

Description of *Paracaprinula syriaca* Piveteau (Hippuritoidea, Plagiptychidae) and a revised age of ophiolite obduction on the African-Arabian Plate in southeastern Turkey

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ABSTRACT

Paracaprinula syriaca, Piveteau (1939, Journal de Conchyliologie 83, 27–34), is described in detail for the first time. While the original description did not provide evidence for characters that indeed justify the genus of being different from *Mitrocaprina* Boehm, specimens collected at the type locality at Yaylaçiftliği (Hatay), and from Alıdamı (Kahta–Adıyaman) are characterized by vesicular structure of the inner shell layer of both valves. Other diagnostic features (myocardial arrangement, relative thickness of outer shell layer in both valves, pallial canals in left valve) are characteristic for the Plagiptychidae so that *Paracaprinula* is considered to be the most derived genus of the family presently known from the Old World. This is consistent with the Late Campanian age derived from strontium-isotope stratigraphy of specimens from the two localities studied. A Maastrichtian or even Late Maastrichtian age that was based on previous biostratigraphical studies (larger benthic, and planktonic foraminifers) of the predominantly siliciclastic transgressive sequence over the ophiolites of the African-Arabian Plate has to be revised. This has implications for the timing of ophiolite emplacement onto the African-Arabian Plate in southeastern Turkey.

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1. Introduction

In southeastern Turkey (Fig. 1), outcrops of Campanian–Maastrichtian transgressive sequences with rudists are largely limited to the regions of Kahta–Adıyaman, Gölbaşı–Kahramanmaraş, and Yayladağı–Hatay. These areas have a characteristic rudist fauna with four genera (*Dictyoptychus* Douvillé, *Paracaprinula* Piveteau, *Vautrinia* Milovanović, *Hatayia* Karacabey–Öztemür) and two additional species (*Hippurites syriaca* Vautrin, *Pironea syriaca* Vautrin) that are endemic to the African-Arabian Plate (Özer, 1986, 1991, 1992a–c, 2006; Philip, 1998). *Paracaprinula syriaca* Piveteau, 1939, was described from Yayladağı–Hatay, but the description provided no information about the myocardial arrangement and only little detail about the internal structure of the shell. Therefore, the genus and species were not recorded at other localities and the name was not used subsequently. According to the information available, *Paracaprinula* appeared to be similar or identical to *Mitrocaprina* Boehm, a derived plagiptychid rudist. Our recent

studies and previous collections of the second author of the present paper have yielded numerous specimens of *Paracaprinula syriaca*, both from the type locality (Yaylaçiftliği–Hatay) and from Alıdamı (Kahta–Adıyaman; Fig. 1). This collection allows us to provide the first detailed description of *Paracaprinula*. The genus is indeed different from *Mitrocaprina* and can be added to the list of endemic taxa known from the Afro-Arabian Plate now exposed in SE Turkey.

2. Geological setting and stratigraphy

Large parts of southeastern Turkey belong to the northwestern margin of the Arabian Plate, which was part of the larger African Plate until the Miocene. Collision with Eurasia in the late Cretaceous resulted in the obduction of ophiolites (Robertson, 2002). In southeastern Turkey, the Arabian platform consists of lower and upper autochthonous and intervening allochthonous units (Righo de Righi and Cortesini, 1964; Sungurlu, 1974; Yalçın, 1976; Perinçek, 1979; Şengör and Yılmaz, 1981; Altıner, 1989; Yılmaz and Yiğitbaş, 1991; Yılmaz, 1993). The lower autochthonous unit comprises Precambrian to Upper Cretaceous platform-type carbonates. The allochthonous units are giant nappe stacks of ophiolitic associations (Kızıldağ ophiolites in the Hatay area, Keban–Cilo ophiolites in the northern Adıyaman area) at the top, and sub-ophiolitic thrust

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sheets (Koçali and Karadut complexes) at the bottom (Yılmaz, 1993). The upper autochthonous units were deposited on top of the ophiolitic nappes and consist of, from bottom to top, red-coloured siliciclastics with rudist limestone lenses (Terbüzek Formation), shallow-water carbonates with rudists (Besni Formation), and pelagic mudstones (Germav Formation). These units show pronounced lateral facies changes indicating diachronous transgressive sedimentation. According to previous studies, deposition of this transgressive sequence started during the late Maastrichtian (Yalçın, 1976; Perinçek, 1979; Yılmaz, 1993) and continued until the Miocene.

2.1. Yaylaçiftliği, Hatay area

Cambrian siliciclastics and platform-type limestones of Triassic–Jurassic and Late Cretaceous age (up to the Santonian) form the autochthonous basement rocks in the Yayladağı–Hatay area (Dubertret, 1955; Delaloye et al., 1980; Selçuk, 1981; Pişkin et al., 1986). According to Al-Maleh (1976) the Jurassic and Cretaceous rocks show very close resemblance to coeval deposits of the Arabian platform. The ophiolitic complex of Kızıldağ consists of tectonites, cumulates, gabbros, sheeted-dike complexes, pillow lavas and volcano-sedimentary rocks, thrust over the basement rocks (Delaloye et al., 1980; Selçuk, 1981; Pişkin et al., 1984, 1986). Neo-autochthonous uppermost Cretaceous to Miocene sedimentary rocks unconformably follow over the autochthonous basement and ophiolitic complex. The rudist specimens described here were collected from the Yalaz Formation (Fig. 2), the oldest unit of the neo-autochthonous transgressive sequence in the region (Selçuk, 1981; Pişkin et al., 1986).

