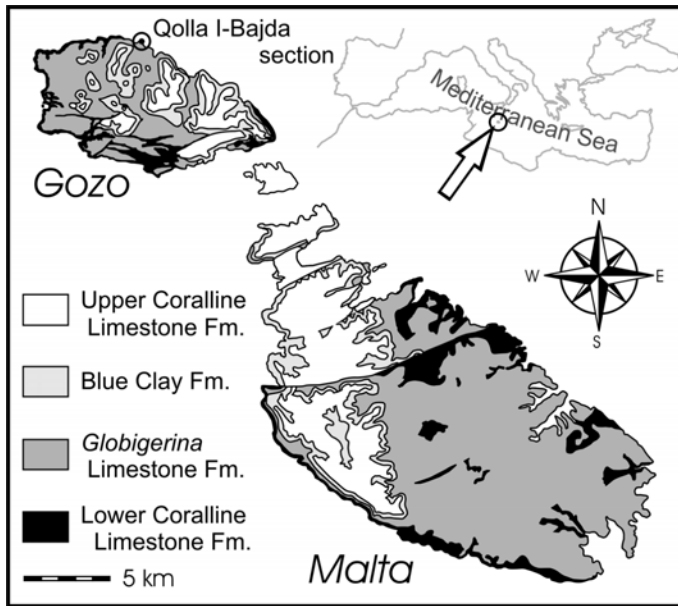


Figure 1. Location of the studied section on the island of Gozo, Maltese Islands (geological map simplified from Pedley et al. 1976).

of Pedley et al. 1976), directly on top of the terminal hardground of the Middle *Globigerina* Limestone. The Xwieni Conglomerate Bed and the Upper *Globigerina* Lst. are of Langhian age based on foraminiferal and calcareous nannoplankton evidence (nannozone CN4, NN5; Giannelli & Salvatorini 1972, Mazzei 1985). Additional samples from other *Globigerina* Limestone outcrops all over the Maltese Islands have been studied for comparative purposes.

### 3 MATERIAL AND METHODS

Several bulk samples of about 5 kg each were collected from the locality mentioned with permission from the Malta National Museum of Natural History in Mdina (permit no. T/00/1). Loose fine material was removed in the field by dry sieving with a sieve with an effective mesh width of 1.5 mm. The material originates from the weathered surface of the cliff face and was readily washable by wet sieving. Fresh sediment could only be processed by dissolving the rock in acetic acid. The fresh and weathered residues, however, yielded the same taxa in similar quantities only much more poorly preserved, thus testifying to the autochthonous nature of the material from the weathered sediment. After wet sieving through standard sieve sets, the residues were dried and hand picked by naked eye and under a stereo microscope. Specimens for SEM analysis were cleaned with hydrogen peroxide and in an ultrasonic bath, mounted on stubs and then gold coated.

Both bulk samples and processed ophiuroid material are deposited at the Geologisch-Paläontologische

Abteilung at the Naturhistorisches Museum Wien (NHMW).

### 4 RESULTS

Class Ophiuroidea Gray, 1840  
 Subclass Ophiuridea Gray, 1840  
 Order Euryalina Lamarck, 1816  
 Family Euryalidae Gray, 1840

#### **Euryalidae indet.**

(Figs. 2-3)

*Material studied* – 105 vertebrae (NHMW 2003z0068/0001-2) originating from bulk sample Xwieni Bay 0702, and 86 vertebrae (NHMW 2003z0069/0001-6) originating from bulk sample Xwieni Bay 0800. Both bulk samples were taken from the Xwieni conglomerate bed, basal Upper *Globigerina* Limestone about 0.5 to 1.5 m above the terminal hardground of the Middle *Globigerina* Limestone at the Qolla I-Bajda section, Xwieni Bay, Gozo, Maltese Islands. Although it cannot be demonstrated beyond doubt, all vertebrae are here considered to be conspecific.

#### **Description**

*“Typical” vertebrae* – Vertebrae range in size from less than 1 to ca. 5.5 mm in diameter, and show a characteristic hourglass-shaped, streptospondylous articulation. In lateral view they are about half as wide as high and the lateral furrow between the proximal and distal insertion areas shows a strong ornament. This ornament consists of irregularly rounded knobs and ridges arranged in two more or less conspicuous vertical rows. The dorsal groove is shallow and U-shaped, the ventral groove deep and V-shaped. In vertebrae from the median to distal part of the arms, the ventral groove is crossed by a “bridge-like” structure (compare Mortensen 1933: pp. 3-4) attached to tips of the ridge bearing the ventral lobes (oral fossae). The ventral lobes are large and well differentiated from the remaining ossicle surface. The first arm vertebrae could also be identified in the material studied; these occur in the size classes down to diameters of >3.5 mm (these vertebrae can easily be recognized a different articulation pattern at their distal face).

