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GUADALUPIAN BRACHIOPODS FROM WESTERN TAURUS, TURKEY

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Abstract. Here we describe 41 brachiopod species belonging to the orders Productida, Orthotetida, Orthida, Rhynchonellida, Athyridida, Spiriferida, Spiriferinida, and Terebratulida coming from the Guadalupian lower-middle part of the Pamuçak Formation at Çürük Dağ, Antalya (Western Taurus, Turkey). Associated conodonts are also reported and illustrated.

The brachiopod taxa are either pedicle attached genera, with one genus also stabilized by penetration of its elongate umbo, or free living concavo-convex semi-infaunal genera; this indicates that the energy of the environment was never very high, as in settings just below the fair weather wave-base or in a back-reef, more protected inner platform. The brachiopods from the Pamuçak Formation are very similar to the Wordian fauna of southeastern Oman, and they are similar to the Guadalupian assemblages of Chios, North Iran, South Thailand, and Salt Range. In comparison they share only a few taxa with the Guadalupian faunas of Central Afghanistan and Karakorum. Therefore the biotic affinity of the Guadalupian brachiopods of the Pamuçak Formation is clearly peri-Gondwanan.

The brachiopod record at Çürük Dağ has implications for understanding the pattern of the end-Guadalupian (pre-Lopingian) biotic crisis. The pre-Lopingian crisis assemblages are quite diverse and nearly totally consist of Guadalupian genera and species except for a single Lopingian incomer. Their stratigraphic range terminates rather abruptly and the following 120 metres of shallow water limestones are barren of brachiopods, after which there is the first occurrence of Lopingian brachiopod taxa, which show a much lower biodiversity. This pattern is different from that observed in South China and it shows that the end-Guadalupian crisis is not only characterized by taxonomic selectivity, but also by a strong local control on the extinction/recovery pattern of some groups.

Riassunto. Nel presente lavoro vengono descritte 41 specie di brachiopodi appartenenti agli ordini Productida, Orthotetida, Orthida, Rhynchonellida, Athyridida, Spiriferida, Spiriferinida e Terebratulida, provenienti dalla parte medio-bassa della piattaforma carbonatica della Formazione Pamuçak affiorante lungo i versanti del Çürük Dağ, Antalya (Turchia), di età Guadalupiana. Vengono inoltre riportati e illustrati i conodonti associati alle faune a brachiopodi.

I taxa descritti comprendono sia forme attaccate al substrato tramite peduncolo che generi concavo-convessi, liberi e semi-infaunali. Questa distribuzione di stili di vita suggerisce che l'energia idrodinamica dell'ambiente non fosse mai elevata, ma caratteristica di ambienti posti al di sotto del livello di base dell'onda normale o di retroscogliera e piattaforma interna protetta. I brachiopodi della Formazione Pamuçak risultano estremamente simili alle faune di età Wordiana dell'Oman sudorientale; sono inoltre simili alle associazioni Guadalupiane di Chios, dell'Iran settentrionale, della Tailandia meridionale e del Salt Range, mentre hanno solo pochi taxa in comune con le faune coeve dell'Afghanistan centrale e del Karakorum. Questo permette di affermare che l'affinità biotica delle associazioni a brachiopodi della Formazione di Pamuçak è chiaramente peri-Gondwaniana.

La distribuzione dei brachiopodi nelle sezioni di Çürük Dağ riveste un importante ruolo nell'interpretazione della crisi biotica di fine Guadalupiano. Le associazioni di età Wordiano-Capitaniano, ovvero quelle che precedono la crisi, sono caratterizzate da un'alta biodiversità e comprendono quasi totalmente generi e specie del Guadalupiano, oltre ad una specie che è nota sinora solo nel Lopingiano. La loro distribuzione stratigrafica viene bruscamente troncata a ca. 500 m dalla base della formazione; i 120 m di serie successivi comprendono calcari di acque basse privi di macrofaune, al di sopra dei quali compaiono taxa Lopingiani che formano associazioni a bassa e molto bassa biodiversità. Queste modalità di estinzione e della successiva ripresa sono diverse da quanto si osserva in altre località, in particolare in Cina meridionale, e mettono in evidenza che la crisi di fine Guadalupiano non è caratterizzata solo da selettività tassonomica, ma anche da un forte controllo locale sulle modalità di estinzione e ripresa di alcuni gruppi fossili.

Introduction

The aim of this paper is to systematically describe the brachiopod assemblages collected bed-by-bed in

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the lower to middle part of the Pamuçak Formation of the Antalya Nappes complex in the Taurus Range, Turkey, and discuss their stratigraphic significance. The Lopingian brachiopods from the upper part of the formation have been already described by Angiolini et al. (2007). This study increases the knowledge of Guadalupian brachiopods from the Neotethyan margins which are important to understand the pattern of the end-Guadalupian (pre-Lopingian) biotic crisis (i.e. Jin et al. 1994; Clapham et al. 2009). Recent studies (Isozaki & Aljinovich 2009; Shen & Shi 2009) have in fact shown that several fossil groups, including large fusulinids, giant bivalves, rugose corals, and brachiopods, underwent extinction before the Guadalupian-Lopingian chronostratigraphic boundary with different timing of extinction in several palaeogeographic settings, stretching from Tunisia and Croatia in the Tethyan Gulf to South China and then Japan in the Panthalassa. The causes for this pattern of extinction and taxonomic selectivity are still not clear and may involve the Signor-Lipps effect, local facies changes (Shen & Zhang 2008; Shen & Shi 2009), and/or temperature drop of seawater coupled with eutrophication (Isozaki & Aljinovich 2009).

The systematic study of the brachiopods from the Pamuçak Formation is also important because it provides the base to establish their palaebiogeographical affinity and thus add new data for understanding the debated provenance of the Antalya Nappes (Ricou et al. 1975, 1979, 1984; Marcoux et al. 1989; Stampfli et al. 1991; Robertson et al. 2003; Moix et al. 2008). A palaeobiogeographic reconstruction of the region will be addressed in details in a following paper.

Geological setting

The Çürük Dağ composite section crops out southwest of Antalya and it belongs to the Antalya Nappes complex of the western Taurus Range (Fig. 1). The western Taurus consists of a stack of carbonate platform successions including the so-called autochtonous and parautochthonous units, which are overthrust by ophiolitic nappes and slope to basinal sedimentary allochthonous units (Marcoux 1977, 1979; Ricou et al. 1979). The platform units, cropping out in tectonic windows below the thrust sheets system, are Cambrian to Miocene in age (Ricou et al. 1975). Their sedimentological and palaeontological records belong to Gondwana according to Ricou et al. (1975) and Gutnic et al. (1979), forming the so-called "Axe calcaire du Taurus".

The Antalya Nappes complex has been subdivided into the Lower, Middle and Upper Nappes, and each of these is further subdivided into tectonic units (Lefèvre 1967; Marcoux & Lefèvre 1970; Marcoux 1977, 1979; Brunn et al. 1971). They overlay the Beydağları parautochthonous platform sequences (see Moix et al. 2008, fig. 11).

The Çürük Dağ locality belongs to the Kemer Gorge Unit (Marcoux 1979) of the Upper Antalya Nappes. The origin of the Antalya Nappes and their

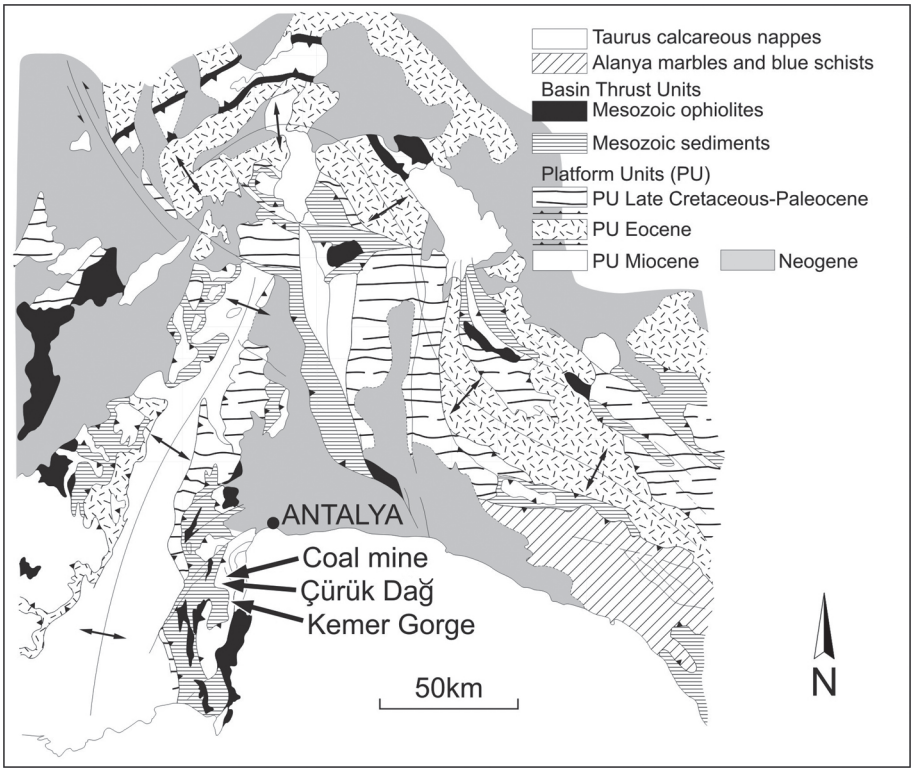


Fig. 1 - Geological sketch map of the Western Taurus showing the location of the Çürük Dağ composite section at N36°41'32-E30°27'40, 1425 m a.s.l.

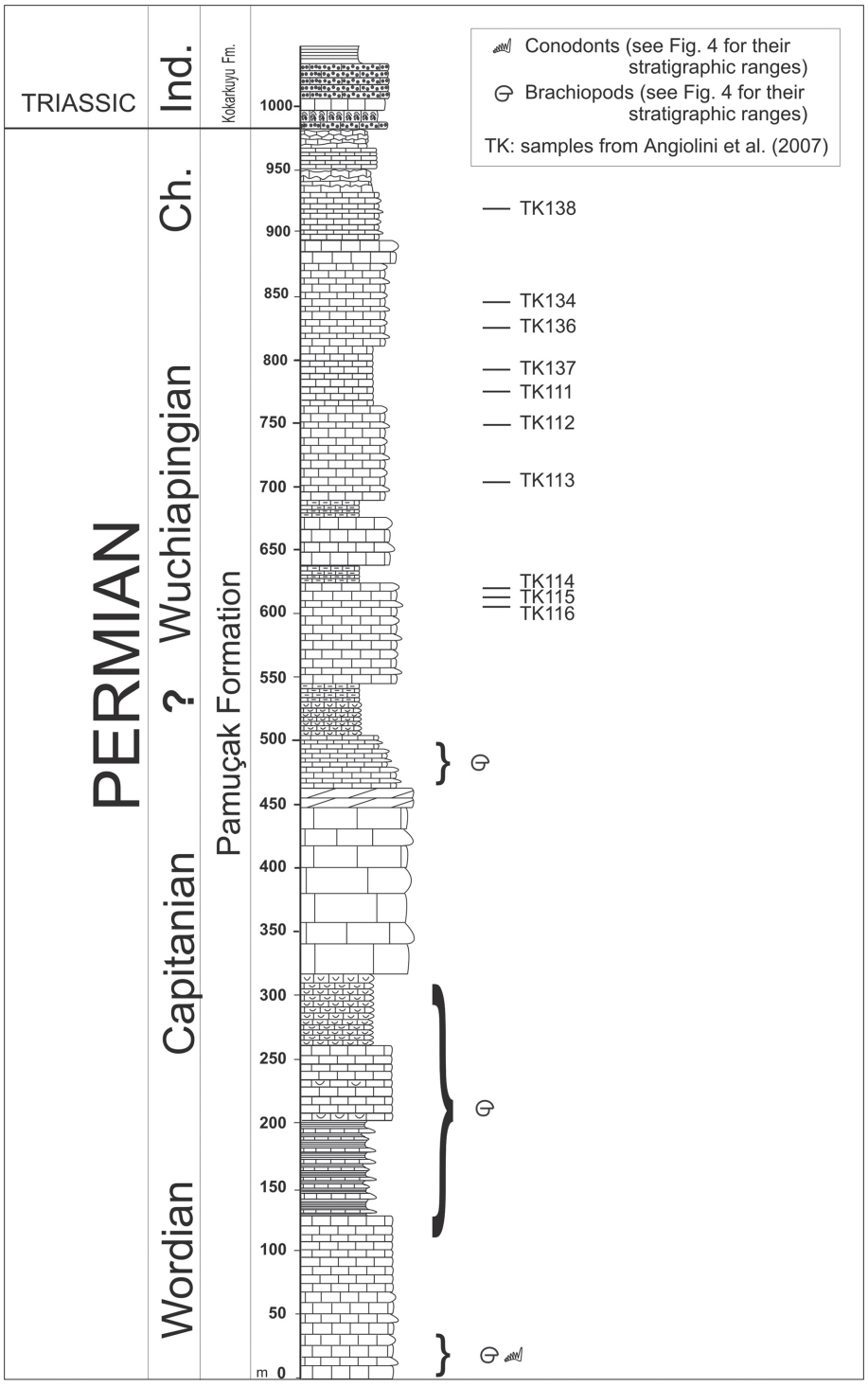


Fig. 2 - Log of the Çürük Dağ composite section, 1050-m thick. (Baud and Marcoux, unpublished log).

relationships to the Taurus Autochthon/Parautochthon (Beydağları Unit) are revised and discussed in details by Robertson et al. (2003). According to Marcoux in Stampfli et al. (1991), the Antalya Nappes consist of Cretaceous oceanic crust and slivers, belonging to the former Neotethyan southern continental margin, obducted southward on the Taurus Autochthon as first proposed by Ricou et al. (1975, 1979, 1984) and by Marcoux et al. (1989). According to Moix et al. (2008) the Antalya Nappes are instead part of the South-Tauride exotic units tectonically emplaced south of the Taurus Terrane, but made of exotic elements of the Anatolian Terrane.