The Yalaz Formation is 25–300 m thick and consists of, from bottom to top, conglomerates, sandstones, limestones, and argillaceous limestones (Fig. 2). The basal conglomerate with predominantly ophiolitic components contains 2–4 m thick lenses of sandstone and sandy limestone. Rudist-bearing sandy limestones are exposed at two localities between Yalaz village and Yaylaçiftliği. Specimens of *Paracaprinula* were collected at Yaylaçiftliği, where they occur together with *Vautrinia syriaca* (Vautrin), *Dictyoptychus*

orontica Karacabey-Öztemür, *Pironaea syriaca* (Vautrin), *P. corrugata* (Woodward), *Hippurites syriaca* Vautrin, *Pseudopolyconites* cf. *ovalis* Milovanović, *Hatayia spinosa* Karacabey-Öztemür and Selçuk, *Lapeirousella anatolica* Karacabey-Öztemür and Selçuk and *L. yalazensis* Karacabey-Öztemür and Selçuk (Dechaseaux, 1954; Karacabey-Öztemür, 1981; Selçuk, 1981; Karacabey-Öztemür and Selçuk, 1981; Özer, 1991). The conglomerate that contains the rudist bearing lenses of sandy limestones passes upwards into sandstones with c. 10 cm thick limestone lenses that contain benthic foraminifers such as *Orbitoides media* (d'Archiac), *O. apiculatus* Schlumberger, *Siderolites calcitropoides* Lamarck, *Omphalocyclus macroporus* Lamarck, *Lepidorbitoides socialis* (Leymerie), *Loftusia* sp. and *Rotalia* sp. These deposits both laterally and vertically pass into limestones with planktonic foraminifers such as *Gansserina gansseri* Bolli, *Globotruncana mayaroensis* Bolli and *G. arca* (Cushman). Based on the benthic and planktonic foraminifers, the age of the Yalaz Formation was considered to be Maastrichtian or Late Maastrichtian (Dechaseaux, 1954; Dubertret, 1966; Selçuk, 1981; Karacabey-Öztemür and Selçuk, 1981; Pişkin et al., 1986). A Maastrichtian age was also adopted for the rudists of the Yalaz Formation (Özer, 1991) based on comparison with other rudist faunas of southeastern Turkey (Karacabey-Öztemür, 1981; Meriç et al., 1985; Özer, 1986) and supported by the benthic foraminifers in the overlying limestone lenses.

2.2. Alıdamı, Kahta–Adıyaman area

The Karadut complex (Cenomanian–Lower Turonian limestones, bedded cherts, shales and turbiditic conglomerates) and the Koçali ophiolitic complex (Upper Jurassic–Lower Cretaceous submarine volcanics, serpentinites, limestones with planktonic foraminifers, dolomitic limestones, radiolarites) form the allochthonous units in the region of Alıdamı (Fig. 1). According to long-established geological concepts, these nappes were emplaced on the Kastel Formation, an alternation of shales and sandstones with planktonic foraminifers of Campanian–early Maastrichtian age, deposited in the Kastel intracratonic basin (Sungurlu, 1974; Yalçın, 1976; Perinçek, 1979; Şengör and Yılmaz, 1981; Altner, 1989; Yılmaz, 1993).

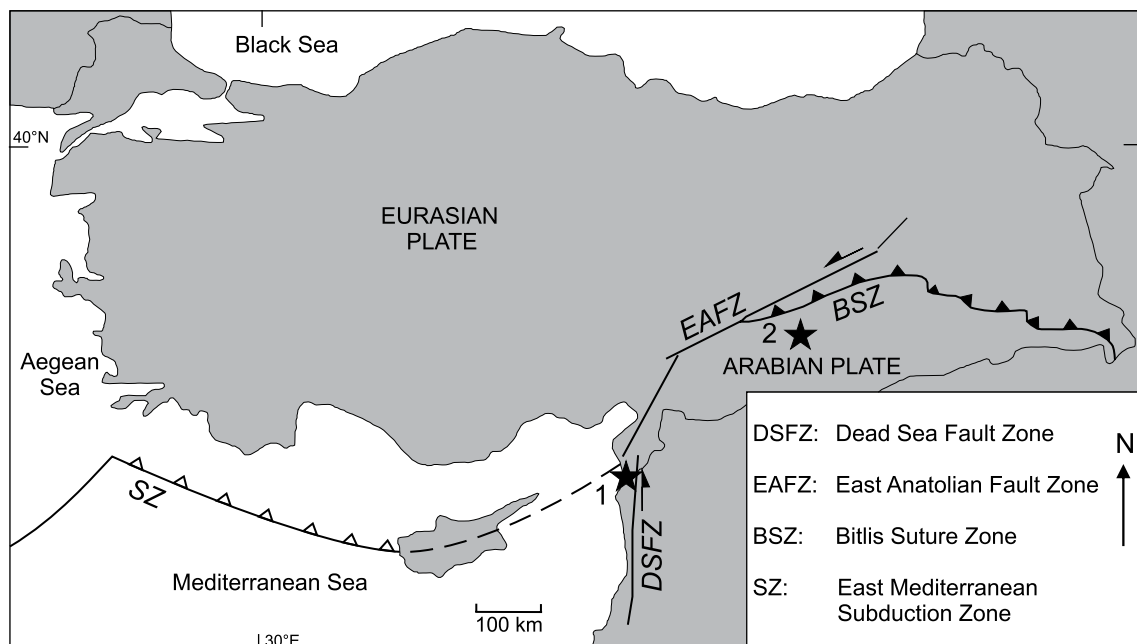


Fig. 1. Locality map (after Piper et al., 1996); 1, Yaylaçiftliği–Hatay area; 2, Alıdamı, Kahta–Adıyaman.