*Branching vertebrae* – Only a single branching vertebra was found among the material picked from the bulk samples. It is closely similar to the “Typical” vertebrae in all aspects, apart from being slightly wider and exhibiting two articulation facets at its distal face. It is worn, but it also bears the ornament on its lateral faces mentioned above.

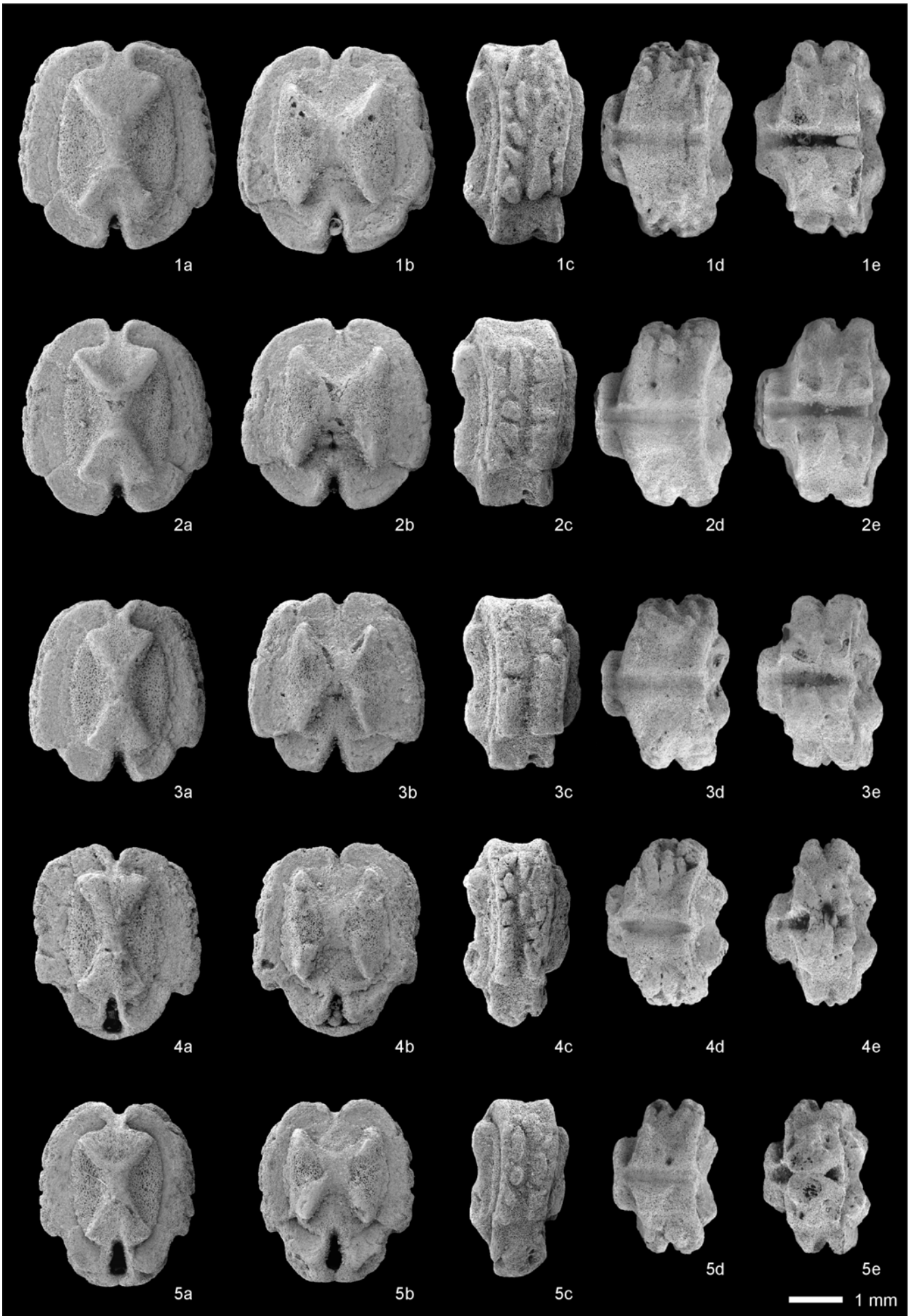


Figure 2. Euryalid vertebrae from Qolla I-Bajda, Xwieni Bay, Gozo, Maltese Islands. “Typical” vertebrae, a: distal view; b: proximal view; c: lateral view; d: dorsal view; e: ventral view. NHMW 2003z0069/0002-6. Scale bar equals 1 mm.