The Permian-Triassic carbonate platform crops out in the western Taurus within different tectonic units of the Upper Antalya Nappes (Fig. 1). The succession comprises Permian shallow water carbonates belonging to the Pamuçak Formation and Lower Triassic calcimicrobial rocks, belonging to the Kokarkuyu Formation (Lys & Marcoux 1978; Altiner 1981, 1984; Marcoux & Baud 1986; Crasquin-Soleau et al. 2002, 2004a, 2004b; Richoz 2004; Baud et al. 2005; Angiolini

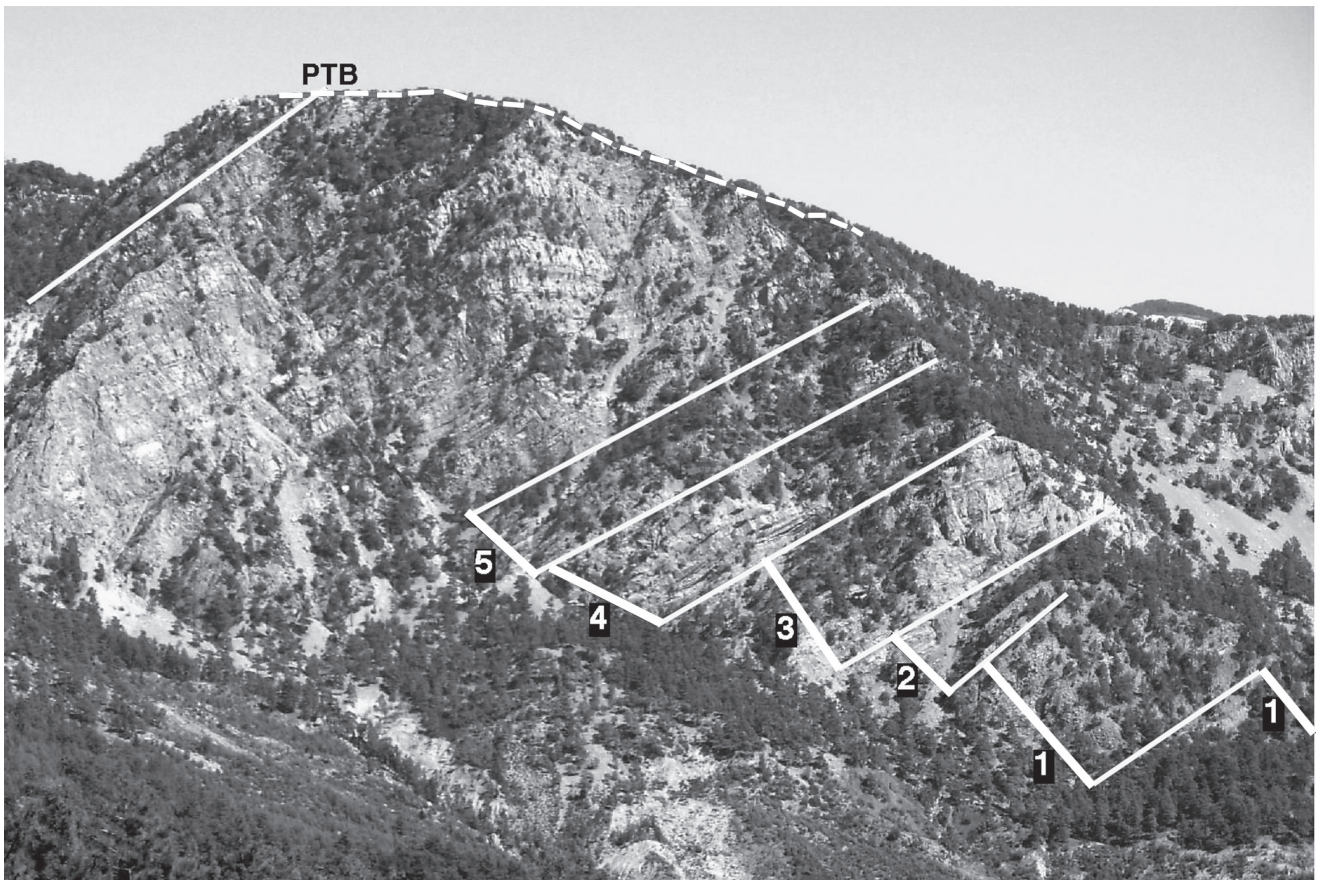


Fig. 3 - View of the southern flank of Çürük Dağ with the Guadalupian composite section 1 (represented by two segments) to 5 (white lines) and location of the Angiolini et al. (2007) Lopingian crest section (dotted line). PTB: Permian-Triassic boundary.

et al. 2007; Baud & Richoz in Crasquin et al. 2009).

One of the best exposure of the Guadalupian-Lopingian succession and of the Permian/Triassic (P/T) boundary is at Çürük Dağ (Figs 2, 3), a section through shallow water carbonates more than 1000 m-thick, located at about 15 km NW of Kemer (Fig. 1). Here, the Pamuçak Formation is up to 950 m-thick and consists of well bedded bioclastic wackestone and packstone of open-marine conditions, with occasional occurrence of more restricted conditions, as testified by the dolomitic horizon at the top of section 4. These limestones were deposited during the Guadalupian-Lopingian in a subtidal environment affected by storm events and represent a thick cyclic succession of inner to outer platform facies. They are capped by a 30-50 cm-thick oolitic limestone characterized by an impoverished fauna, mainly consisting of foraminifers, bivalves and ostracods that were dated by conodonts as late Changhsingian (Angiolini et al. 2007).

The overlying Kokarkuyu Formation starts with microbialites (Baud et al. 1997; Richoz 2004; Baud et al. 2005; Pruss et al. 2006; Kershaw et al. 2010), followed by an alternation of yellow shale, multicoloured limestone and marlstone rich in bivalves.

The brachiopods described in the present paper come from the lower-middle part of the Pamuçak Formation along four sections on the southern slope of Çürük Dağ (Figs 3, 4):

section 1, 36° 41' 11" N, 30° 27' 56" E for the base

section 2, 36° 41' 14" N, 30° 27' 52" E for the base

section 3, 36° 41' 15,6" N, 30° 27' 47" E for the base

section 5, 36° 41' 19,7" N, 30° 27' 42,6" E for the base

Another section has been measured in the lower part of the Pamuçak Formation starting from the coal mine at 36° 42' 45" N, 30° 29' 35" E. Three brachiopod-bearing samples have been obtained from the base of the coal mine section (TK2), and from the marlstone and marly bioclastic limestone with large fusulinids (TK8-TK9). Their positions are shown in the composite section of Figure 4.

Other specimens were collected in two fossiliferous localities stratigraphically corresponding to section 2:

in the Kemer Gorge at 36° 37' 07 N, 30° 29' 11" E, 1330 m a.s.l.

in the isolate locality TK147 at Kopuk Dağ, at

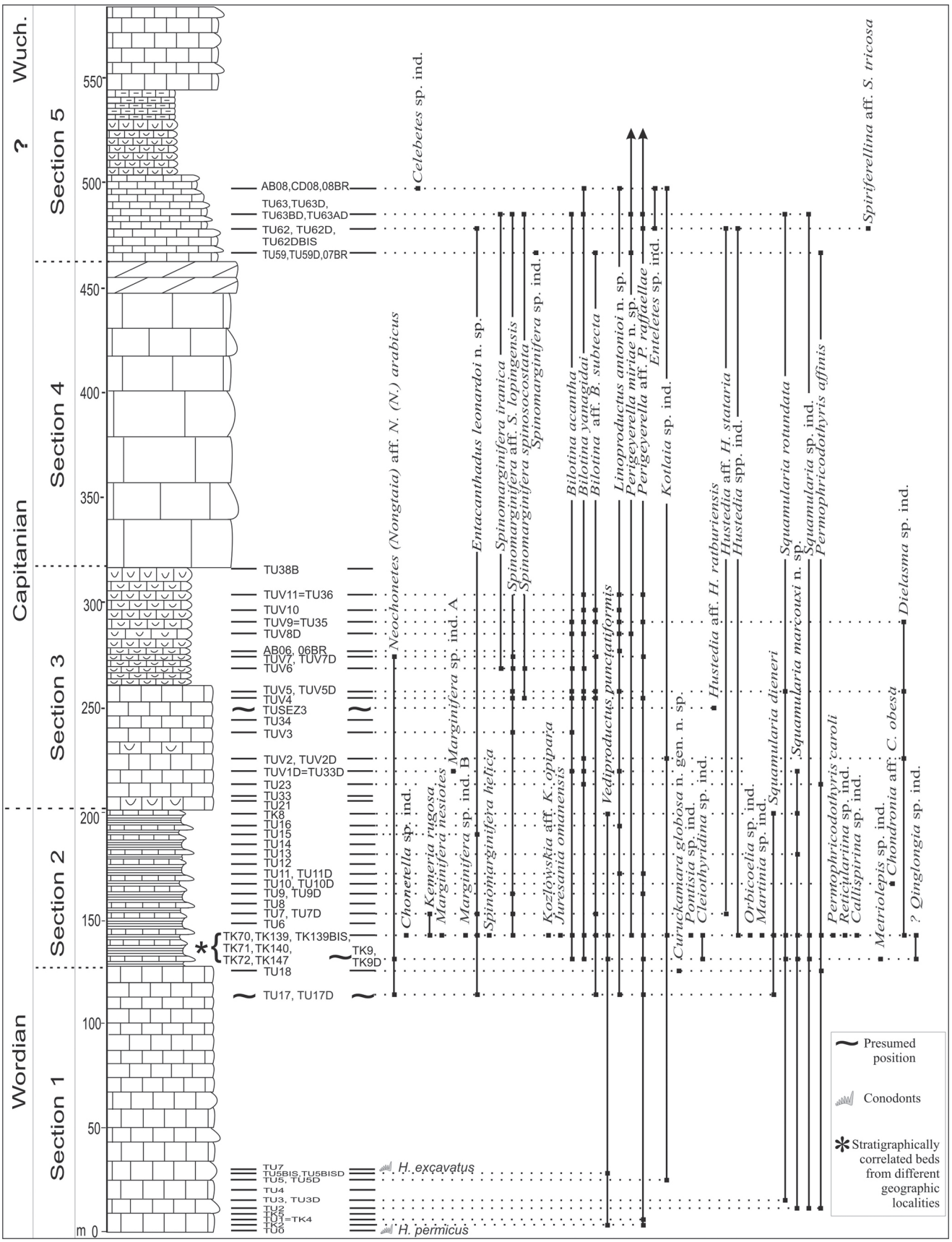


Fig. 4 - Detailed composite log of Çürük Dağ showing the distribution of brachiopods from section 1 to section 5.

36° 43' 08,9" N, 30° 29' 06,6" E, 1040 m a.s.l.

Most of the brachiopods described come from assemblages stratigraphically below the lower assemblage described by Angiolini et al. (2007) from beds TK111-116. However, some specimens of *Perigeyerella miriae* n. sp. and *P.* aff. *P. raffaellae* here described come from beds TK115 and TK138 and thus overlap with the lower assemblage of Angiolini et al. (2007) which is Wuchiapingian in age.

The brachiopod fauna and its regional affinities

The brachiopod fauna from the lower-middle part of the Pamuçak Formation is comprised of 610 specimens of 41 species: *Neochonetes* (*Nongtaia*) aff. *N.* (*S.*) *arabicus* (Hudson & Sudbury, 1959), *Chonetella* sp. ind., *Celebetes* sp. ind., *Kemeria rugosa* (Angiolini in Angiolini & Bucher, 1999), *Marginifera nesiotes* Grant, 1976, *Marginifera* sp. A., *Marginifera* sp. B, *Entacanthadus leonardoi* n. sp., *Spinomarginifera helica* (Abich, 1878), *S. iranica* Fantini Sestini, 1965a, *S.* aff. *S. lopingensis* (Kayser, 1883), *S. spinosocostata* (Abich, 1878), *Spinomarginifera* sp. ind., *Kozlowskia* aff. *K. opipara* Grant, 1976, *Juresania omanensis* Hudson & Sudbury, 1959, *Bilotina acantha* (Waterhouse & Piyasin, 1970), *B. yanagidai* Angiolini in Angiolini & Bucher, 1999, *B.* aff. *B. subtecta* Reed, 1944, *Vediproductus punctatiformis* (Chao, 1927), *Linoproductus antonioi* n. sp., *Perigeyerella miriae* n. sp., *P.* aff. *P. raffaellae* Angiolini in Angiolini & Bucher, 1999, *Enteletes* sp. ind., *Kotlaia* sp. ind., *Curuckamara globosa* n. gen. n. sp., *Pontisia* sp. ind., *Cleiothyridina* sp. ind., *Hustedia* aff. *H. ratburiensis* Waterhouse & Piyasin, 1970, *H. stataria* Cooper & Grant, 1976b, *Hustedia* spp. ind., *Orbicoelia* sp. ind., *Martinia* sp. ind., *Squamularia dieneri* Gemmellaro, 1899, *S. marcouxi* n. sp., *S. rotundata* Gemmellaro, 1899, *Squamularia* sp. ind., *Permophricodothyris affinis* (Gemmellaro, 1899), *P. caroli* (Gemmellaro, 1899), *Reticulariina* sp. ind., *Callispirina* sp. ind., *Spiriferellina* aff. *Spiriferellina tricosa* Cooper & Grant, 1976b, *Metriolepis* sp. ind., *Chondronia* aff. *C. obesa* Cooper & Grant, 1976b, *Dielasma* sp. ind., and *?Qinlongia* sp. ind. They belong to the orders Productida, Orthotetida, Orthida, Rhynchonellida, Athyridida, Spiriferida, Spiriferinida, and Terebratulida.

Seven brachiopod species occur at the base of the succession and, except for one (*Vediproductus punctatiformis*), all range to section 5 or even above (Fig. 4). Most other taxa first occur at the top of section 1 or at the base of section 2. The latter records the maximum biodiversity with 35 brachiopod species. Of these, some are restricted to the Kemer Gorge locality which stratigraphically correspond to the base of section 2. A few species have their first occurrence in section 3: *S. iranica*, *S. spinosocostata*, and *H.* aff. *H. ratburiensis*, whereas *Celebetes* sp. ind. and *S.* aff. *S. tricosa* only occur in section 5.

Perigeyerella miriae n. sp. and *P.* aff. *P. raffaellae* range upward respectively to TK138 and TK115 and specimens of *S.* cf. *S. helica*, *S.* cf. *S. iranica*, *S.* cf. *S. spinosocostata* have been reported to occur up to the top of the Pamuçak Formation by Angiolini et al. (2007).

The brachiopod species which occur in the bioclastic limestones of sections 1, 3 and 5 are characterized by an equal proportion of seminfaunal, concavo-convex productids and pediculate orthids, rhynchonellids, spiriferids, spiriferinids and terebratulids, including also a single genus (*Perigeyerella*) which beside being pediculate is stabilized by penetration of the elongate umbonal region. Cemented taxa that are very well known from coeval peri-Gondwanan successions such as those from Tunisia, Sosio, and West Texas, are totally lacking. This suggests that the energy of the environment was never very high, just below the fair weather wave-base in a back-reef, protected inner platform delimited by a marginal reef which is recorded in the Pysidian units North of Antalya (J. Marcoux, past oral communication).

The brachiopod fauna of the marlstone and marly bioclastic limestone of section 2, is more diverse and it shows again both semi-infaunal concavo-convex spiny productids, which usually inhabited quiet water, muddy bottoms with low or moderate nutrient supply, and pediculate orthotetids, orthids, rhynchonellids, spiriferids, spiriferinids and terebratulids. Large photozoan fusulinids, which probably had photosymbionts, are also present, suggesting low nutrient supply and clear, shallow water in the quiet, protected embayment indicated by the brachiopods.

In general, the brachiopod assemblages from the Pamuçak Formation have many genera and even species in common with the Wordian-Capitanian faunas of peri-Gondwana, in particular with southeastern Oman (Angiolini & Bucher 1999; Angiolini et al. 2003, 2004); they are also similar, but to a lesser extent, to the faunas of Chios (Grant 1993; Angiolini et al. 2005), the Cimmerian blocks of North Iran (Crippa & Angiolini in progress) and South Thailand (Waterhouse & Piyasin 1970; Grant 1976), and to the Salt Range (Waagen 1882-1885). In comparison, they share only a few taxa with the Guadalupian faunas of Sosio (Gemmellaro 1899) and Tunisia (Termier et al. 1977; Verna et al. 2010) in the Tethyan Gulf and the northern Cimmerian blocks of Central Afghanistan (Termier et al. 1974) and Karakorum (Angiolini 1996, 2001).

Therefore, the biotic affinity of the Guadalupian brachiopods of the Kemer Gorge Unit is clearly peri-Gondwanan, in agreement with their original position

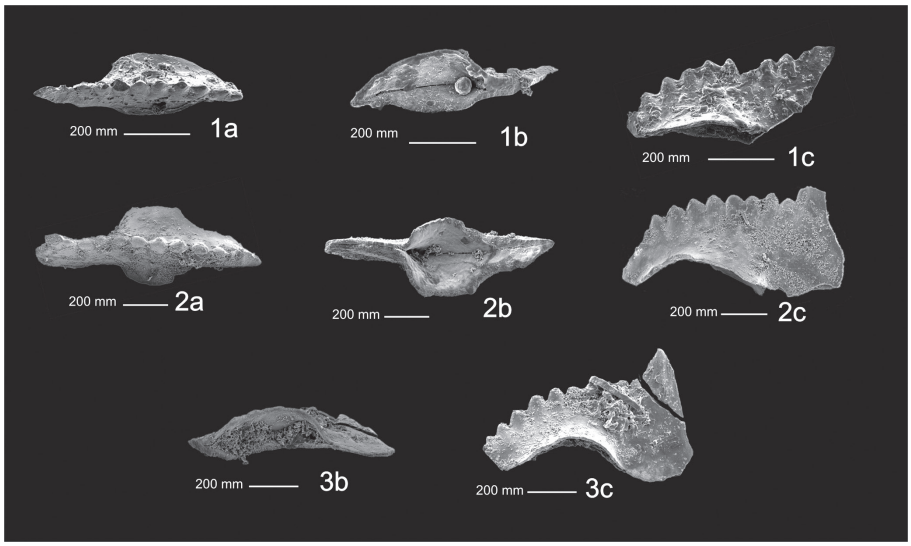


Fig. 5 - Conodonts from section 1 at Çürük Dağ.
1 a,b,c - *Hindeodus permicus* (Igo, 1981), sample TU0; 2 a,b,c - *Hindeodus excavatus* (Behnken, 1975), sample TU07; 3 b,c - *Hindeodus excavatus* (Behnken, 1975), sample TU07; a = Upper view; b = lower view; c = lateral view.

along the southern Neotethyan margin (Marcoux et al. 1989; Marcoux in Stampfli et al. 1991).