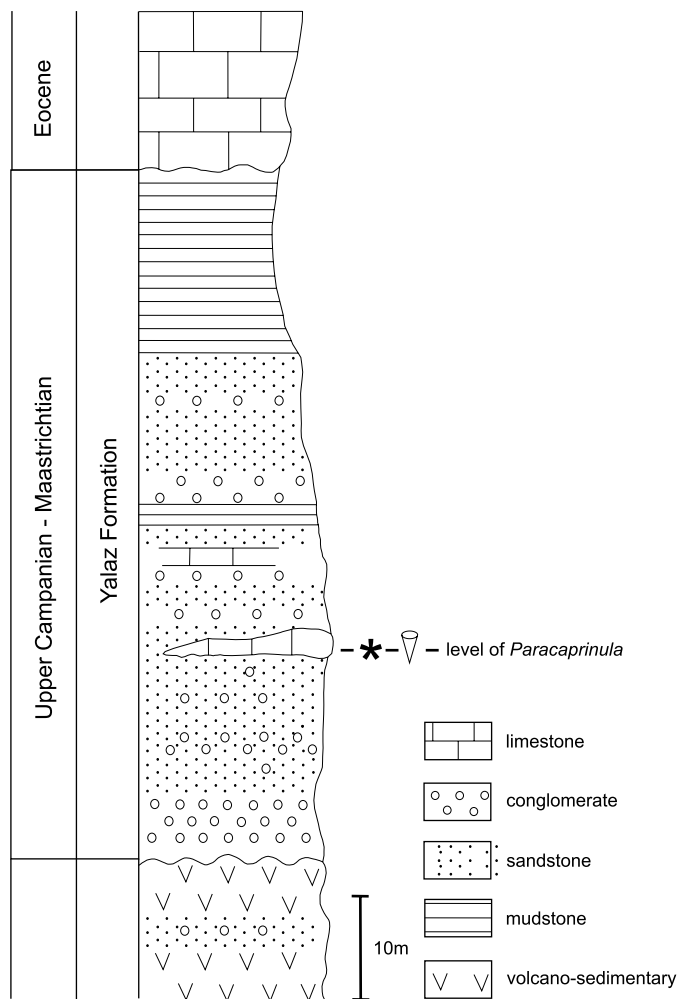


Fig. 2. Measured stratigraphical section at Yaylaçiftliği–Hatay showing level of *Paracaprlnula* (after Karacabey-Öztemür and Selçuk, 1981 and Özer, 1991).

The Upper Cretaceous transgressive sequence unconformably follows over the Koçali ophiolitic complex and the Kastel Formation in the Kahta–Adıyaman area (Fig. 3). It consists of, from bottom to top, Terbüzek, Besni and Germav formations (Sungurlu, 1974; Yalçın, 1976; Perinçek, 1979; Meriç et al., 1985, 1987; Özer, 1986; Özcan, 1993; Yılmaz, 1993). The Terbüzek Formation has mainly red-coloured conglomerates, but also sandstones and mudstones. At Alıdamı, five levels of impure limestone lenses are intercalated in the siliciclastics (Fig. 3). Specimens of *Paracaprlnula* were collected from the third level by the second author in 1988. Lenses of impure limestone are 0.5–4 m thick and contain abundant rudists (Fig. 3): *Vautrinia syriaca* (Vautrin), *Vaccinites vesiculosus* (Woodward), *Dictyoptychus euphratica* Karacabey-Öztemür, *D. leesi* (Kühn), *D. striatus* (Douville), *Pseudosabina klinghardti* (Boehm), *Pseudopolyconites cf. ovalis* Milovanović, and *Hippurites syriaca* Vautrin (Karacabey-Öztemür, 1981; Özer, 1986). The rudist levels also contain benthic foraminifers such as *Orbitoides media* (d'Archiac), *Siderolites calcitrapoides* Lamarck, *Omphalocyclus macroporus* (Lamarck), *Lepidorbitoides socialis* (Leymerie) and *Loftusia sp.* Meriç et al. (1985, 1987) and Özer (1986, 1992c) suggested a Maastrichtian age based on the association of rudists and benthic foraminifers. Meriç and Görmüş (2001) and Meriç et al. (2001) also evaluated the palaeobiogeographic distribution of the *Loftusia*-bearing fauna of larger benthic foraminifers in the Maastrichtian of the Tethyan realm. However, Özcan (1993) identified *Praesiderolites douvillei* Wannier, *Pseudosiderolites vidali* (Douville), *Sirtina orbitoidiformis* Brönniman and Wirz, and *Radotruncana calcarata* (Cushman) in the

lowest limestone lense with rudists and concluded on a Late Campanian age. The Terbüzek Formation passes upwards into the mudstones of the Germav Formation containing planktonic foraminifers of late Maastrichtian–Paleocene age (Meriç et al., 1985, 1987) such as *Gansserina gansseri* (Bolli), *Radotruncana calcarata* (Cushman), *Globotruncana falsostuarti* Sigal, *Globanomalina compressa* (Plummer), *Praemurica inconstans* (Subbotina).