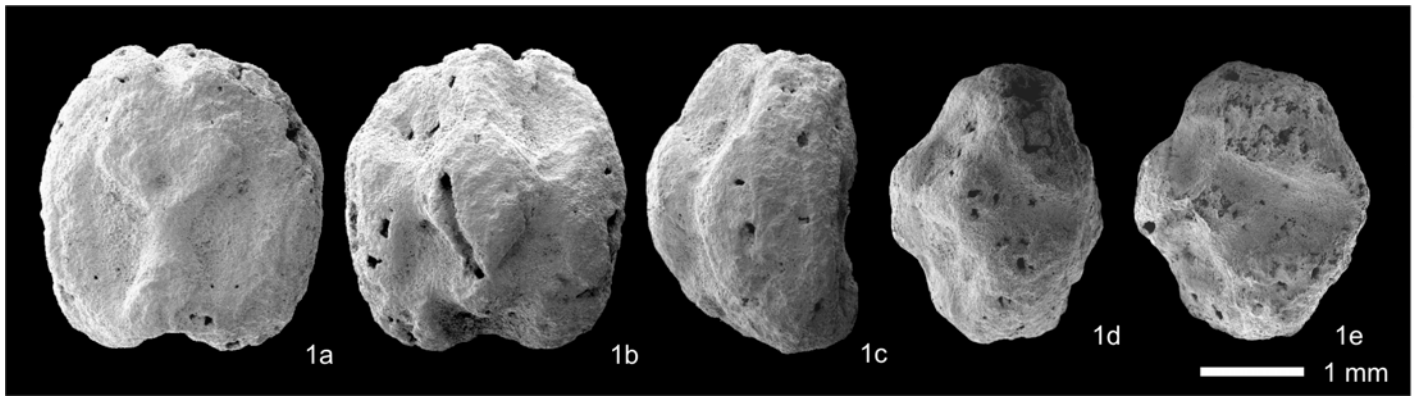


Figure 3. Euryalid vertebra from Qolla I-Bajda, Xwieni Bay, Gozo, Maltese Islands. “Branching” vertebra, a: distal view; b: proximal view; c: lateral view; d: dorsal view; e: ventral view. NHMW 2003z0068/0002. Scale bar equals 1 mm.

Table 1. Size distribution of dissociated euryalid vertebrae from bulk samples Xwieni Bay 0702 and 0800. (Abbreviations: tv/ovg = “Typical” vertebrae with open ventral groove; tv/cvg = “Typical” vertebrae with “bridged” ventral groove; bv = “Branching” vertebrae; fv = 1<sup>st</sup> vertebrae)

<b>Bulk sample Xwieni Bay 0702</b>								
Diameter (mm)	>4.5	>4.0	>3.5	>3.0	>2.5	>2.0	>1.5	>1.0
tv/ovg		5	19	23	22	10	4	1
tv/cvg					4	8	7	
bv					1			
fv			1					
<b>Bulk sample Xwieni Bay 0800</b>								
Diameter (mm)	>4.5	>4.0	>3.5	>3.0	>2.5	>2.0	>1.5	>1.0
tv/ovg	2	9	22	20	17	6	4	
tv/cvg				1	2	1	2	

## 5 DISCUSSION

The vertebrae studied can clearly be assigned to the family Euryalidae based on vertebral shape, streptospondylous articulation, presence of branching vertebrae, and most important the “bridge-like” structures in vertebrae from the median and distal part of the arm. The latter feature is found only in the Euryalidae (Mortensen 1933), while the other features are found in other groups as well. Another good indicator for this family is the strong ornamentation on the lateral faces of the vertebrae, which is present in all euryalids examined so far. It is, however, also present in Late Cretaceous material from northwest Europe (see Jagt & Kutscher 1998, Kutscher & Jagt 2000), which might belong to basal members of this group. The rarity of branching vertebrae (compare Table 1) supports the attribution of the ossicles studied to the Euryalidae. Branching is absent in asteroschematids and asteronychids; It is common in most euryalids and gorgonocephalids. While there may be more than 30 bifurcations in each arm and a small number of “Typical” vertebrae between bifurcation in the latter, in euryalids (except *Euryale* itself) there are usually

few bifurcations and a high “Typical” vertebrae to “Branching” vertebrae ratio (compare Table 2 in Kroh 2003).

The family Euryalidae is a group of ophiuroids which today is restricted to the Indo-West Pacific region (Fig. 4). They range from southern Japan to southern Australia and New Zealand. Although there are some extreme shallow-water and deep-water species, most euryalids are found between 50 to 300 meters water depth (total known range: 0-1,185 m). Palaeo-depth estimates for *Globigerina* Limestone Formation are range from 50+ m to more than 300 m (Felix 1973, Pedley et al. 1976, Challis 1980, Pedley & Clarke, 2002). The environment was interpreted as deep-shelf margin and toe of slope carbonate setting by Boggild & Rose (1985). The semi-autochthonous phosphorite formation occurred during periods of non-deposition which may reflect shallowing events (Pedley & Bennett 1985). The habitat of the fossil euryalids from Malta thus was similar to that of most extant species.