Age and implications for the end-Guadalupian crisis

The age of the brachiopods described in the present paper, coming from section 1 to 5 in the lower-middle part of the Pamuçak Formation, is constrained at the top by the age of the lower assemblage of Angiolini et al. (2007) which is Wuchiapingian. This is based on the occurrence of the brachiopod genus *Alatorthotetina* which occurs elsewhere only in the late Wuchiapingian Members II and III of the Longtan Formation of Sichuan, SW China (Shen & Zhang 2008). The latter has been collected about 130 m above the brachiopod assemblages of section 5 (Fig. 3). Upward in the succession, the first occurrence of the biseriamminid foraminifer *Paradagmarita monodi* at 150 m below the top of the formation indicates a Changhsingian age (Gaillot & Vachard 2007). Nicora in Angiolini et al. (2007) reported the conodont *H.* cf. *H. preparvus* Kozur, 1996 of latest Changhsingian age from the topmost oolitical grainstone of the Pamuçak Formation. The beginning of the Triassic is recorded by foraminifers and ostracods (Crasquin-Soleau et al. 2002, 2004a, b; Angiolini et al. 2007) at the base of the Kokarkuyu Formation. Richoz (2004) reported *Isarcicella staeschei* Dai & Zhang, 1989 and above it *Hindeodus parvus* Kozur & Pjatakova, 1976 from the basal metre of the Kokarkuyu Formation (see discussion in Angiolini et al. 2007).

The age of the assemblages at the base of the Pamuçak Formation is well constrained by conodonts and also by fusulinids. Along section 1, beds TU0 and TU7, A. Nicora found the conodonts *Hindeodus permicus* (Igo, 1981) and *H. excavatus* (Behnken, 1975) = *H. wordensis* Wardlaw, 2000 in Angiolini et al. 2003, 2004 (Fig. 4), which are known to range from the late Kungurian to the early Capitanian (e.g. Behnken 1975; Wardlaw 2000; Angiolini et al. 2003; Henderson & Nicora *in* Baud & Bernecker 2010) (Fig. 5).

Brachiopods from section 2 are associated with large fusulinids (*Polydiexodina bithinica* Erk, 1942 and *P. afghanensis* Thompson, 1946) already described by Lys & Marcoux (1978), which are of Wordian age and with the trilobites *Pseudophillipsia* (*Carniphillipsia*) *kemerensis* Lerosey-Aubril in Lerosey-Aubril & Angiolini, 2009 and *Pseudophillipsia* (*Nodiphillispia*) aff. *obtusicauda* (Kayser, 1883) (Lerosey-Aubril & Angiolini 2009). Most brachiopod species from sections 1 and especially 2 are restricted to the Guadalupian (mostly Wordian) of Tunisia, Sicily, Oman, North Iran, Salt Range, South Thailand, Peninsular Malaysia, South China and West Texas (*Neochonetes (Nongtaia) arabicus*, *Kemeria rugosa, Marginifera nesiotes, Kozlowskia opipara, Juresania omanensis, Bilotina acantha, B. yanagidai, B. subtecta*, *Vediproductus punctatiformis, Linoproductus antonioi* n. sp., *Hustedia ratburiensis*, *H. stataria, Squamularia dieneri, S. rotundata, Permophricodothyris affinis, P. caroli,* and *Chondronia obesa*). A few of the taxa range up to section 5 (Fig. 4), suggesting that this part of the Pamuçak Formation is still Guadalupian, as further supported by the presence of the Guadalupian genus *Celebetes* in TK8 and of the species *S.* aff. *S. tricosa* in TU62D.

However, other brachiopod species occurring in section 3 to 5, i.e. species of *Spinomarginifera*, are also known to occur in the Lopingian. More specifically, *S. spinosocostata* and *S. helica* occur from the Guadalupian to the Lopingian (Angiolini & Carabelli 2010), *S. lopingensis* is one of the most common species in the Wuchiapingian of South China, but it also occurs in the latest Guadalupian (Shen & Shi 2009), whereas *S. iranica* has only been reported up to now from the Lopingian of North Iran and Turkey (Angiolini & Carabelli

2010; Angiolini et al. 2007). The appearance of some Lopingian brachiopod species in Capitanian rocks has also been recently discovered by Shen & Shi (2009) in South China.

Therefore, the age of the brachiopod assemblages from sections 1 to 5 is Guadalupian, most probably Wordian to late Capitanian. As they show a less mixed character between the Lopingian and the Guadalupian than the Capitanian faunas of South China (Shen & Shi 2009), they could be slightly older.

Shen & Shi (2009) showed that brachiopods from the Penglaitan section (Guangxi, South China) underwent the end-Gudalupian crisis several metres below the Guadalupian-Lopingian boundary, slightly above the extinction level of rugose corals and below the extinction levels of large fusulinids, conodonts and ammonoids (Shen & Shi 2009, fig. 2).

Even though heavy sampling was carried out, we did not find conodonts except at the base and at the top of the Pamuçak Formation, so we cannot constrain the

PLATE 1

Fig. 1 - *Neochonetes (Nongtaia)* aff. *N. (S.) arabicus* (Hudson & Sudbury, 1959). Ventral valve. MPUM10262 (TUV7D-1A), x3.

Fig. 2 - *Neochonetes* (*Nongtaia*) aff. *N. (S.) arabicus* (Hudson & Sudbury, 1959). Ventral valve. MPUM10263 (TU17D-3C), x3.

Fig. 3 - *Neochonetes (Nongtaia)* aff. *N. (S.) arabicus* (Hudson & Sudbury, 1959). Ventral valve. MPUM10264 (TUV7D-2B), x3.

Fig. 4 - *Neochonetes (Nongtaia)* aff. *N. (S.) arabicus* (Hudson & Sudbury, 1959). Dorsal valve interior. MPUM10265 (TU17D-3D), x3.

Fig. 5 - *Chonetella* sp. ind. Ventral valve. MPUM10267 (TK139-206), x2.

Fig. 6 - *Celebetes* sp. ind. Ventral valve. MPUM10268 (TK8-37), x2.

Fig. 7 - *Kemeria rugosa* (Angiolini in Angiolini & Bucher, 1999). Ventral valve. MPUM10269 (TK72-144), x2.

Fig. 8 - *Kemeria rugosa* (Angiolini in Angiolini & Bucher, 1999). Ventral view of an articulated specimen. MPUM10270 (OL126-1), x2.

Fig. 9 - *Kemeria rugosa* (Angiolini in Angiolini & Bucher, 1999). Ventral valve. MPUM10271 (OM13-1), x1.

Fig. 10 - *Kemeria rugosa* (Angiolini in Angiolini & Bucher, 1999). Ventral view of an articulated specimen. MPUM10272 (OM13-2), x1.

Fig. 11 - *Kemeria rugosa* (Angiolini in Angiolini & Bucher, 1999). External cast of a dorsal valve. MPUM10273 (TK139-12), x1.

Fig. 12 - *Marginifera nesiotes* Grant, 1976. Ventral valve. MPUM10277 (TK72-150), x2.

Fig. 13 - *Marginifera* sp. A. Ventral valve. MPUM10278 (TUV1D-17), x2.

Fig. 14 - *Marginifera* sp. B. Ventral view of an articulated specimen. MPUM10279 (TK139bis-15), x2.

Fig. 15 - *Entacanthadus leonardoi* n. sp. Ventral valve. MPUM10280 (TU7D-8), x2.

Fig. 16 - *Entacanthadus leonardoi* n. sp. Ventral valve. MPUM10281 (TK72-115), x2.

Fig. 17 - *Entacanthadus leonardoi* n. sp. Ventral valve. MPUM10282 (TK139-6), x2.

Fig. 18 - *Entacanthadus leonardoi* n. sp. Ventral valve. MPUM10283 (TU7D-11), x2.

Fig. 19 - *Entacanthadus leonardoi* n. sp. Ventral valve. MPUM10284 (TU15-3), x2.

Fig. 20 - *Entacanthadus leonardoi* n. sp. Ventral valve. MPUM10285 (TU15-4), x2.

Fig. 21 - *Entacanthadus leonardoi* n. sp. Ventral valve. MPUM10286 (TK72-73), x2.

Fig. 22 - *Spinomarginifera helica* (Abich, 1878). Ventral valve. MPUM10289 (TK147-9), x2.

Fig. 23 - *Spinomarginifera iranica* Fantini Sestini, 1965a. Ventral valve. MPUM10290 (TUV6-11), x2.

Fig. 24 - *Spinomarginifera* aff. *S. lopingensis* (Kayser, 1883). Ventral view of an articulated specimen. MPUM10293 (TUV3-3), x2.

Fig. 25 - *Spinomarginifera* aff. *S. lopingensis* (Kayser, 1883). Dorsal view of an articulated specimen. MPUM10293 (TUV3-3), x2.

Fig. 26 - *Spinomarginifera* aff. *S. lopingensis* (Kayser, 1883). Ventral view of an articulated specimen. MPUM10294 (TUV6-5) x2.

Fig. 27 - *Spinomarginifera* aff. *S. lopingensis* (Kayser, 1883). Dorsal view of an articulated specimen. MPUM10294 (TUV6-5), x2.

Fig. 28 - *Spinomarginifera* aff. *S. lopingensis* (Kayser, 1883). Ventral view of an articulated specimen. MPUM10295 (TUV5D-1), x2.

Fig. 29 - *Spinomarginifera* aff. *S. lopingensis* (Kayser, 1883). Dorsal view of an articulated specimen. MPUM10295 (TUV5D-1), x2.

Fig. 30 - *Spinomarginifera* aff. *S. lopingensis* (Kayser, 1883). Ventral valve. MPUM10296 (TUV7-3), x2.

Fig. 31 - *Spinomarginifera spinosocostata* (Abich, 1878). Ventral valve. MPUM10299 (TU63D-5), x2.

Fig. 32 - *Spinomarginifera spinosocostata* (Abich, 1878). Ventral view of an articulated specimen. MPUM10300 (TUV4-7). x2.

Fig. 33 - *Spinomarginifera spinosocostata* (Abich, 1878). Ventral valve. MPUM10301 (TUV4-5). x2.

Fig. 34 - *Kozlowskia* aff. *K. opipara* Grant, 1976. Ventral view of an articulated specimen. MPUM10304 (TK72-60), x1.

Fig. 35 - *Kozlowskia* aff. *K. opipara* Grant, 1976. Ventral view of an articulated specimen. MPUM10305 (TK139BIS-70), x1.

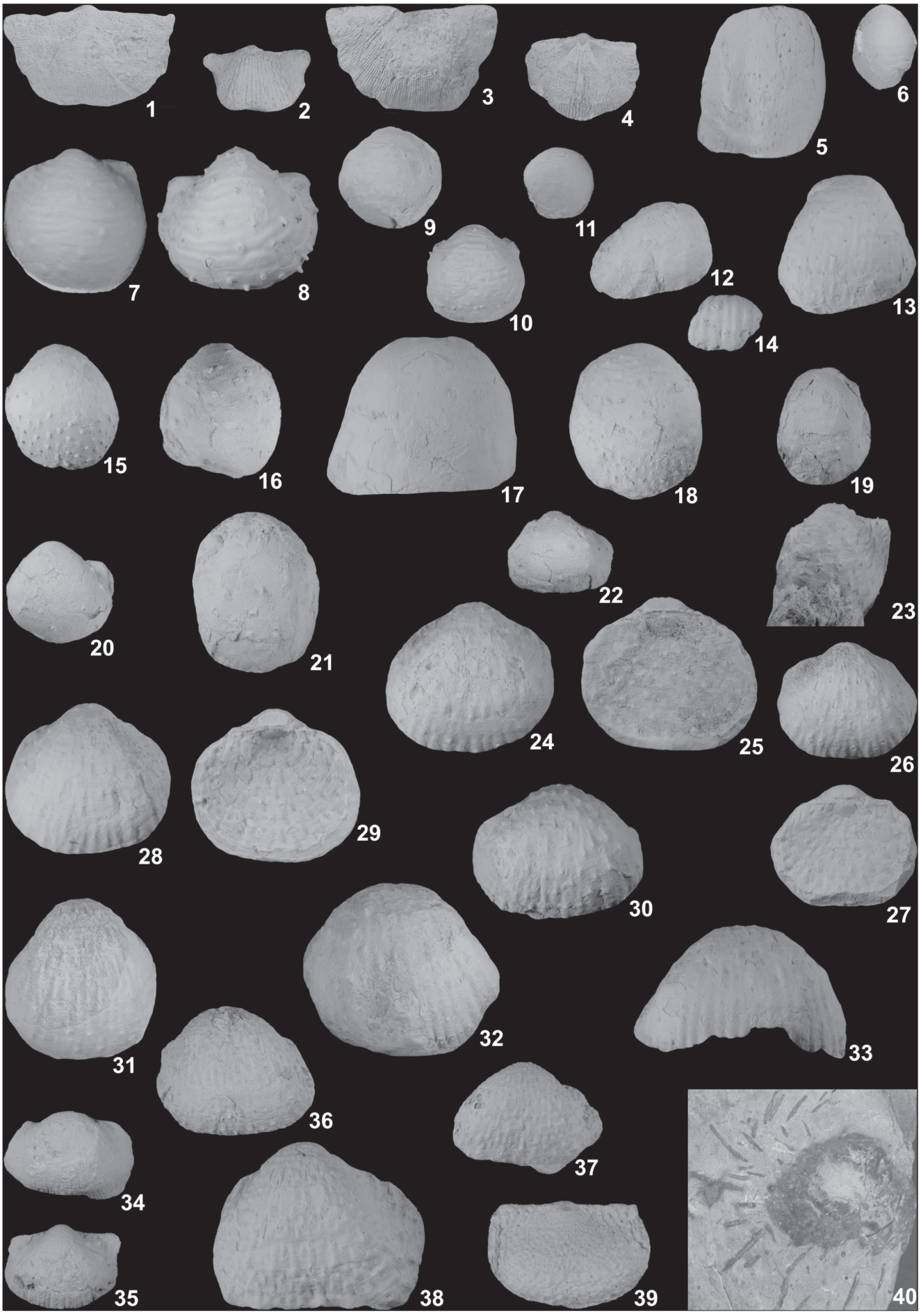
Fig. 36 - *Juresania omanensis* Hudson & Sudbury, 1959. Ventral view of an articulated specimen. MPUM10306 (TK72-181), x1.

Fig. 37 - *Juresania omanensis* Hudson & Sudbury, 1959. Ventral valve. MPUM10307 (TK72-177), x1.

Fig. 38 - *Juresania omanensis* Hudson & Sudbury, 1959. Ventral view of an articulated specimen. MPUM10308 (TK72-143), x2.

Fig. 39 - *Juresania omanensis* Hudson & Sudbury, 1959. Dorsal valve. MPUM10309 (TK72-178), x1.

Fig. 40 - *Juresania omanensis* Hudson & Sudbury, 1959. Ventral valve showing spines in life position. MPUM10310 (TK70-14), x1.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exact position of the Guadalupian-Lopingian boundary in our composite section.