2.3. Stratigraphy of the rudist formations

2.3.1. Biostratigraphy

The rudists of the Yayladağı–Hatay region were determined by Vautrin (1933), Dechaseaux (1954) and Dubertret (1966), and a Maastrichtian age was assigned to the fauna because of larger benthic foraminifers found in higher levels of the Yalaz Formation. Later, Selçuk (1981) and Pişkin et al. (1986) pointed out that the pillow lavas and spilitic massive lavas of the ophiolitic complex are transgressively overlain by volcanic breccias and conglomerates containing reworked rudist fragments of apparently Late Campanian–Maastrichtian age. However, the same authors accepted a Late Maastrichtian age for the beginning of the transgression over the ophiolitic basement. Karacabey-Öztemür and Selçuk (1981) described a new genus (*Hatayia spinosa*) and new species of *Lapeirousella* (*L. anatolica* and *L. yalazensis*) and suggested a Maastrichtian age, though without any new biostratigraphic evidence. Özer (1991) evaluated the rudist fauna and its paleobiogeographical significance, and also adopted the Maastrichtian age suggested in previous studies (Selçuk, 1981; Pişkin et al., 1986; Karacabey-Öztemür, 1981). In summary, the biostratigraphy of the Latest Cretaceous rudist formations of the Yayladağı–Hatay region is based on the larger benthic and planktonic foraminifers from sandstones overlying the rudist associations and considered to be of middle–Late Maastrichtian age.

In the Alıdamı–Kahta area, the rudist-bearing limestone lenses contain larger benthic foraminifers such as *Omphalocyclus macroporus*, *Lepidorbitoides socialis*, and *Loftusia sp.*, accepted to indicate a Maastrichtian age (Meriç et al., 1985, 1987). Özer (1986, 1992a–c) consequently assigned the same age to the rudist fauna. However, Özcan (1993) reported some benthic foraminifers from the bottom level of the Terbüzek Formation that had been reported from Campanian strata (Goharian, 1971; Wannier, 1983; Gušić and Jelaska, 1990) in the Mediterranean region, including Turkey (Meriç, 1988), but that were also found in lower Maastrichtian deposits (Neumann, 1983; Philip, 1983; Bilotte, 1984; Meriç et al., 1995; Meriç and Görmüş, 1997).

In regional studies of the plate-tectonic evolution of south-eastern Turkey (Sungurlu, 1974; Yalçın, 1976; Perinçek, 1979; Şengör and Yılmaz, 1981; Yılmaz and Yiğitbaş, 1991; Yılmaz, 1993), a Late Maastrichtian age was accepted for the basal part of the transgressive sequence developed over the allochthonous ophiolitic units in the Hatay and Adıyaman areas, respectively.

2.3.2. Strontium-isotope stratigraphy

Sr-isotope values were analyzed with a Finnigan MAT 252 thermal ionisation mass spectrometer following conventional methods of Sr purification and measurements. Elemental concentrations were analyzed by ICP-AES from splits of the same samples used for Sr-isotope analysis. See Steuber (2003a) for further details on analytical methods. Numerical ages are derived from the “look-up” table of McArthur et al. (2001; see also McArthur and Howarth, 2004). Precision of Sr isotope analysis (2 s.e. = 8×10^{-6}) was calculated from results of 4 samples of EN-1 standard analyzed together with rudist samples.

Strontium isotope stratigraphy indicates a Late Campanian age (c. 73 Ma) for the two localities with *Paracaprlnula* (Table 1), using the time scale of Gradstein et al. (2004). Two samples of

Table 1
Concentrations of Sr, Mg, Mn, Fe (nd = not determined) of skeletal calcite of rudist shells, and of one sample of calcite cement (YY2 – V) from the localities studied

| Locality | Sample | Sr [ppm] | Mg [ppm] | Mn [ppm] | Fe [ppm] | $^{87}\text{Sr}/^{86}\text{Sr}$ | +/- 2 s.e. $\times 10^{-6}$ | Age (Ma) |
|-----------------------|------------|----------|----------|----------|----------|---------------------------------|-----------------------------|--------------------------|
| Alidamı, Terbüzek Fm. | AL IV – I | 1837 | 1125 | 4 | 139 | 0.707689 | 7 | 72.1 < 72.7 < 73.2 |
| | AL IV – II | 1746 | 1321 | 11 | 124 | 0.707670 | 7 | |
| | Mean | | | | | 0.707680 | 8 | |
| Alidamı, Germav Fm. | | 1773 | 2260 | 11 | 178 | 0.707735 | 7 | 70.4 < 70.9 < 71.6 |
| | | 1937 | 1882 | 41 | 265 | 0.707729 | 7 | |
| | Mean | | | | | 0.707732 | 8 | |
| Yayladağı, Yalaz Fm. | YY2 – II | 1540 | 621 | 17 | 222 | 0.707684 | 7 | 72.1 < 72.6 < 73.0 |
| | YY2 – V | nd | nd | nd | nd | 0.707764 | 7 | n/a (diagenetic calcite) |

Samples are from the level with *Paracaprinula* in the Terbüzek and Yalaz formations, respectively (Figs. 2–3) and from the lowermost level with *Dictyoptychus* of the Germav Formation (Fig. 3).