The first undoubted fossil record of this family reported herein extends its range back to the Middle Miocene. Furthermore, this record widens the spatial

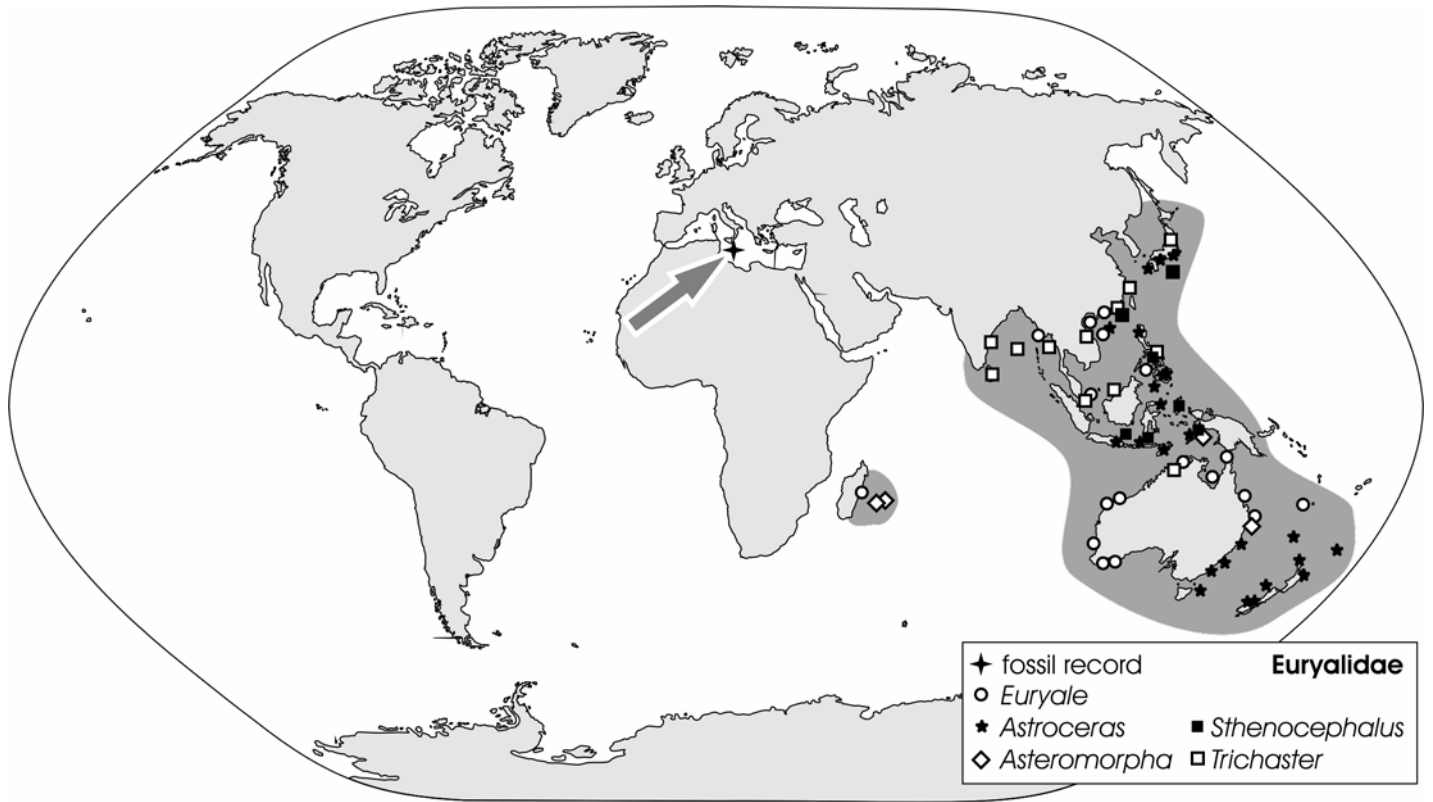


Figure 4. Distribution of extant Euryalidae and location of the fossil record (compiled from Döderlein 1911, 1927, 1930, Mortensen 1933, Baker 1980, Liao & Clark 1995, Rowe & Gates 1995). Note that the absence of records from large parts of the Indian Ocean may be a sampling artifact.

distribution of the Euryalidae to the Mediterranean region. The high similarity of the studied skeletal material with those of extant euryalids suggests that the family was already well differentiated from other euryalines during the Middle Miocene and a pre-Miocene origin thus seems likely. Moreover, as migration between Mediterranean and Indo-Pacific was becoming increasingly difficult during the Middle Miocene (see Jones 1999 and reference therein). This fits well with the Eocene origin of the family Euryalidae proposed by Smith et al. (1995: fig. 5).

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