However, the brachiopod record at Çürük Dağ shows that the high diversity assemblages of sections 1 to 5, which nearly totally consist of Guadalupian genera and species except for a single Lopingian incomer (*S. iranica* in TUV6 and TU63), rather abruptly terminate at bed AB8 (Figs 2, 4). Above this bed, there is no evidence of subaerial exposure or unconformity which could testify the occurrence of the global end-Guadalupian regression (Scotese & Langford 1995) and the following 120 metres of shallow water limestones are apparently barren of brachiopods. A fossiliferous bed was possibly present between 500 and 550 metres along the section (Fig. 4), but it was not accessible for sampling.

The first occurrence of Lopingian brachiopod taxa is recorded in bed TK116 (Fig. 2 and fig. 4 in Angiolini et al. 2007). They show a much lower biodiversity than the Guadalupian assemblages comprising just two species. These two species may be slightly younger than early Wuchiapingian due to the occurrence of *Alatorthotetina* (first occurrence in TK114), which has only been recorded elsewhere in the Longtan Formation of SW China, late Wuchiapingian in age according to Shen & Zhang (2008) and not early Wuchiapingian as erroneously reported by Chen et al. (2005).

The pre-Lopingian crisis assemblages are diverse and well recorded in the Pamuçak Formation, whereas the post crisis interval tends to be barren of brachiopods. This is in contrast with the pattern observed by Shen & Zhang (2008) in southern Hunan (South China). The late Wuchiapingian-Changhsingian assemblages are dramatically impoverished.

The pattern described herein shows that the end-Gudalupian crisis is not only characterized by taxonomic selectivity, but also by a strong local facies control on the extinction/recovery pattern of some groups (i.e. brachiopods) and probably by artificial range truncation (Signor Lipps effect).

According to Clapham et al. (2009) the pre-Lopingian crisis was not abrupt, but was gradual and mostly caused by lower origination rates in the Capitanian and Wuchiapingian due to the Kamura cooling event (Isozaki 2007) and/or spread of anoxic deep water masses (Powers & Bottjer 2007) and/or reduction in marine habitat area (Shen & Shi 2002).

Systematic Palaeontology (V. Verna and L. Angiolini)

All the described specimens are housed in the Palaeontological Museum of the Department of Earth Sciences "A. Desio", University of Milan, Italy. Specimens are registered with a prefix MPUM followed by a four to five digit number. The systematic study follows the classifications of Racheboeuf (2000) for the chonetidinids, Brunton et al. (2000) for the productidines, Williams & Brunton (2000) for the orthotetidines, Williams & Harper (2000) for the orthids, Savage et al. (2002) for the rhynchonellids, Alvarez & Rong (2002) and Alvarez (2007) for the athyridids, Johnson et al. (2006) for the ambocoelioids, Carter & Gourvennec (2006) for the martinioids and reticularioids, Carter (2006) for the pennospiriferoids, Jin & Lee (2006) for the cryptonelloids and Jin et al. (2006) for the dielasmatoids.

Phylum **Brachiopoda** Duméril, 1806

Subphylum **Rhynchonelliformea** Williams et al., 1996

Class **Strophomenata** Williams et al., 1996

Order **Productida** Sarytcheva & Sokolskaya, 1959

Suborder **Chonetidina** Muir-Wood, 1955

Superfamily Chonetoidea Bronn, 1862

Family Rugosochonetidae Muir-Wood, 1962

Subfamily Rugosochonetinae Muir-Wood, 1962

Genus *Neochonetes* Muir-Wood, 1962
(= *Quadranetes* Sadlick, 1963)

Subgenus *Neochonetes (Nongtaia)* Archbold, 1999

Type species: *Neochonetes (Nongtaia) taoni* Archbold, 1999, from the Guadalupian of Thailand

Remarks. *Neochonetes (Nongtaia)* differs from *Neochonetes (Sommeriella)* Archbold, 1982, because of its smaller size, coarser costellae and deeper and wider sulcus; and from *Neochonetes (Huangichonetes)* Shen & Archbold, 2002, because of its less numerous costellae at the anterior margin.

Neochonetes (Nongtaia) aff. **N. (N.) arabicus**
(Hudson & Sudbury, 1959)

Pl. 1, figs 1-4

Material: Three figured ventral valves: MPUM10262 (TUV7D-1A), MPUM10264 (TUV7D-2B), MPUM10263 (TU17D-3C); 3 ventral valves: MPUM10266 (TK9-47, TUV7D-2A, TU17D-3A); 1 figured dorsal valve: MPUM10265 (TU17D-3D).

Occurrence: Turkey, Pamuçak Fm., Çürük Dağ, section 1 (TU17D); Çürük Dağ, section 3 (TUV7D); coal mine section (TK9).

Description. Small sized, concavo-convex shell with transverse subpentagonal outline; maximum width at the hinge: 6.9-10.9 mm, corresponding length: 4.6-7 mm. Cardinal extremities weakly alate; anterior commissure slightly uniplicate to rectimarginate. Ventral valve convex, with small, subtriangular and concave ears; ventral sulcus shallow, widening anteriorly.

Dorsal valve concave with subtriangular ears. Ornamentation of fine costellae increasing by bifurcation and numbering 9-16 per 2 mm anteriorly; few spines present near the cardinal margin around 0.1 mm in diameter; growth lamellae irregularly spaced anteriorly. Surface radially pitted between costellae due to pseudopunctation.

Interior of ventral valve with median septum extending to one third of the length of the valve. Interior of dorsal valve with a low cardinal process with a deep alveolus at the base, prominent and thick socket ridges, deep, subtriangular sockets, anderidia extending to one third of the valve length, and a median septum arising two third of the valve length and thickening anteriorly. Adductor scars evident at each side between the anderidium and the socket ridge; endospines radially aligned.

Dimensions (in mm)

Specimen	Width	Length	W/L	Number of costellae per 2 mm anteriorly
TK9-47	8.0	7.0	1.1	9
TU17D-3A	7.0	5.8	1.2	/
TU17D-3C	6.9	4.6	1.5	10
TU17D-3D	7.8	5.3	1.5	/
TUV7D-2A	8.8	5.0	1.8	16
TUV7D-2B	10.9	7.0	1.5	14
TUV7D-1A	11.0	6.5	1.5	12

Discussion. The species *N. (N.) arabicus*, erected by Hudson & Sudbury (1959, pl. 3, figs 6-16; pl. 6, figs 14-18; text-fig. 2) as *Chonetes arabicus*, and coming from the Guadalupian of Oman, was considered by Angiolini in Angiolini & Bucher (1999) as belonging to *N. (Sommeriella)*, but it was later transferred to the subgenus *N. (Nongtaia)* Archbold, 1999.

The Turkish specimens are similar to *N. (Nongtaia) arabicus* by the number of costellae and the cardinal spines, but differs slightly because of the maximum width at the hinge, the more alate cardinal extremities and the less acute ventral umbo. Most specimens of *N. (Nongtaia) arabicus* described by Angiolini in Angiolini & Bucher (1999) show the maximum width located at midlength.

Geographic and stratigraphic occurrence. *N. (N.) arabicus* has been found in the Guadalupian of southeastern Oman (Hudson & Sudbury 1959; Angiolini & Bucher 1999).

Suborder **Productidina** Waagen, 1883

Superfamily Productoidea Gray, 1840

Family Productellidae Schuchert, 1929

Subfamily Productininae Muir-Wood & Cooper, 1960

Tribe Chonetellini Licharew, 1960

Genus *Chonetella* Waagen, 1884

Type species: *Chonetella nasuta* Waagen, 1884, from the Guadalupian-Lopingian of Salt Range, Pakistan

Remarks. *Chonetella* is similar to *Bibatiola* Grant, 1976, but differs by its strongly nasute outline, the less evident ribbing, and the long, narrow cardinal process.

Chonetella sp. ind.

Pl. 1, fig. 5

Material: One figured ventral valve: MPUM10267 (TK139-206).

Occurrence: Turkey, Pamuçak Fm., Kemer Gorge locality (TK139).

Description. Medium sized valve with subrectangular, strongly nasute outline and long trail; maximum width: ~13 mm, corresponding length: >15 mm; trail anteriorly nasute. The ventral valve shows a median protuberance starting anteriorly to the umbonal region with a sharp top and bounded by a weak and parallel sulcus on one side. Ventral surface exfoliated. On one flank, two spine bases are observable, 0.3 mm (the posterior one) and 0.5 mm (near anterior commissure) in diameter.

Discussion. The strongly nasute outline, the occurrence of numerous, dense, fine and elongated dimples on the exfoliated shell, and some spine bases, indicate that this specimen belongs to the genus *Chonetella* Waagen, 1884. The Turkish specimen resembles the specimens of *Chonetella nasuta* Waagen (1884) from the Salt Range (Pakistan), but it differs by its more elongated outline, a greater convexity, much steeper flanks, and an asymmetric sulcus. The nomenclature is left open due to the preservation of the single available valve.

Genus *Celebetes* Grant, 1976

Type species: *Celebetes gymnus* Grant, 1976, from the Guadalupian of South Thailand

Remarks. *Celebetes* Grant, 1976 differs from *Chonetella* Waagen, 1884, because of the absence of a clear nasute outline and its smooth shell.

Celebetes sp. ind.

Pl. 1, fig. 6

Material: One figured ventral valve: MPUM10268 (TK8-37).
Occurrence: Turkey, Pamuçak Fm., Çürük Dağ section 5.

Description. Small sized; ventral valve convex with suboval and elongated outline; maximum width: 7.5 mm, length: ~9 mm; geniculation absent; anterior commissure slightly nasute. Ornamentation nearly absent, except for fine growth lamellae and two barely visible spine bases, arranged so that one is on the median region (0.25 mm wide), and the other is on the anterior region (0.35 mm wide).

Discussion. The Turkish specimen clearly belongs to the genus *Celebetes*, but its state of preservation does not allow a specific determination. The specimen differs from *Celebetes leptus* Grant, 1976 by its elongated outline; from *C. gymnus* Grant, 1976 by its smaller size; from *C. manarollai* Angiolini & Bucher, 1999 because of its elongated profile; and from *C. yunnanensis* Shen et al., 2002, for its smaller size and lower convexity.

Subfamily Overtoniinae Muir-Wood & Cooper, 1960

Tribe Costispiniferini Muir-Wood & Cooper, 1960

Genus *Kemeria* n. gen.

Type species: *Dyschrestia rugosa* Angiolini in Angiolini & Bucher, 1999, from the Guadalupian of southeastern Oman

Derivation of name: from the locality of Kemer, Antalya, Turkey.

Diagnosis: Medium sized, broadly subovate, widest near shell midlength; rugae on the visceral disk; spines of variable diameter, widely scattered on the ventral disk and trail, set in curved rows delimiting the ears or in groups on flanks; dorsal spines slender; endospines numerous.

Discussion. *Kemeria* n. gen. is very similar to *Dyschrestia* Grant, 1976, but differs by its larger size and the occurrence of rugae on the visceral disks of both valves. Also, *Dyschrestia* has been described as having ventral spines of two distinct sizes (Grant 1976, p. 101; Brunton et al. 2000, p. 434), whereas the new genus is characterized by interspersed spines of very variable diameter.

Neoplicatifera Ching, Liao & Hou, 1974 differs from the new genus because it has finer spines of one size only, arranged posteriorly on the rugae and it shows a weak ventral sulcus.

Kemeria rugosa (Angiolini in Angiolini & Bucher, 1999)

Pl. 1, figs 7-11

1999 *Dyschrestia rugosa* Angiolini in Angiolini & Bucher, p. 680, pl. 13, figs 11-17.

Material: Two figured articulated specimens: MPUM10270 (OL126-1), MPUM10272 (OM13-2); 1 articulated specimen: MPUM10274 (OM16-6); 2 figured ventral valves: MPUM10271 (OM13-1), MPUM10269 (TK72-144), 3 ventral valves: MPUM10275 (AO56-36, TK139-205, TU7D-1); 1 figured external cast of dorsal valve: MPUM10273 (TK139-12); 5 fragments: MPUM10276 (TK139-212(A-E)).

Occurrence: Turkey, Pamuçak Fm, Kemer Gorge locality (TK72, TK139); Çürük Dağ section 5 (TU7D).

Description. Medium to large sized, concavo-convex shell with shallow corpus cavity, with subcircular to subovate outline; maximum width at shell midlength: 11.5-14.3 mm, corresponding length: 13.5-15.7 mm; anterior commissure rectimarginate. Ventral valve strongly convex, recurved without geniculation; flanks very steep; umbo small, slightly recurved and weakly convex; ears small and acute; ventral sulcus absent. Dorsal valve strongly concave with geniculation starting at one third of the length; dorsal fold absent. Ornamentation of ventral valve consisting of numerous, rather strong concentric rugae on the disk; of fine growth lamellae; of hollow spine bases, rather rounded and swollen, with very variable diameter (0.1-1.2 mm); spine bases in two groups: 1) in curved rows, each of a maximum of 10 spine bases, delimiting the ears and bifurcating anteriorly along each flank, or forming groups of 3 or 4 spines; these have a diameter of 0.4 mm on average; 2) widely scattered on the visceral disk and on the trail, with variable diameter, from 0.15 mm to 1.2 mm. Few large specimens show indistinct and interrupted ridges extending anteriorly from the base of the spines. Ornamentation of dorsal valve consisting of concentric rugae posteriorly, fine spine bases more closely arranged than in the ventral valve, dimples, and very fine growth lamellae.

Interior of dorsal valve with a small W-shaped cardinal process.

Dimensions (in mm)

Specimen	Width (without ears)	Length	W/L	Spine bases minimum width	Spine bases maximum width
TK72-144	14.1	13.3	1.1	0.25	1.2
TK139-12	14.3	15.7	0.9	0.15	1.1
TK139-205	12.3	12.5	1.0	/	/
TU7D	11.5	13.5	0.8	0.2	0.6

Discussion. *Kemeria rugosa* was originally erected as a new species of *Dyschrestia* by Angiolini in Angiolini & Bucher (1999). However, the finding of new conspecific material in Turkey and re-examination of the Oman types would suggest that they more properly belong to a new genus, *Kemeria* n. gen., based on the presence of rugae and the size and arrangement of the ventral spines.

The specimens from Oman described as *Mar-*

ginifera spinosocostata (Abich, 1878) by Hudson & Sudbury (1959, p. 34, pl. 2, figs 10 a-c) are not included in the synonymy of *Kemeria rugosa*, because of the absence of any concentric ornament and the occurrence of ribs on the trail.

Geographic and stratigraphic occurrence. *Kemeria rugosa* has been previously found in the Wordian Khuff Formation in southeastern Oman (Angiolini & Bucher 1999).

Subfamily Marginiferinae Stehli, 1954

Tribe Marginiferini Stehli, 1954

Genus *Marginifera* Waagen, 1884

Type species: *Marginifera typica* Waagen, 1884, from the Guadalupian-Lopingian of Khisor Range, Pakistan

Remarks. *Marginifera* is very similar to *Spinomarginifera* Huang, 1932, but the latter differs in showing more evident and coarse rugae, generally no costae, usually thin spine bases, no rows of spine bases on the flanks and more densely arranged spine bases on the visceral disk. The spine arrangement is distinctive, and variations in the pattern serve to distinguish among species (Grant 1976, p. 109). According to Grant (1993, p. 12) *Marginifera* is a typical member of the Tethyan Permian fauna, extending from Sicily, at the western extreme, all the way to East Asia. It does not extend to America.

Marginifera nesiotes Grant, 1976

Pl. 1, fig. 12

1976 *Marginifera nesiotes* Grant, p. 112, pl. 27, figs 1-34.

Material: One figured ventral valve: MPUM10277 (TK72-150).

Occurrence: Turkey, Pamuçak Fm., Kemer Gorge locality (TK72).