Dictyoptychus from the lowest rudist-bearing level of the Germav Formation (Fig. 3) indicate the latest Campanian (71 Ma). High Sr and low Fe and Mn concentrations of the five samples of skeletal rudist calcite studied suggests limited diagenetic alteration (Steuber, 2003a,b, 2005) so that the numerical ages derived from the look-up table of McArthur et al. (2001) are considered reliable. Diagenesis of skeletal calcite tends to result in higher $^{87}\text{Sr}/^{86}\text{Sr}$ values than the original seawater composition (McArthur, 1994), as indicated by the Sr-isotope value of a single sample of diagenetic calcite obtained from a rudist shell from Yayladağı. In case of

undetected diagenetic alteration of the rudist calcite, the true numerical ages would hence be even higher. The convergence of the Sr-isotope values of the five samples that are considered well preserved are further evidence for the preservation of the original seawater composition (McArthur, 1994).

3. Systematic palaeontology

Superfamily: Hippuritoidea Gray, 1848
Family: Plagioptychidae Douvillé, 1888
Genus *Paracaprinula* Piveteau, 1939

Type species. *Paracaprinula syriaca* Piveteau, 1939, p. 34, text-figs. 4–5, by monotypy.

Type locality. Yayladağı, north of Yayla Çiftliği, SE Turkey, locality 1 in Fig. 1. N35° 54,551'; E036° 05,813'.

Stratigraphic horizon. Yalaz Formation; age of type level is Late Campanian.

Material. Six specimens from the type locality: YD-06/01, YD-06/02, YD-06/03, YD-06/04, YD-06/05, YD-06/06, C755, C756; six specimens from the Terbüzek Formation at Alidamı–Kahta (N37° 55,769'; E038° 54,347'): KA-88/10, KA-88/26, KA-88/28, KA-88/29, KA-88/34, KA-88/36. All specimens are deposited in the Dokuz Eylül University, Geological Engineering Department, İzmir, Turkey.

Description. A well preserved, disarticulated bivalve specimen (C755) from the type locality is described in detail (Figs. 4A–B, 5, 6). The right valve (RV) is conical, the beak of the left valve (LV) is overhanging the RV and curved anteriorly. Largest diameter at commissure is 190 mm. The outer shell layer is less than 2 mm thick in the LV, and up to 5 mm thick in the RV. The LV inner shell layer has a canaliculate structure as in *Mitrocaprina* Boehm, 1895, with numerous marginal pyriform canals that are less than 1 mm wide. Interiorly, these are followed by polygonal canals that are arranged in up to four rows in the posterior shell wall. The juvenile shell has a canal pattern of the same complexity, but pyriform and polygonal canals are much smaller. A septum connects the posterior tooth with the posteroventral shell wall and demarcates a posteroventral cavity. In contrast to other Plagioptychidae, the apical parts of the posterior cavity are sealed by vesicular structure and are not filled with sediment (Fig. 4A).

The RV contains a large posterior myophoral cavity similar to that of other plagioptychids (cf. Skelton and Smith, 2000, fig. 5). Although recrystallization has obliterated some of the vesicular structure of the inner layers of the RV, this type of structure was most pronounced in the ventral shell wall, the massive central tooth, and in the septum that separates the posterior myophoral

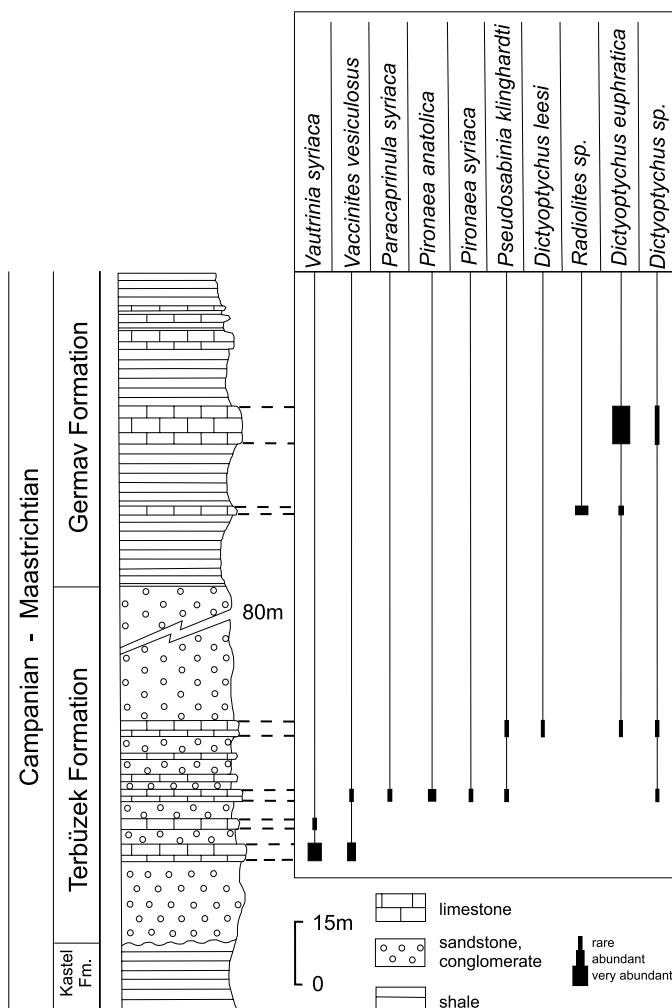


Fig. 3. Measured stratigraphical section at Alidamı–Kahta showing the level of *Paracaprinula* and distribution of other rudists (after Özer, 1986, 1992c).

cavity from the main body cavity (Fig. 6). It is similar to that found in other derived rudists, e.g. in the radiolitid *Pseudosabinia klinghardtii* or in species of *Vaccinites*. A prominent infolding of outer shell layer indicates the position of the ligament (Fig. 4B).