Description. Small and convex ventral valve, with geniculation at around one third of the length; maximum width: 11.8 mm, corresponding length: 10 mm. Umbo pointed, wide and strongly projected beyond the hinge; ears small; anterior commissure slightly uniplicate. Shallow, but evident sulcus starting at the umbo and widening anteriorly. Ornamentation of broad ribs anteriorly, and rounded and widely spaced spine bases, 0.3-0.5 mm wide, some arranged to form a row of at least four spine bases along each flank, some dispersed on umbonal region and trail; weak rugae present in the umbonal region.

Discussion. The diagnostic characters of this species are the small dimensions, the broad ribs on the trail, and the sulcus which widens anteriorly. *Marginifera nesiotes* differs from *M. otaria* Grant, 1976, because of its stronger ribs and smaller ears; from *M. drastica* Grant, 1976, by the smaller size and the coarser ornamentation; and from *M. arenaria* Grant, 1976, because of the less densely dispersed spine bases.

Stratigraphic and geographic occurrence. *M. nesiotes* comes from the Guadalupian Rat Buri Limestone of Ko Muk in South Thailand (Grant 1976).

Marginifera sp. ind. A

Pl. 1, fig. 13

Material: One figured ventral valve: MPUM10278 (TUV1D-17).

Occurrence: Turkey, Pamuçak Fm., Çürük Dağ section 3 (TUV1D).

Description. Small ventral valve, with sub-triangular outline; maximum width: 13 mm, length: 14 mm; geniculation anterior to one third of the shell length. Umbo slightly pointed, large; ears small. No sulcus, but presence of a flattening on the venter. Ornamentation of weak umbonal rugae, and spine bases, around 0.3-0.5 mm wide, clearly visible only along the flanks, where they form a row of at least four spine bases.

Discussion. This specimen is referred to the genus *Marginifera* based on the spine bases which are arranged to form a row on each flank, even if the absence of the sulcus is atypical for *Marginifera*. However, these characters are not sufficient to identify the species.

Marginifera sp. ind. B

Pl. 1, fig. 14

Material: One figured articulated specimen: MPUM10279 (TK139bis-15).

Occurrence: Turkey, Pamuçak Fm., Kemer Gorge locality (TK139bis).

Description and discussion. Small, biconvex shell with subtriangular outline; maximum width: 7 mm, length: 6 mm. Ornamentation of fine concentric growth lamellae, of ribs starting anteriorly from the umbo and bearing spine bases, 0.1-0.4 mm wide. Presence of one row of spine bases, diagnostic for the genus, on each flank. The state of preservation does not allow a specific determination, but the specimen clearly differs from the other species of *Marginifera* occurring in the Pamuçak Formation by its smaller size and fine concentric lamellae.

Genus *Entacanthadus* Grant, 1993

Type species: *Entacanthadus chioticus* Grant, 1993, from the Guadalupian of Chios Island, Greece

Remarks. *Entacanthadus* Grant, 1993 can be easily confused with *Echinauris* Muir-Wood & Cooper, 1960, from which it differs by the following characters: 1) spine bases only on the ventral valve, and not on both valves as in *Echinauris* (Grant 1993, p.14), 2) small ears, 3) the uniform size of the spines on the trail and on the flanks, and 4) the absence of a sulcus on the ventral valve and a fold on the dorsal one. In comparison, *Echinauris* is described (Cooper & Grant 1975, p. 1000) as having a ventral valve obscurely to moderately strongly sulcate and an anterior commissure with faint dorsal fold.

According to Grant (1993, p. 14) the lack of rugae or ribs separates *Entacanthadus* from *Marginifera*, the absence of dorsal spines can readily distinguish it from *Echinauris* or *Costispinifera*, the absence of dorsal spines and the presence of a dorsal marginal rim exclude it from *Dyschrestia*, and the presence of numerous long endospines in the ventral umbonal region seems to be a feature unique to the genus. The etymology chosen by Grant (1993, p. 13) is in fact: "ento", Greek, within; "acanthos", Greek, thorn; "ados", Greek, having.

Entacanthadus leonardoi n. sp.

Pl. 1, figs 15-21

Holotype: TU15-4, ventral valve, from the Pamuçak Fm., Çürük Dağ section 2, bed TU15.

Derivation of name: in honour of Leonardo Verna.

Material: Seven figured ventral valves: MPUM10286 (TK72-73), MPUM10281 (TK72-115), MPUM10282 (TK139-6), MPUM10280 (TU7D-8), MPUM10283 (TU7D-11), MPUM10284 (TU15-3), MPUM10285 (TU15-4); 3 ventral valves: MPUM10287 (TU7D-4, TU15-1, TU17D-8); 1 dorsal valve interior: MPUM10288 (TU62Dbis-5).

Occurrence: Turkey, Pamuçak Fm., Çürük Dağ, section 1 (TU17D); Kemer Gorge locality, (TK72, TK139); Çürük Dağ section 2 (TU7D, TU15); Çürük Dağ section 5 (TU62Dbis).

Diagnosis: Small species of *Entacanthadus* with subrectangular outline and rugae on the ears.

Description. Small sized, concavo-convex, geniculated shell, with suboval to elongated subrectangular outline; maximum width at shell midlength: 7.5-12.8 mm, corresponding length: 7.6-15.4 mm. Umbo small, pointed; ears small, subtriangular; ventral sulcus absent. Ornamentation of spine bases, 0.3-0.6 mm wide, widely dispersed on the venter and flanks, with uniform diameter; concentric and well developed rugae on the posterior region, especially on the ears.

Interior of dorsal valve with bilobed cardinal process and lateral ridges, parallel to the cardinal margin; adductor scars elongated anteriorly.

Dimensions (in mm)

Specimen	Width	Length	W/L	Thickness	Width of spine bases at midlength
TK72-73	11.5	14.7	0.8	/	0.6
TK72-115	12.8	15.4	0.8	7.3	0.6
TU7D-4	12.0	14.1	0.8	8.9	0.4
TU7D-8	12.6	14.4	0.9	/	0.3
TU7D-11	9.5	11.3	0.8	/	0.3
TU15-1	10.3	12.8	0.8	/	0.4
TU15-3	8.7	10.9	0.8	/	0.3
TU17D-8	7.5	7.6	1.0	5.6	0.4
TU62Dbis-5	8.3	7.0	1.2	/	/
TU15-4	10.4	10	1.0	6.2	0.4

Discussion. *Entacanthadus leonardoi* n. sp. differs from *E. chioticus* Grant, 1993 from the Guadalupian of Chios (Greece), by its elongated subrectangular outline (Fig. 6) and stronger rugae on the posterior region.

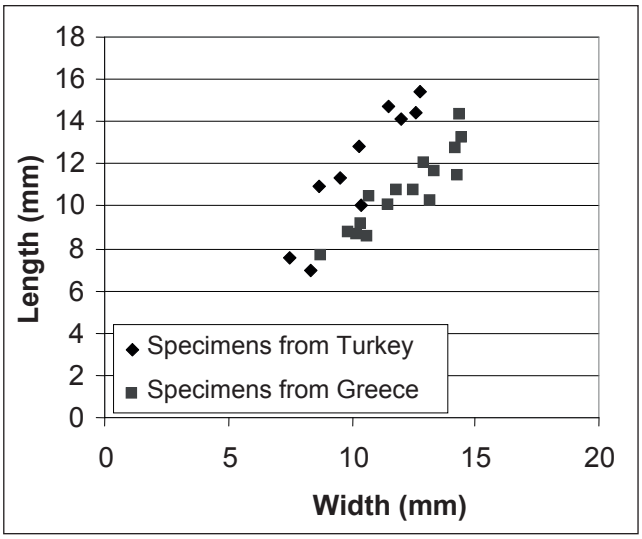


Fig. 6 - Width vs. length diagram showing that *Entacanthadus leonardoi* n. sp. from Turkey, has a more elongated outline than *E. chioticus* Grant, 1993 from the Guadalupian of Chios, Greece.

Genus *Spinomarginifera* Huang, 1932

Type species: *Spinomarginifera kueichowensis* Huang, 1932, from the Lopingian of South China

Spinomarginifera helica (Abich, 1878)

Pl. 1, fig. 22

1878 *Productus intermedius helicus* Abich, p. 44, pl. 5, fig. 7; pl. 10, figs 3, 12-13, 17, 19-20.

1878 *Productus aculeatus* Abich, p. 50, pl. 5, fig. 12; pl. 10, fig. 21.

1878 *Productus spinulosus* Abich, p. 51, pl. 5, fig. 9.

1878 *Productus indeterminatus* Abich, p. 47, pl. 10, fig. 16; p. 48, pl. 10, figs 4, 18.

1900 *Marginifera intermedia helica* - Arthaber, p. 265, pl. 20, figs 10-12.

1903 *Marginifera helica* - Diener, p. 74, pl. 3, fig. 9.

1933 *Marginifera intermedia helica* - Simic, p. 42, pl. 3, figs 1-4.

1937 *Productus - intermedius-helicus* var. *multispinosa* Licharew, p. 69, pl. 10, figs 7-10.

1937 *Productus - intermedius-helicus* var. *mutabilis* Licharew, p. 70, pl. 10, figs 11-20.

1939 *Productus - intermedius-helicus* - Licharew, p. 95, pl. 22, fig. 9.

1958 *Marginifera helica helica* - Ramovs, p. 501, pl. 2, fig. 8.

1960 *Spinomarginifera intermedia-helica* - Sarytcheva et al., p. 228, pl. 38, fig. 14.

1963 *Spinomarginifera intermedia-helica* - Schréter, p. 118, pl. 5, figs 3-11.

1965b *Spinomarginifera helica* - Fantini Sestini, p. 47, pl. 5, figs 6-7.

1965 *Spinomarginifera helica* - Sarytcheva & Sokolskaya in Ruzhentsev & Sarytcheva, p. 226, pl. 37, figs 9-11.

1966 *Spinomarginifera helica* - Fantini Sestini & Glaus, p. 904, pl. 64, fig. 6.

1969 *Spinomarginifera helica* - Stepanov et al., pl. 5, fig. 3a-b.

2010 *Spinomarginifera helica* – Angiolini & Carabelli, p. 13, pl. 1, figs 10-11.

Material: One figured ventral valve: MPUM10289 (TK147-9).

Occurrence: Isolate locality TK147 at Kopuk Dağ, stratigraphically corresponding to section 2.

Description. Small sized, convex ventral valve with a transverse subpentagonal outline; maximum width: 10 mm, corresponding length: 7.9 mm. Umbo small, not projecting on the hinge. The median sulcus is very shallow and visible only at shell midlength. Ornamentation of sparsely and randomly dispersed subcircular spine bases, 0.2-0.5 mm wide. Weak ribs present anteriorly.

Discussion. According to Sarytcheva & Sokolskaya in Ruzhentsev & Sarytcheva (1965), *S. helica* is a very variable species. Features such as size, outline of the shell, number of spines and their position on the valves are variable and this variability is mostly ontogenetic. *S. helica* differs from *S. lopingensis* Kayser, 1883 by its relatively smaller size, ornamentation of widely spaced and not elongated spine bases and less strongly geniculated lateral profile.

Stratigraphic and geographic occurrence. *S. helica* has been also found in the Wuchiapingian *Araxalevis*, *Oldhamina* and *Haydenella* beds of Transcaucasia (Sarytcheva & Sokolskaya in Ruzhentsev & Sarytcheva 1965), in the Guadalupian-Lopingian Ruteh Limestone and Nesen Formation of North Iran (Fantini Sestini 1965b; Fantini Sestini & Glaus 1966; Angiolini & Carabelli 2010), in the Lopingian of the Himalaya (Diener 1903), of North Caucasus (Licharew 1937, 1939) and of SE Europe (Simic 1933; Ramovs 1958). Specimens of *S.* cf. *S. helica* have been already reported from the Wuchiapingian of Turkey (Angiolini et al. 2007).

Spinomarginifera iranica Fantini Sestini, 1965a

Pl. 1, fig. 23

1965a *Spinomarginifera iranica* Fantini Sestini, p. 992, pl. 94, figs 2-5.

2010 *Spinomarginifera iranica* – Angiolini & Carabelli, p. 16, pl. 1, figs 12-18

Material: One figured ventral valve: MPUM10290 (TUV6-11); 3 ventral valves: MPUM10291 (TU63D-3B, TU63D-3A, TUV6-13); 1 fragment: MPUM10292 (TU63D-3C).

Occurrence: Turkey, Pamuçak Fm., Çürük Dağ section 3 (TUV6); Çürük Dağ section 5 (TU63D).

Description. Small sized, concavo convex shell, with a suboval to subpentagonal outline; maximum width: 10-12 mm, length: 10.7-12.5 mm. Hinge shorter than the maximum width; ears small, subtriangular. Ventral valve very convex, with a broad, rounded and weakly projected umbo; geniculation starting at about one third of the shell length. Ventral sulcus shallow or absent. Ornamentation of spine bases, 0.1-0.8 mm wide, slightly elongated, not forming ribs, and rather densely arranged; very thin growth lamellae and fine rugae on the flanks, ears and umbonal region.

Dimensions (in mm)

Specimen	Width	Length	W/L	Spine bases maximum width at the anterior margin	Spine bases minimum width in the umbonal region
TU63D-3A	11.0	10.5	1.0	0.6	0.2
TU63D-3B	12.0	/	/	0.5	0.2
TUV6-11	>11.5	~12.5	/	0.8	0.3
TUV6-13	>10.0	10.7	/	0.7	0.1

Discussion. *S. iranica* differs from *S. helica* in having a swollen umbo, a deeper ventral sulcus, an ornamentation of densely arranged and slightly elongated spine bases, and no ribs.

Stratigraphic and geographic occurrence. Specimens of *S. iranica* have been sampled in the Lopingian of North Iran (Fantini Sestini 1965a; Angiolini & Carabelli 2010). Specimens of *Spinomarginifera* cf. *S. iranica* have been already reported from the Lopingian of Turkey (Angiolini et al. 2007).

Spinomarginifera spinosocostata (Abich, 1878)

Pl. 1, figs 31-33

1878 *Productus spinosocostatus* Abich, p. 41, pl. 10, figs 6, 7 and 10.

1878 *Productus spinosocostatus* var. *cariniferus* Abich, p.41, pl. 10, fig. 8.

1878 *Productus spinosocostatus* var. *expansus* Abich, p. 42, pl. 5, figs 8, 11.

1900 *Marginifera spinoso costata* - Arthaber, p. 262, pl. 20, figs 6.

1911 *Productus (Marginifera) spinuloso-costatus* - Frech, p. 175, pl. 27, figs 1-2.

1936 *Marginifera spinosocostata* - Licharew, 1936, p. 125, pl. 10, fig.37.

1937 *Productus spinosocostatus* - Licharew, p. 71, pl. 10, fig. 37.

1965b *Marginifera spinosocostata* - Fantini Sestini, p. 43, pl. 5, figs 2-3.

1965 *Spinomarginifera spinosocostata* - Sarytcheva & Sokolskaya in Ruzhentsev & Sarytcheva, p. 225, pl. 37, figs 6-8.

1966 *Spinomarginifera spinosocostata* - Fantini Sestini & Glaus, p. 905, pl. 64, fig. 5.

2010 *Spinomarginifera spinosocostata* – Angiolini & Carabelli, p. 13, pl. 1, figs 21-22.

Material: One figured articulated specimen: MPUM10300 (TUV4-7); 2 figured ventral valves: MPUM10299 (TU63D-5), MPUM10301 (TUV4-5); 2 ventral valves: MPUM10302 (TUV6-12, TUV6-14).

Occurrence: Turkey, Pamuçak Fm., Çürük Dağ section 3 (TUV4, TUV6); Çürük Dağ section 5 (TU63D).

Description. Small to medium sized, concavo-convex and geniculated shell, with subtriangular outline; maximum width: 11-21 mm, corresponding length: 10.4-17.4 mm. Ventral valve very convex with a strong geniculation starting anteriorly to one third of the valve length; umbo rounded, wide and weakly recurved on the dorsal valve; ears small, triangular. The trail shows a median flattening, or a shallow sulcus. Ornamentation of elongated spine bases which form quite prominent ribs on the trail, thin but evident growth lamellae and concentric and fine rugae on the umbonal region and on the ears. The single dorsal valve is slightly concave, fan-like in shape, with numerous concentric and fine rugae, randomly arranged spine bases, and a thin and median incision starting from the umbonal region and ending at around midvalve, which may represent the external expression of a myophragm.

Dimensions (in mm)

Specimen	Width	Length	W/L	Thickness	Spine bases width at the anterior margin	Spine bases width in the umbonal region
TU63D-5	14.4	15.5	0.7	~9.5	0.6	0.3
TUV4-5	21.0	~17.4	1.2	/	1.1	0.4
TUV4-7	19.4	17.5	1.1	11.0	0.7	0.3
TUV6-12	11.0	>10.4	/	/	0.5	0.4
TUV6-14	/	15.0	/	/	0.6	0.4

Discussion. *S. spinosocostata* is chiefly characterized by its large size and its coarse spines and spine ridges. *S. spinosocostata* differs from the type-species *S. kueichowensis* Huang, 1932 because of its strongly projecting umbo, its very weak median sulcus and the distribution and coarseness of the spines; from *S. helica* by its large size, different outline, and densely dispersed spine bases always forming distinct ridges.

Stratigraphic and geographic occurrence. *S. spinosocostata* (Abich, 1878) has been found in the Permian of Djulfa, Azerbaijan (Abich 1878), in the Guadalupian-Lopingian Ruteh and Nesen Formations of North Iran (Fantini Sestini 1965a, Fantini Sestini & Glaus 1966; Angiolini & Carabelli 2010), in the Lopingian of North Caucasus (Licharew 1937) and in the Wuchiapingian *Araxilevis* beds and *Oldhamina* beds of Transcaucasia (Ruzhentsev & Sarytcheva 1965). Specimens of *S.* cf. *S. spinosocostata* have been reported from the Changhsingian of Turkey (Angiolini et al. 2007).

Spinomarginifera aff. **S. lopingensis** (Kayser, 1883)

Pl. 1, figs 24-30

Material: Three figured articulated valves: MPUM10293 (TUV3-3), MPUM10295 (TUV5D-1), MPUM10294 (TUV6-5); 2 articulated valves: MPUM10297 (TUV5D-14, TUV6-15); 1 figured ventral valve: MPUM10296 (TUV7-3); 10 ventral valves MPUM10298 (TK139-4, TU7/26(A-B), TU9D-3, TU63D-6, TUV4-6, TUV4-14, TUV5-19, TUV5-37, TUV6-7).

Occurrence: Turkey, Pamuçak Fm., Çürük Dağ section 2 (TU7, TU9D); Çürük Dağ section 3 (TUV3, TUV4, TUV5, TUV5D, TUV6, TUV7); Çürük Dağ section 5 (TU63D); Kemer Gorge locality (TK139).

Description. Small sized, moderately geniculated and concavo-convex shell, with an approximately triangular, transverse outline; maximum width at shell midlength: 8-17.1 mm, length: 7.2-16.3 mm long. The length/width ratio is nearly constant during the growth (Fig. 7). Ventral valve strongly curved transversally, less

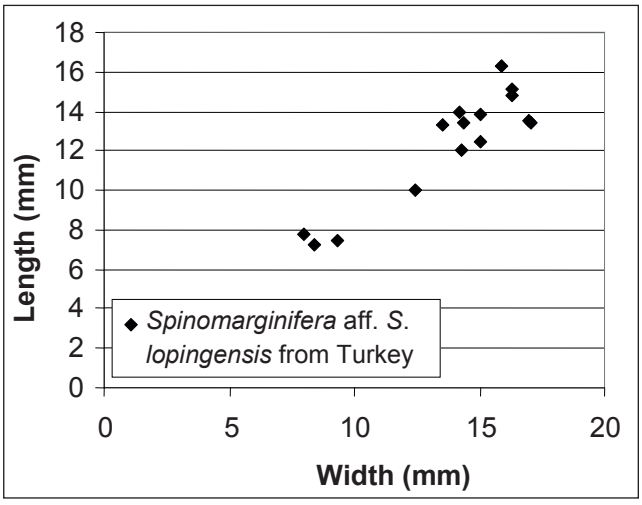


Fig. 7 - Width vs. length diagram showing a nearly constant relationships during growth in *Spinomarginifera* aff. *S. lopingensis* (Kayser, 1883).

so longitudinally; visceral disk extending to one third of the length of the valve. Umbo, rounded and wide, very slightly recurved on the dorsal valve; ears small; flanks very steep. Sulcus very shallow, starting anteriorly to the umbo. Ornamentation of fine and elongated spine bases, quincuncially arranged, whose maximum width is 0.3-0.8 mm at the anterior margin, 0.3-0.6 mm in the umbonal region; elongated spine bases form ribs on the trail in several specimens; rugae can be present on the umbonal region or on the flanks. Dorsal valve concave, not geniculated, with transverse subrectangular outline. Very weak fold anteriorly. Ornamentation of fine and elongated spine bases, slightly more widely spaced than the ones on the ventral valve and not always clearly quincuncially arranged; fine and concentric rugae.

Dimensions (in mm)

Specimen	Width	Length	W/L	Thickness	Spine bases maximum width at the anterior margin	Spine bases minimum width in the umbonal region
TU7/26A	8.0	7.8	1.0	/	/	/
TU7/26B	9.3	7.5	1.2	/	/	/
TU63D-6	15.9	16.3	1.0	/	0.6	0.5
TUV3-3	16.3	14.8	1.1	6.2	0.8	0.4
TUV4-6	17.0	13.5	1.2	/	/	0.6
TUV4-14	15.0	13.8	1.1	/	0.7	/
TUV5-19	14.2	14.0	1.0	/	/	0.4
TUV5-37	14.4	13.4	1.1	6.7	/	0.4
TUV5D-1	16.3	15.1	1.1	7.6	0.6	0.5
TUV5D-14	15.0	12.5	1.2	6.0	0.4	0.4
TUV6-5	14.3	12.0	1.2	5.7	0.4	0.4
TUV6-7	13.5	13.3	1.0	/	0.4	0.5
TUV6-15	12.4	10.0	1.2	5	/	0.4
TUV7-3	17.1	13.4	1.3	/	0.4	0.4
TU9D-3	8.4	7.2	1.2	/	0.3	0.3

Discussion. These specimens have been classified as *S.* aff. *S. lopingensis* (Kayser, 1883) because: 1) the dimensions are on average smaller than the ones of the Chinese types (Shen & Shi 2009, p. 157); 2) the number of the elongated spine bases per 5 mm at the anterior margin is 4-5, whereas that of the specimens from China is 5-6 (Shen & Shi 2009, p. 157); 3) on the dorsal valves the spine bases are not always clearly in quincunx as the ones of Chinese types; 4) the concentric rugae on the dorsal valves are more numerous. According to Shen & Shi (2009, p. 158) *S. lopingensis* differs from *S. kueichowensis* Huang, 1932 in having a smaller size, more prominent costae and less transverse outline.

Stratigraphic and geographic occurrence. *Spinomarginifera lopingensis* is one of the most common species in the Wuchiapingian of South China and occasionally it persists into lower Changhsingian (Shen et al. 2002, p. 677). This species also occurs in the latest Guadalupian in South China (Shen & Shi 2009).

Spinomarginifera sp. ind.

Material: Two ventral valves: MPUM10303 (TU7/20(A-B)).
Occurrence: Turkey, Pamuçak Fm., Çürük Dağ section 5.

Description and discussion. Two ventral valves, respectively 7.4 and 9.4 mm wide and 6 and 8 mm long, longitudinally and transversally slightly convex with a subpentagonal to subtriangular outline. They have no sulcus and an ornamentation of numerous spine bases, not elongated, on the visceral disk. Based on this ornamentation they are placed in the genus *Spinomarginifera*; however their poor preservation does not allow a specific determination.

Family Productidae Gray, 1840

Subfamily Productinae Gray, 1840

Tribe Kozlowskiini Brunton, Lazarev & Grant, 1995

Genus *Kozlowskia* Fredericks, 1933

Type species: *Productus capaci* d'Orbigny, 1842, from the Cisuralian of Capinota, Bolivia

Remarks. *Kozlowskia* Fredericks, 1933 differs from *Marginifera* Waagen, 1884 in the nature of its overlapping trails and the spine pattern; the spines are less numerous and not arranged in rows on the lateral flanks.

Kozlowskia aff. **Kozlowskia opipara** Grant, 1976

Pl. 1, figs 34-35

Material: Two figured articulated specimens: MPUM10304 (TK72-60), MPUM10305 (TK139BIS-70).
Occurrence: Turkey, Pamuçak Fm., Kemer Gorge locality (TK72, TK139bis).

Description. Concavo-convex shell with transverse subrectangular outline and elongated, pointed and triangular ears; maximum width: 21-25 mm, corresponding length: 16.5-17 mm. Ventral valve convex, with gentle geniculation starting posteriorly to shell midlength and steep flanks; relatively short trail; sulcus absent. Ornamentation of weak ribs starting anteriorly to the umbo, of unequal width and relief; fine growth lamellae; weak rugae posteriorly along the cardinal margin; spine bases mostly arranged along the hinge and on the postero-lateral regions. Spines occur also on the trail, but they are difficult to observe because of the state of preservation.

Dimensions (in mm)

Specimen	Width	Length	W/L	Thickness	Spine bases minimum width	Spine bases maximum width	No. of ribs per 5 mm at the anterior margin
TK72-60	25.0	17.0	1.5	14.0	0.3	0.9	8
TK139bis-70	21.0	16.5	1.3	9.0	0.2	0.8	5

Discussion. The comparison of the Turkish specimens with those of *K. opipara* studied by Grant (1976, p. 121, pl. 28) suggests that the specimens under examination have greater dimensions and that they do not show the typical anteriorly arranged row of spines which is present in the type material. Grant (1976, p. 122) compares *K. opipara* with the topotypes of *K. capaci* (d'Orbigny, 1842) from Yarichambi (Bolivia), pointing out its greater dimensions, more numerous spines, weaker geniculation, less strong rugae and proportionately shorter trail. The specimens under study differ from those from Oman described by Angiolini & Bucher (1999, p. 682, figs 13.18-21) as *Kozlowskia tescorum* (Hudson & Sudbury, 1959) by their larger size, more transverse profile and weaker ribs.

PLATE 2

Fig. 1 - *Juresania omanensis* Hudson & Sudbury, 1959. Ventral view of an articulated specimen. MPUM10311 (TK-139BIS-48), x1.

Fig. 2 - *Juresania omanensis* Hudson & Sudbury, 1959. Ventral view of an articulated specimen. MPUM10312 (TK-139BIS-34), x1.

Fig. 3 - *Juresania omanensis* Hudson & Sudbury, 1959. Ventral valve. MPUM10313 (TK72-216), x1.

Fig. 4 - *Bilotina acantha* (Waterhouse & Piyasin, 1970). Ventral valve. MPUM10317 (TUV1D-5), x1.

Fig. 5 - *Bilotina acantha* (Waterhouse & Piyasin, 1970). Ventral valve. MPUM10318 (TUV4-13), x1.

Fig. 6 - *Bilotina acantha* (Waterhouse & Piyasin, 1970). Ventral valve. MPUM10319 (TUV9-9), x1.

Fig. 7 - *Bilotina acantha* (Waterhouse & Piyasin, 1970). Ventral valve. MPUM10320 (TUV8D-5), x1.

Fig. 8 - *Bilotina acantha* (Waterhouse & Piyasin, 1970). Ventral valve. MPUM10321 (TK139BIS-10), x1.

Fig. 9 - *Bilotina yanagidai* Angiolini in Angiolini & Bucher, 1999. Ventral valve. MPUM10323 (TUV1D-2), x1.

Fig. 10 - *Bilotina yanagidai* Angiolini in Angiolini & Bucher, 1999. Ventral valve. MPUM10324 (TK139-8), x1.

Fig. 11 - *Bilotina yanagidai* Angiolini in Angiolini & Bucher, 1999. Ventral view of an articulated specimen. MPUM10325 (TUV4-9), x1.

Fig. 12 - *Bilotina yanagidai* Angiolini in Angiolini & Bucher, 1999. Dorsal view of an articulated specimen. MPUM10325 (TUV4-9), x1.

Fig. 13 - *Bilotina yanagidai* Angiolini in Angiolini & Bucher, 1999. Ventral valve. MPUM10326 (TUV6-3), x1.

Fig. 14 - *Bilotina yanagidai* Angiolini in Angiolini & Bucher, 1999. Ventral valve. MPUM10327 (TUV5-4), x1.

Fig. 15 - *Bilotina yanagidai* Angiolini in Angiolini & Bucher, 1999. External cast of dorsal valve. MPUM10328 (TUV1D-19), x1.

Fig. 16 - *Bilotina yanagidai* Angiolini in Angiolini & Bucher, 1999. External cast of dorsal valve. MPUM10329 (TUV5-8), x1.

Fig. 17 - *Bilotina yanagidai* Angiolini in Angiolini & Bucher, 1999. External cast of dorsal valve. MPUM10330 (TUV8D-4), x1.

Fig. 18 - *Bilotina* aff. *B. subtecta* Reed, 1944 - Ventral valve. MPUM10334 (TK140-2), x2.

Fig. 19 - *Bilotina* aff. *B. subtecta* Reed, 1944 - Ventral valve. MPUM10335 (TUV5D-15), x1.

Fig. 20 - *Bilotina* aff. *B. subtecta* Reed, 1944 - Ventral valve. MPUM10336 (TUV7-1A), x1.

Fig. 21 - *Bilotina* aff. *B. subtecta* Reed, 1944 - Ventral valve. MPUM10337 (TUV9-19), x1.

Fig. 22 - *Bilotina* aff. *B. subtecta* Reed, 1944 - Ventral valve. MPUM10338 (TUV10-11), x2.

Fig. 23 - *Vediproductus punctatiformis* (Chao, 1927) - Ventral valve. MPUM10340 (TK2-30a), x1.

Fig. 24 - *Vediproductus punctatiformis* (Chao, 1927) - Ventral view of an articulated specimen. MPUM10341 (TK72-77), x1.

Fig. 25 - *Vediproductus punctatiformis* (Chao, 1927) - Ventral valve. MPUM10342 (TK9-31), x1.

Fig. 26 - *Vediproductus punctatiformis* (Chao, 1927) - Ventral valve. MPUM10343 (TK8-46), x1.

Fig. 27 - *Vediproductus punctatiformis* (Chao, 1927) - External cast of dorsal valve. MPUM10344 (TK8-44), x1.

Fig. 28 - *Linoproductus antonioi* n. sp. - Ventral valve. MPUM10346 (BAUD06-1A), x1.

Fig. 29 - *Linoproductus antonioi* n. sp. - Ventral view of an articulated specimen. MPUM10347 (TUV1D-4), x1.

Fig. 30 - *Linoproductus antonioi* n. sp. - Dorsal view of an articulated specimen. MPUM10347 (TUV1D-4), x1.

Fig. 31 - *Linoproductus antonioi* n. sp. - Ventral valve. Holotype MPUM10348 (TUV5-5), x1.

Fig. 32 - *Linoproductus antonioi* n. sp. - Ventral valve. MPUM10349 (TUV5D-4), x1.

Fig. 33 - *Linoproductus antonioi* n. sp. - Ventral valve. MPUM10350 (TUV11-1), x1.

Fig. 34 - *Linoproductus antonioi* n. sp. - Ventral valve. MPUM10351 (TUV11-19), x1.