Variability. All studied RVs are conical, ranging from 100 to 190 mm in length. The commissural diameter of the oval-shaped RVs ranges from 100 to 200 mm. The specimen described by Piveteau (1939) has a commissural diameter of 155 mm. The outer shell wall is thick (3–6 mm) compared to that of the LV (c. 2 mm). The inner layer in all specimens is of vesicular structure with irregular rectangular, polygonal, or quadrangular voids. The LV is capuloid in shape and strongly incurved anteriorly. In some specimens, the vesicular structure invades the posterior tooth. The inner shell layer of the LV consists of marginal pyriform canals followed interiorly by polygonal canals. Walls of pyriform canals bifurcate up to two times, forming up to two rows of marginal pyriform canals. Three to four rows of polygonal canals are present in the posterior shell, but only two rows exist in the ventral shell.

Remarks. The original description of *Paracaprinnula syriaca* provided so few details that the name was not subsequently used in the description of other specimens. Piveteau's description and figures show the external morphology of a typical plagiocytychid, the

structure of the pallial canals being diagnostic for *Mitrocaprinnula Boehm, 1895*. In fact, Piveteau mentioned the similarities to *Coralliochama bayani Douvillé, 1888*, without apparently being aware that this species was designated type species of *Mitrocaprinnula* previously (Boehm, 1895). However, the new genus and species was never synonymised with *Mitrocaprinnula* because no internal features except for a small sector of the LV pallial canals were known. We were not able to trace the type specimen of *Paracaprinnula syriaca*. No repository or inventory number was given in the original description (Piveteau, 1939). However, the specimens described here represent the only rudist morphotype occurring at the type locality that is similar to *Paracaprinnula* so that we are confident that Piveteau's genus is in fact identical to the specimens we have described.

The description provided here shows that *Paracaprinnula* can be considered as the most derived genus of the Plagiocytychidae in the Old World, the large size, complex canaliculate structure of the LV, and the tabulated body cavity being considered as derived characters. *Paracaprinnula syriaca* is very similar to *Mitrocaprinnula bulgarica Tzankov, 1965*, and differs only by a slightly more complex pattern of pallial canals in the LV, and the vesicular inner shell in both valves. However, only the tabulae that reduce the size of the body cavity in both valves and the resulting vesicular structure justify a separate genus, different from *Mitrocaprinnula*. This character