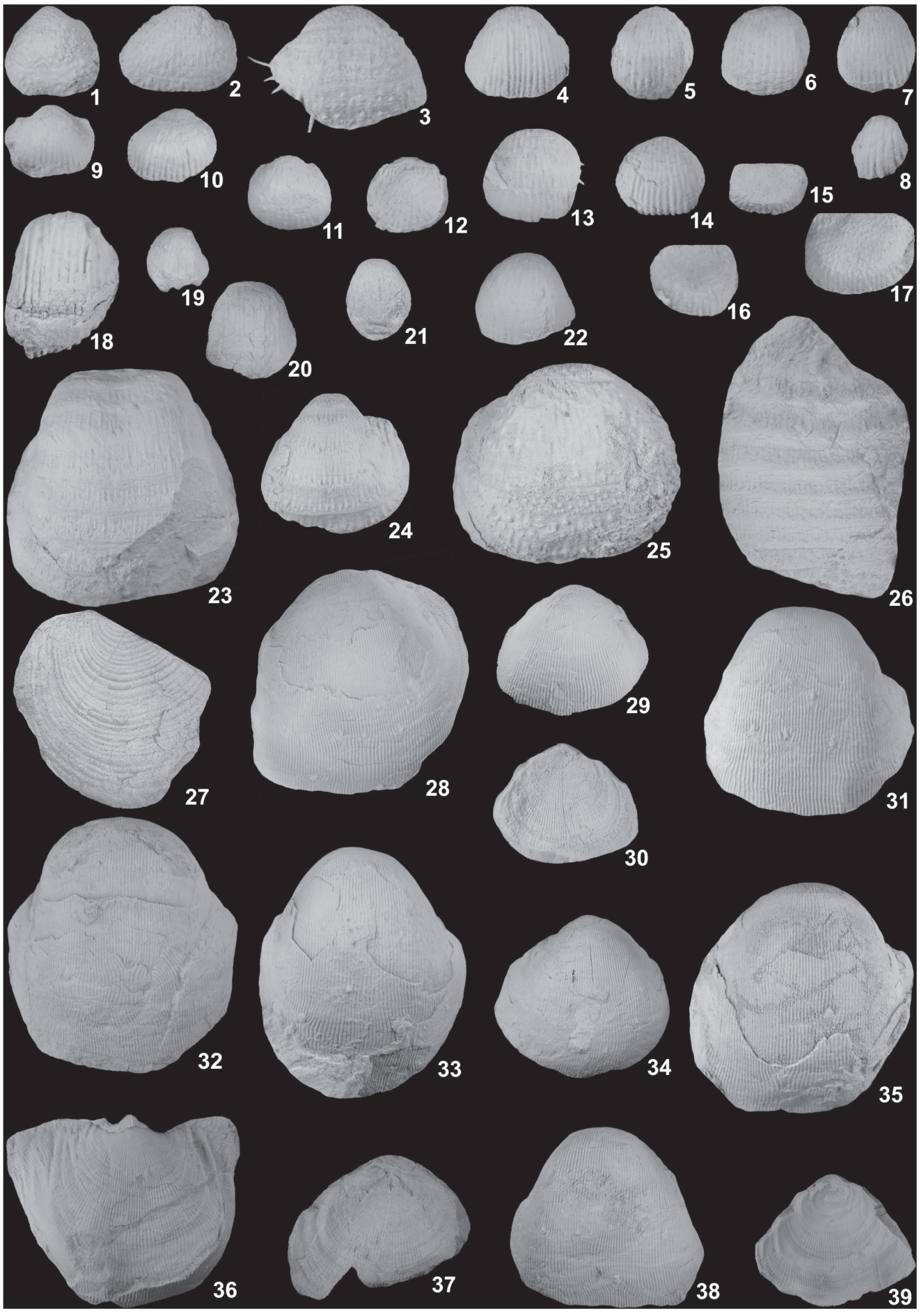
Fig. 35 - *Linoproductus antonioi* n.sp. - Ventral valve. MPUM10352 (TUV11-5), x1.

Fig. 36 - *Linoproductus antonioi* n. sp. - External cast of dorsal valve. MPUM10353 (BAUD06-1B), x1.

Fig. 37 - *Linoproductus antonioi* n.sp. - Dorsal valve. MPUM10354 (TUV8D-3), x1.

Fig. 38 - *Linoproductus antonioi* n. sp. - Ventral valve. MPUM10355 (TUV5-12), x1.

Fig. 39 - *Linoproductus antonioi* n. sp. - Dorsal view of an articulated specimen. MPUM10356 (TUV9-2), x1.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Stratigraphic and geographic occurrence. *K. opipara* has been found in the Guadalupian of Phangnga, South Thailand (Grant 1976).

Superfamily Echinoconchoidea Stehli, 1954

Family Echinoconchidae Stehli, 1954

Subfamily Juresaniinae Muir-Wood & Cooper, 1960

Tribe Juresaniini Muir-Wood & Cooper, 1960

Genus *Juresania* Fredericks, 1928

Type species: *Productus juresanensis* Tschernyschew, 1902, from the Cisuralian of Juresan River, Russia

Remarks. *Juresania* is not a well known genus and its type-species has not been described in detail.

Juresania differs from *Buxtonia* Thomas, 1914 by its outline, more convex venter, ornamentation of spine ridges and prostrate spines in two series, absence of costae, and bilobed cardinal process connected by two parallel and separated ridges to the adductor scars. *Juresania* differs from *Rhamnaria* Muir-Wood & Cooper, 1960 by its buxtoniid, posteriorly projecting cardinal process, by its parallel plates connecting the cardinal process to the adductor scars and by the absence of the ventral median septum. Furthermore *Rhamnaria* has a variably developed ventral interarea, whereas *Juresania* has only an impersistent ginglymus.

Juresania omanensis Hudson & Sudbury, 1959

Pl. 1, figs 36-40; Pl. 2, figs 1-3

1959 *Juresania omanensis* Hudson & Sudbury, p. 29, pl. 1, figs 1-4.

1959 *Juresania* sp. – Hudson & Sudbury, p. 31, pl. 2, figs 1-3.

1999 *Juresania omanensis* – Angiolini in Angiolini & Bucher, p. 684, pl. 14, figs 1–16.

Material: Four figured articulated specimens: MPUM10308 (TK72-143), MPUM10306 (TK72-181), MPUM10312 (TK139BIS-34), MPUM10311 (TK-139BIS-48); 3 articulated specimens: MPUM10314 (TK72-44, TK72-49, TK72-67); 3 figured ventral valves: MPUM10310 (TK70-14), MPUM10307 (TK72-177), MPUM10313 (TK72-216); 8 ventral valves: MPUM10315 (TK70-1C (external cast), TK70-2 (external cast), TK72-94, TK72-100(A and B), TK72-195, TK72-204a, TK139-19); 1 figured dorsal valve: MPUM10309 (TK72-178); 2 fragments: MPUM10316 (TK70-12; TK139bis-9).

Occurrence: Turkey, Pamuçak Fm., Kemer Gorge locality (TK70, TK72, TK139, TK139bis).

Description. Medium sized, concavo-convex shell; maximum width: 14.9-29.4 mm, corresponding length: 13.5-25 mm; widest anteriorly; anterior commissure slightly uniplicate. Ventral valve generally convex with subtriangular outline; umbo very recurved, showing a small cicatrix of attachment; a short ginglymus is present. Shallow ventral sulcus starting in front of the umbo and reaching the anterior commissure; trail gently geniculated and long. Ornamentation of ventral valve of elongated spine bases, of several dimensions and arranged in different patterns: finer and shorter in the posterior region (0.1-1.3 mm in diameter), which may be arranged in concentric line; thicker, longer and arranged in quincux in the anterior part (0.2-1.8 mm in diameter). Rugae irregularly arranged on ears; filae on the venter. Dorsal valve with flat visceral disk, geniculated trail, subrectangular to ovoidal outline, and evident triangular ears. Ornamentation of spine bases randomly arranged, with larger size anteriorly and dimples.

Dimensions (in mm)

					Posterior part		Anterior part	
Specimen	Width	Length	Thickness	Spines diameter	Spine bases minimum width	Spine bases maximum width	Spine bases minimum width	Spine bases maximum width
TK70-12	/	/	/	/	0.2	1.1	/	/
TK70-14	24.7	25.5	/	0.8	0.2	0.9	0.4	1.2
TK72-44	27.1	26	10.3	/	0.2	0.7	0.3	1.5
TK72-49	17.1	15.1	8.6	/	0.2	0.5	0.4	1
TK72-67	14.9	13.5	6.6	/	0.2	0.7	0.3	0.8
TK72-94	/	/	/	/	0.1	0.4	0.2	0.8
TK72-100A	21.7	16.5	/	0.3	0.1	0.7	0.2	1.7
TK72-100B	24.6	21.4	/	0.5	0.2	1.0	0.6	1.1
TK72-143	19.5	16.4	7.5	/	0.2	0.6	0.4	1.3
TK72-177	27.1	19.9	/	/	0.1	0.7	0.4	1.2
TK72-178	29.1	18.5	/	/	0.2	0.9	0.2	1.1
TK72-181	29.4	25.0	17.5	/	0.2	1.3	0.8	1.6
TK72-195	/	24.0	/	/	0.2	1.0	0.3	1.8
TK72-204A	20.0	16.8	/	/	0.2	1.0	0.3	1.1
TK72-216	27.5	22.0	/	0.6	0.2	1.1	0.6	1.3
TK139-19	20.5	17.3	/	/	0.3	1.0	0.5	1.1
TK139bis-9	/	/	/	0.6	/	/	/	/
TK139bis-34	22.3	16.5	9.1	/	0.2	0.7	0.2	0.8
TK139bis-48	17.9	17.5	8.0	/	0.1	0.7	0.2	1.7

Discussion. The specimens under examination are very similar to the specimens from the Khuff Formation of Oman described as *Juresania omanensis* by Angiolini & Bucher (1999). They share the same outline which is widest at the anterior part of the shell, the shallow ventral sulcus, the long trail, the small ears, the recurved umbo punctuated by a cicatrix, and the ar-

rangement of spine bases arranged anteriorly in quincunx and posteriorly in concentric lines. They mostly fall in the lower size range of the Oman material.

The specimens described by Campi et al. (2005 p.115, pl. 2. figs D, F, G) as *Juresania omanensis* may belong to another species, having a well defined sulcus and a different outline.

Stratigraphic and geographic occurrence. *Juresania omanensis* has been found in the Khuff Formation (Wordian), southeastern Oman (Hudson & Sudbury 1959; Angiolini & Bucher 1999).

Genus *Bilotina,* Reed 1944

Type species: *Strophalosia (Bilotina) subtecta* Reed, 1944, from the Guadalupian of Kishor Range, Pakistan

Remarks. The genus *Bilotina*, which is an important marker for the Wordian along the southern margin of the Neotethys, is characterized by the internal characters of the dorsal valve, consisting of a bilobed cardinal process with ridges connected to raised adductor platforms and a long and low median septum. These ridges were formerly considered to be a buttress stemming from the cardinal process plates by Grant (1976, p. 147); however, true buttress plates die out after the Early Carboniferous and the plates of *Bilotina* are in fact ridges connecting to the raised muscle platform (Brunton, pers. comm. to Angiolini & Bucher 1999). Another feature of the genus is the ribs, which seem to ornament the ventral trail but are in fact long bases of spines (Angiolini & Bucher 1999).

Bilotina is similar to *Marginifera* Waagen, 1884, but differs by its absence of reticulation on the dorsal disk and the absence of a row of spine bases near the ears. The genus *Paraplicatifera* Zhao & Tan, 1984, is similar, but lacks spine bases on the ventral valve.

Bilotina acantha (Waterhouse & Piyasin, 1970)

Pl. 2, figs 4-8

1970 *Septasteges acanthus* Waterhouse & Piyasin, p. 120, pl. 19, figs 13-21.

1970 *Cancrinella* sp. ind. – Yanagida, p. 83, pl. 15, fig. 15.

1976 *Bilotina acantha* – Grant, p. 148, pl. 36, figs 24-36 and pl. 37, figs 1-28.

Material: Five figured ventral valves: MPUM10321 (TK-139BIS-10), MPUM10317 (TUV1D-5), MPUM10318 (TUV4-13), MPUM10320 (TUV8D-5), MPUM10319 (TUV9-9); 16 ventral valves: MPUM10322 (TK9-39, TK72-24, TK139bis-48, TU63BD-5, TUV3-1, TUV4-2, TUV4-8, TUV5-3, TUV5-17, TUV5-18, TUV5-25(A-B), TUV5-27, TUV5-33, TUV5D-6, TUV5D-7, TUV5D-11, TUV6-8, TUV8D-6, TUV9-22, TUV9-40).

Occurrence: Turkey, Pamuçak Fm., Kemer Gorge locality (TK72, TK139bis); Çürük Dağ section 3 (TUV1D, TUV3, TUV4, TUV5, TUV5D, TUV6, TUV8D, TUV9); Çürük Dağ section 5 (TU63BD); coal mine section (TK9).

Description. Small to medium sized, concavo-convex shell, showing a pseudopunctate shell substance, a strong geniculation and an elongated subrectangular outline; maximum width: 10-20 mm, corresponding length: 11-19.3 mm. Anterior commissure rectimarginate. Ventral valve strongly convex, with geniculation at one third of the shell length; umbo wide, projecting; ears subtriangular; shallow median sulcus starting from the umbonal region and widening anteriorly. Ornamentation of hollow spine bases, 0.1-1.5 mm wide, arranged radially and extended to form long ribs on the trail; they develop anteriorly and anterolaterally at low angle to the surface. Fine growth lamellae present.

Dimensions (in mm)

Specimen	Width	Length	W/L	Thickness	Spine bases maximum width	Spine bases minimum width
TK9-39	10.8	11.0	1.0	/	1.3	0.4
TK72-24	12.0	13.0	0.9	7.4	/	/
TK139bis-10	10.8	12.7	0.8	6.7	1.4	0.2
TU63BD-5	16.0	15.9	1.0	/	1.5	0.3
TUV1D-5	20.0	17.3	1.1	/	0.7	0.3
TUV3-1	~10.0	11.0	~0.9	/	0.8	0.3
TUV4-8	17.3	>15.5	/		1.4	0.3
TUV4-13	>15.0	18.2	/	/	1.3	0.2
TUV5-3	18.0	15.0	1.2	/	1.2	0.3
TUV5-17	15.0	14.5	1.0	/	0.7	0.2
TUV5-18	17.3	>16.5	/	/	0.8	0.2
TUV5-25A	14.2	16.3	0.9	/	1.1	0.3
TUV5-25B	13.4	14.2	0.9	/	1.0	0.3
TUV5-27	12.6	16.0	0.8	/	1.1	0.1
TUV5-33	16.7	17.4	0.9	/	0.8	0.2
TUV5D-6	16.0	18.0	0.9	/	1	0.2
TUV5D-7	17.0	19.3	0.9	14.0	1.1	0.2
TUV5D-11	15.0	17.5	0.8	10.5	/	/
TUV6-8	>11.5	13.0	/	/	1.4	0.2
TUV8D-5	14.8	15.3	1.0		1.3	0.3
TUV9-9	17.0	17.6	1.0	/	1.1	0.2
TUV9-22	11.7	12.0	1.0	/	/	/
TUV9-40	19.0	19.1	1.0	/	1.2	0.2

Discussion. Our specimens fit the description of *Bilotina acantha*. Grant (1976) included *Septasteges acanthus* Waterhouse & Piyasin (1970, p. 120, pl. 19, figs 13-21) in the genus *Bilotina* on the basis of its general shape, ornamention and internal characters.

Stratigraphic and geographic occurrence. *Bilotina acantha* occurs in the Guadalupian of South Thailand (Waterhouse & Piyasin 1970; Yanagida 1970; Grant 1976).

Bilotina yanagidai Angiolini in Angiolini & Bucher, 1999

Pl. 2, figs 9-17

1999 *Bilotina yanagidai* Angiolini in Angiolini & Bucher, p. 686, pl. 14, figs 17-22.