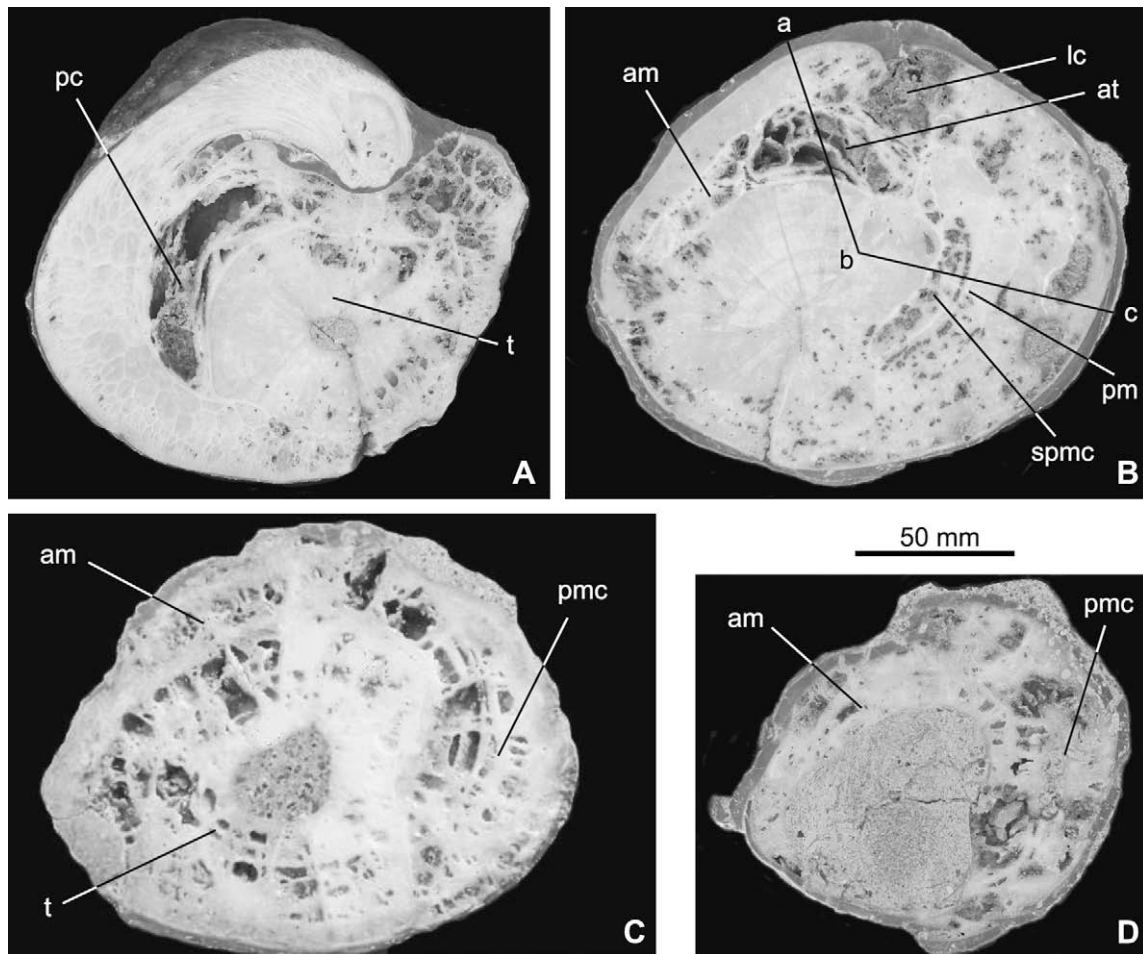


Fig. 4. *Paracaprinnula syriaca* Piveteau, transverse sections. (A) adapical view of LV (C755); pc = posterior cavity; note body cavity, constricted by tabulae (t). (B) adapical view of RV (C755); am = anterior myophore; at = anterior tooth; lc = ligamentary cavity, filled with vesicular structure; pm = posterior myophore; spmc = septum that demarcates posterior myophoral cavity; a–b–c indicates lines of sections shown in Fig. 5. (C) adapical view of RV (YD-06/05); pmc = site of posterior myophoral cavity, filled with vesicular structure in apical parts of the shell; body cavity constricted by tabulae (t). (D) adapical view of RV (C756), sectioned closer to commissure than specimen shown in Fig. 4C.

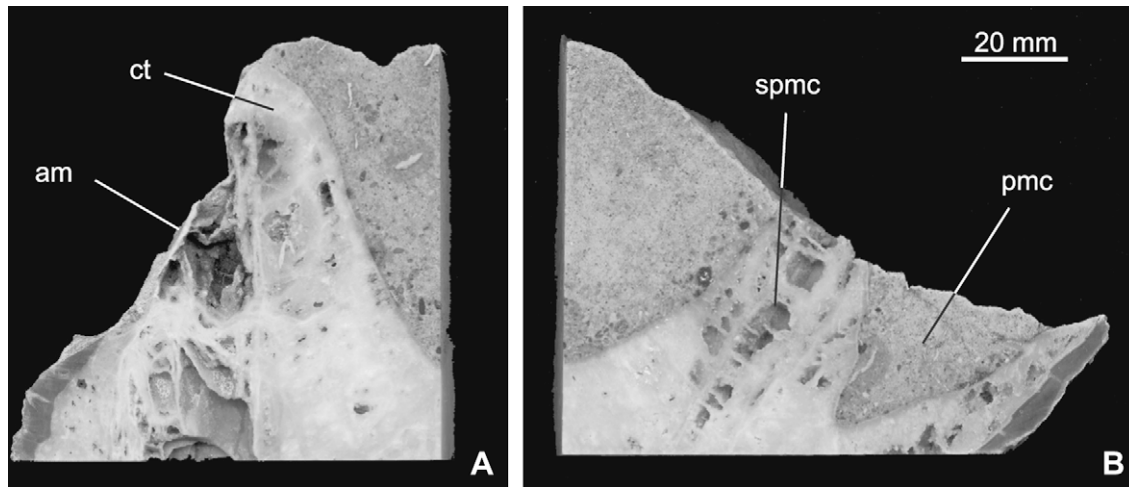


Fig. 5. *Paracaprinula syriaca* Piveteau, longitudinal sections of RV shown in Fig. 4B (C755). (A) section along line a–b (Fig. 4B) showing anterior tooth and dorsal part of anterior myophore. (B) section along line b–c (Fig. 4B) through posterior myophoral cavity; am = anterior myophore; ct = central tooth; pm = posterior myophore; spmc = septum that demarcates posterior myophoral cavity.

is not presently known in other Plagiptychidae and can be considered derived as it increases stability and makes economic use of shell material.

The names of genera of the Plagiptychidae are misleading. The names *Mitrocaprina* and *Paracaprinula* imply a close relation with caprinid genera such as *Caprina* and *Caprinula*. The polyphyletic origin of canaliculate rudists and the fundamental differences between the Caprinidae and Plagiptychidae have been emphasized early and repeatedly (Douvillé, 1888; Mac Gillavry, 1937; Skelton and Smith, 2000) but were often ignored, e.g. in the *Treatise on Invertebrate Paleontology* (Dechaseaux and Perkins, 1969).

Mitrocaprina bulgarica has been described from the mid-Campanian to uppermost Maastrichtian of the eastern Mediterranean region (Tzankov, 1965; Özer, 1983; Accordi et al., 1989; Swinburne et al., 1992; Steuber et al., 2007). *Paracaprinula* was previously

known from the type locality, only, and is here reported from a second locality, both of Late Campanian age and being located on the modern Arabian Plate. During the Cretaceous, this unit was part of the larger Afro-Arabian Plate, and has numerous endemic rudist taxa (Özer, 1992a–c, 2006). The biogeography and stratigraphy of *Paracaprinula* are thus consistent with the theory of allopatric speciation.

4. Conclusions

Paracaprinula syriaca is a derived plagiptychid similar to *Mitrocaprina* but differs by possession of vesicular structure in the inner shell layers and the presence of tabulae in both valves. The genus appears to be endemic to the Afro-Arabian Plate.

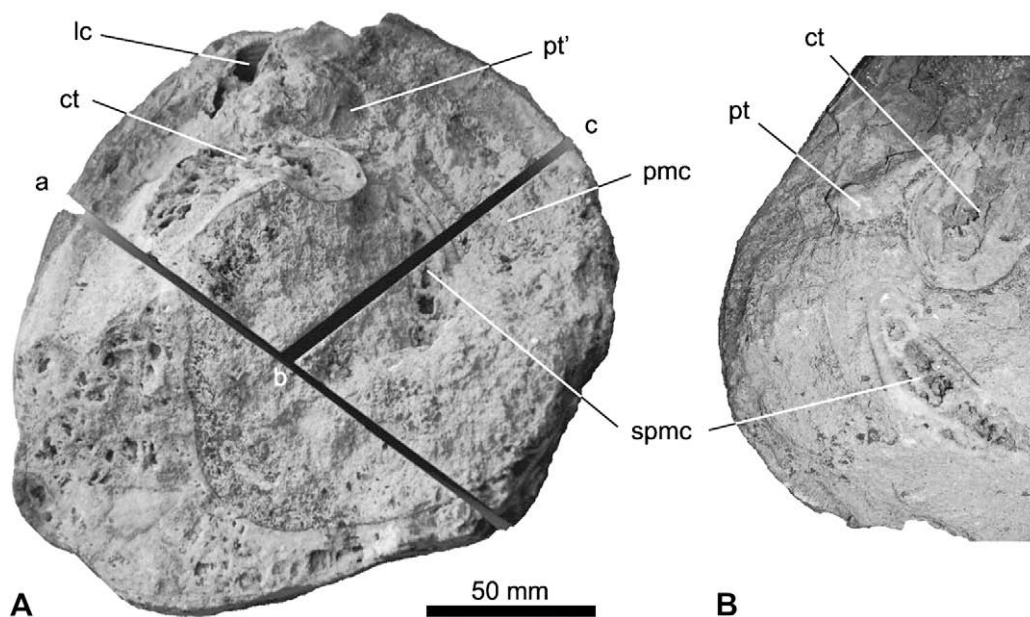


Fig. 6. *Paracaprinula syriaca* Piveteau, adapical aspect of RV (A) and posterior part of LV (B), natural broken surface, approximately at level of commissure (C755). Note vesicular structure of central tooth (ct) and dorsal shell; lc = ligamentary cavity, pmc = posterior myophoral cavity, pt = posterior tooth, pt' = socket of posterior tooth, spmc = septum that demarcates posterior myophoral cavity of RV, here projecting upwards and broken at plane of naturally broken surface; a–b–c indicates lines of sections shown in Fig. 5.

Strontium-isotope stratigraphy indicates a Late Campanian age for specimens from the localities in Yaylaçiftliği, Hatay area and Alıdamı, Kahta–Adıyaman area. Larger benthic foraminifera such as *Omphalocyclus macroporus*, *Orbitoides apiculata* and *Siderolites calcitrapoides* that are conventionally considered to be restricted to the Maastrichtian (Hardenbol et al., 1998) occur together with the rudists at Alıdamı. Schlüter et al. (2008) reported the presence of *Orbitoides apiculata* and *Siderolites calcitrapoides* from Late Campanian rudist formations of Apulia. The stratigraphy of these deposits was also established by SIS, and the numerical age (72.5 Ma) is almost identical to that of the rudist formations studied here. Morris and Skelton (1995) reported *Omphalocyclus* from a level below a likely Campanian rudist association of transgressive deposits on top of ophiolites in the United Arab Emirates. All this indicates that the stratigraphical range of these larger benthic foraminifers must be considerably revised, supporting the recently published data of Özcan (2007).

The Late Campanian age of transgressive deposits of the upper autochthonous units that follow unconformably over the ophiolites of the Afro-Arabian Plate in Turkey requires that the age of ophiolite emplacement onto the Arabian platform – previously considered to be Maastrichtian – needs to be revised.

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List of species

Rudist bivalves

- Vautrinia syriaca* (Vautrin, 1933)
Vaccinites vesiculosus (Woodward, 1855)
Dictyoptychus euphratica Karacabey-Öztemür, 1981
D. leesi (Kühn, 1929)
D. striatus (Douville, 1910)
D. orontica Karacabey-Öztemür, 1981
Paracaprlnula syriaca Piveteau, 1939
Pironaea syriaca (Vautrin, 1933)
P. corrugata (Woodward, 1855)
Hippurites syriaca Vautrin, 1933
Pseudopolyconites cf. *ovalis* Milovanovic, 1935
Pseudosabinia klinghardti (Boehm, 1927)
Hatayia spinosa Karacabey-Öztemür and Selçuk, 1981
Lapeirousella anatolica Karacabey-Öztemür and Selçuk, 1981
L. yalazensis Karacabey-Öztemür and Selçuk, 1981

Benthic foraminifers

- Orbitoides media* (d'Archiac, 1837)
O. apiculatus Schlumberger, 1901
Praesiderolites douvillei Wannier, 1983
Pseudosiderolites vidali (Douville, 1906)
Siderolites calcitrapoides Lamarck, 1801
Sirtina orbitoidiformis Brönnimann and Wirz, 1962
Omphalocyclus macroporus (Lamarck, 1816)
Lepidorbitoides socialis (Leymerie, 1851)
Loftusia sp.
Rotalia sp.

Planktonic foraminifers

- Abathomphalus mayaroensis* (Bolli, 1951)
Gansserina gansseri (Bolli, 1951)
Globotruncana falsostuarti Sigal, 1952
G. arca (Cushman, 1926)
Radotruncana calcarata (Cushman, 1927)
Globanomalina compressa (Plummer, 1926)
Praemurica inconstans (Subbotina, 1953)