Material: One figured articulated specimen: MPUM10325 (TUV4-9); 2 articulated specimens: MPUM10333 (TUV5-32, TUV5D-8); 4 figured ventral valves: MPUM10324 (TK139-8), MPUM10323 (TUV1D-2), MPUM10327 (TUV5-4), MPUM10326 (TUV6-3); 46 ventral valves: MPUM10331 (BaudCD08(A-C), BaudCD08(1-3), TK9-41, TK72-193, TK139-73B, TU20-1, TU23-2, TUV1D-3A, TUV1D-6, TUV1D-12(A-B), TUV1D-16, TUV1D-20, TUV2D-4, TUV2D-6, TUV4-4, TUV4-12, TUV5-2, TUV5-21, TUV5-23, TUV5-24, TUV5-30, TUV5-31, TUV5-34, TUV5D-9, TUV5D-12, TUV6-2(A-C), TUV6-4, TUV6-6, TUV6-10, TUV9-3, TUV9-10, TUV9-12, TUV9-13, TUV9-17, TUV9-20, TUV9-50, TUV10-6, TUV10-10, TUV11-25); 3 figured external casts of dorsal valves: MPUM10328 (TUV1D-19), MPUM10329 (TUV5-8), MPUM10330 (TUV8D-4); 12 external casts of dorsal valves: MPUM10332 (TK139-73A, TK139-203(A-B), TU63D-1, TUV1D-3B, TUV1D-7, TUV5-6, TUV5-29, TUV5D-13, TUV9-26, TUV9-27, TUV9-56).

Occurrence: Turkey, Pamuçak Fm., Kemer Gorge locality (TK72, TK139); Çürük Dağ section 2 (TU20); Çürük Dağ section 3 (TU23, TUV1D, TUV2D, TUV4, TUV5, TUV5D, TUV6, TUV8D, TUV9, TUV10, TUV11); Çürük Dağ section 5 (08Br, TU63D); coal mine section (TK9).

Description. Medium sized, concavo-convex, geniculated shell, with subrectangular to suboval outline; maximum width at shell midlength: 11.1-22 mm, corresponding length: 11-17.5 mm. Ventral valve with wide umbo, pointed and slightly recurved on the dorsal valve; maximum convexity just anterior to the umbonal region; the venter is weakly convex or almost flat and wide; sulcus absent. Ornamentation of radially arranged spine bases, 0.1-1.2 mm wide, elongated to form coarse ribs on the trail; spine bases set in suberect tufts on the ears. Dorsal valve with transverse subrectangular outline; very slightly concave visceral disk, which anteriorly undergoes a very strong geniculation. Ornamentation of suboval spine bases, elongated to form ribs only anteriorly; concentric rugae on the visceral disk; growth lamellae anteriorly.

Dimensions (in mm)

Specimen	Width	Length	W/L	Thickness	Spine bases maximum width	Spine bases minimum width
BaudCD08A	16.7	16.0	1.0	/	1.1	0.1
BaudCD08B	11.1	11.1	1.0	/	0.6	0.2
TK139-8	17.7	13.5	1.31	/	1.1	0.1
TK139-73A	16.2	11.0	1.5	/	/	/
TU20-1	20.3	18.0	1.1	/	0.8	0.1
TU23-2	15.5	14.0	1.1	/	/	/
TUV1D-2	18.0	15.0	1.2	/	1.0	0.3
TUV1D-3B	17.0	11.5	1.5	/	/	/
TUV1D-6	17.5	14.0	1.2	/	0.9	0.2
TUV4-9	15.0	15.0	1.0	7	0.8	0.2
TUV4-12	16.5	15.9	1.0	/	1.2	0.3
TUV5-2	18.0	16.0	1.1	/	0.8	0.2
TUV5-4	17.5	14.5	1.2	/	1.1	0.3
TUV5-8	15.9	14.5	1.1	/	/	/
TUV5-21	~22.0	15.9	~1.4	/	1.0	0.2
TUV5-24	~19.5	18.0	~1.1	/	1.1	0.2
TUV5-30	15.2	16.8	0.9	/	1.0	0.3
TUV5-32	16.5	14.0	1.2	9.0	0.5	0.2
TUV5D-8	19.7	16.4	1.2	10.4	0.8	0.3
TUV5D-9	19.3	15.0	1.3	/	0.9	0.3
TUV5D-12	15.0	14.0	1.1	/	0.9	0.1
TUV5D-13	16.3	13.0	1.2	/	/	/
TUV6-3	21.5	18.0	1.2	/	1.0	0.2
TUV6-4	18.0	17.9	1.0	/	0.9	0.1
TUV6-6	12.7	12.7	1.0	/	0.8	0.3
TUV9-3	~22.0	17.5	~1.2	/	1.1	0.2
TUV9-17	15.4	15.0	1.0	/	0.9	0.2
TUV9-20	18.5	17.2	1.1	/	0.9	0.3
TUV9-26	17.0	12.4	1.4	/	/	/
TUV10-10	12.8	11.1	1.1	/	0.7	0.2
TUV11-25	14.4	14.0	1.0	/	0.9	0.1

Discussion. *Bilotina yanagidai* differs from *Bilotina acantha* Waterhouse & Piyasin, 1970 because of its transverse outline, the less elongated and narrower spine bases, and the absence of a sulcus. It also differs from *Bilotina subtecta* Reed, 1944 because the latter shows thinner, more numerous and closely arranged spine bases and a more elongated trail.

The difference in size between the specimens from Turkey and those from Oman (Angiolini in Angiolini & Bucher 1999) is shown in Fig. 8.

Stratigraphic and geographic occurrence. *Bilo-*

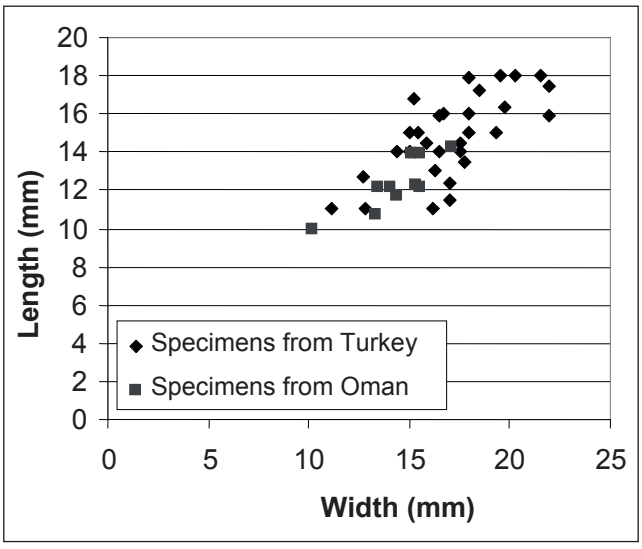


Fig. 8 - Width vs. length diagram of the specimens of *Bilotina yanagidai* from Oman (Angiolini in Angiolini & Bucher 1999), and those from Turkey; the latter seem to reach a larger size than those from Oman.

tina yanagidai has been found in the Wordian Khuff Formation of southeastern Oman (Angiolini & Bucher 1999).

Bilotina aff. **B. subtecta** Reed, 1944

Pl. 2, figs 18-22

Material: Five figured ventral valves: MPUM10334 (TK140-2), MPUM10335 (TUV5D-15), MPUM10336 (TUV7-1A), MPUM10337 (TUV9-19), MPUM10338 (TUV10-11); 11 ventral valves: MPUM10339 (TU7D-5, TU17D-9, TU59-2, TUV4-11, TUV4-16, TUV5D-10, TUV5D-16, TUV7-1B, TUV7-2, TUV9-5, TUV9-21).

Occurrence: Turkey, Pamuçak Fm., Kemer Gorge locality (TK140); Çürük Dağ section 2 (TU7D, TU17D); Çürük Dağ section 3 (TUV4, TUV5D, TUV7, TUV9, TUV10); Çürük Dağ section 5 (TU59).

Description. Small to medium sized, concavo-convex, geniculated shell, with subrectangular to suboval outline; maximum width: 9.1-20 mm, corresponding length: 13-18.5 mm; anterior commissure rectimarginate. Elongated ventral valve with geniculation starting at around one third of the length; venter flat transversally; flanks sharply bent. Umbo wide and weakly projecting towards the dorsal valve. Ornamentation of hollow spine bases, 0.1-1 mm wide, forming thin ribs of uniform width, which start from the umbo and reach the anterior margin; coarse concentric rugae present on the flanks; fine growth lamellae also present.

Dimensions (in mm)

Specimen	Width	Length	W/L	Spine bases maximum width	Spine bases minimum width
TK140-2	9.1	~13.0	~0.7	0.5	0.2
TU17D-9	13.5	>12.2	/	0.7	0.1
TU59-2	12.5	11.5	1.08	0.6	0.2
TUV4-11	/	16.5	/	0.9	0.3
TUV4-16	12.0	13.7	0.9	1.0	0.2
TUV5D-15	11.4	11.5	1.0	0.8	0.2
TUV5D-16	10.5	>10.0	/	0.7	0.1
TUV7-1A	~20	~18.5	~1.1	1.0	0.2
TUV7-1B	/	16.7	/	0.9	0.2
TUV7-2	13.7	14.2	1.0	0.8	0.1
TUV9-5	14.5	17.5	0.8	1.1	0.3
TUV9-19	12.0	15.9	0.7	0.5	0.3
TUV9-21	11.8	12.2	1.0	/	/
TUV10-11	9.6	11.0	0.9	0.7	0.2

Discussion. The doubt in the assignment of the Turkish specimens to *B. subtecta* derives from the observation that the shell is proportionately long and narrow, but not as long and narrow as shown by the specimens studied by Grant (1976, p. 149-150). As our specimens are neither numerous nor well preserved, we prefer to leave them in open nomenclature. *B. subtecta* differs from *B. acantha* by its longer and narrower outline, thinner, more numerous and more closely set spine bases, and absence of a median sulcus.

Stratigraphic and geographic occurrence. *B. subtecta* occurs in the Guadalupian of South Thailand (Grant 1976) and of the Salt Range (Reed 1944).

Genus *Vediproductus* Sarytcheva in Ruzhentsev & Sarytcheva, 1965

Type species: *Vediproductus vediensis* Sarytcheva in Ruzhentsev & Sarytcheva, 1965, from the Guadalupian of Transcaucasia

Remarks. *Vediproductus* is a typical palaeo-equatorial genus, found in the Guadalupian of Transcaucasia (Ruzhentsev & Sarytcheva 1965) and is common in the Wordian and Capitanian of South and North China (Chao 1927; Liang 1982, 1990; Shen et al. 2002; Tazawa & Chen 2006), in Malaysia (Campi et al. 2002), and in Oman (Angiolini et al. 2004). *Vediproductus* has not been sampled in beds younger than the Guadalupian (Shen et al. 2002).

Vediproductus differs from *Calliprotonia* Muir-Wood & Cooper, 1960 because of its deep, regularly convex ventral valve, less lamellose and more raised bands, and spines that are distinctly divided into those that are longer posteriorly and those that are thinner anteriorly. It also differs from *Juresania* because of its spine bands of strong relief, the maximum width located anteriorly to cardinal margin, and the ornamentation of the dorsal valve which is concentrically arranged. *Vediproductus* differs from the Lopingian genus *Chenxianoproductus* Liao & Meng, 1986 because of its quincuncially arranged pustules posteriorly and its elongated (not rounded) spine bases.

Vediproductus punctatiformis (Chao, 1927)

Pl. 2, figs 23-27

1927 *Echinoconchus puncatiformis* Chao, p. 72, pl. 6, figs 9-12.

1978 *Bathymyonia punctatiformis* – Feng & Jiang, p. 256, pl. 90, fig. 10.

1978 *Vediproductus punctatiformis* – Tong, p. 225, pl. 79, fig. 16.

1983 *Vediproductus punctatiformis* – Hu, pl. 2, figs 5, 6.

1990 *Vediproductus punctatiformis* – Liang, p. 187, pl. 27, fig. 5.

1995 *Vediproductus punctatiformis* – Zeng et al., pl. 6, fig.11.

2000 *Vediproductus punctatiformis* – Campi et al., fig. 4B.

2002 *Vediproductus punctatiformis* – Campi et al., figs 6G-I, L, O.

2002 *Vediproductus punctatiformis* – Shen et al., p. 673, fig. 3: 19-24.

2005 *Vediproductus punctatiformis* – Campi et al., p. 115, pl. 2, figs B-C, E, H-P; text-figs 6,7.

Material: One figured articulated specimen: MPUM10341 (TK72-77); 3 figured ventral valves: MPUM10340 (TK2-30a), MPUM10343 (TK8-46), MPUM10342 (TK9-31); 1 ventral valve: MPUM10345 (TU5bisD-1); 1 figured external cast of dorsal valve: MPUM10344 (TK8-44).

Occurrence: Turkey, Pamuçak Fm., Kemer Gorge locality (TK72); coal mine section, (TK2, 8, 9); Çürük Dağ section 1 (TU-5bisD).

Description. Medium to large sized shell, planoconvex or concavo-convex, with subtriangular outline; maximum width anterior to the cardinal margin: 27.5-45 mm, corresponding length: 29.8-38.1 mm; anterior commissure weakly uniplicate. Ventral valve convex with short, recurved umbo and long trail, slighly geniculated, showing a shallow median sulcus. Ornamentation of 7 to 9 concentric and very distinct bands, covered by elongated spine bases of two dimensions: thicker, longer and evenly dispersed along one row posteriorly, thinner spines arranged on several rows anteriorly. On the posterior part of the ventral valve, the width of the spine bases varies between 0.1 and 1.7 mm, on the anterior part between 0.1 and 1.1 mm. Dorsal valve concave to almost flat, with subrectangular to ovoidal outline. Ornamentation of numerous finer bands, with finer spine bases, more closely set than in the ventral valve.

Dimensions (in mm)

				Posterior part		Anterior part	
Specimen	W	L	T	Spine bases minimum width	Spine bases maximum width	Spine bases minimum width	Spine bases maximum width
TK2-30a	>40.5	>45.0	/	0.3	0.9	0.2	1.1
TK8-44	~45.0	>38.1	/	0.1	0.3	0.2	0.4
TK8-46	>40.0	>38.0	/	0.2	0.7	0.2	0.7
TK9-31	42.3	39.3	/	0.3	1.7	0.2	1.0
TK72-77	27.5	25.9	1.1	0.1	0.5	0.1	0.7
TU5bisD-1	36.0	>35.0	~22.0	/	/	0.2	1.1

Discussion. *Vediproductus punctatiformis* (Chao, 1927) is very similar to the type-species *Vediproductus vediensis* Sarytcheva in Ruzhentsev & Sarytcheva, 1965, but differs by its less inflated ventral valve, the larger umbo, and the shorter concentric bands. Furthermore, the sulcus is generally deeper, and the number of concentric bands can be greater in *V. vediensis*. Shen et al. (2002) considered *V. punctatiformis* and *V. vediensis* conspecific, however, we agree with Sarytcheva in Ruzhentsev & Sarytcheva, 1965, who considered them two different species.

Stratigraphic and geographic occurrence. *Vediproductus punctatiformis* (Chao, 1927) occurs in Jiangxi and western Yunnan, south China, where it has been found from stratigraphic horizons older than the Roadian. *V. punctatiformis* is also reported from the Capitanian of southeast China and Malaysia (Shiino 2009). *V. punctatiformis* is thus widespread across South China, but it has not been found above the Guadalupian-Lopingian boundary (Shen et al. 2002). *Vediproductus punctatiformis* (Chao, 1927) also comes from the Guadalupian of northeastern Japan (Shiino 2009) and Peninsular Malaysia (Campi et al. 2005).

Superfamily Linoproductoidea Stehli, 1954

Family Linoproductidae Stehli, 1954

Subfamily Linoproductinae Stehli, 1954

Genus *Linoproductus* Chao, 1927

Type species: *Productus cora* d'Orbigny, 1842, from the Cisuralian of Cochabamba, Bolivia

Remarks. This genus can be considered one of the most abundantly sampled, widely distributed, described and discussed Productida. *Linoproductus* is also abundant in Turkey, but unfortunately it generally shows a poor preservation. *Levisapicus* Tong in Tong et al., 1990 from the Cisuralian of Sichuan is similar to *Linoproductus*, but it differs because it has a cluster of spines on the ears. *Linoproductus* is also similar to the Carboniferous genus *Balakhonia* Sarytcheva in Sarytcheva et al., 1963, but the latter differs in having gently sloping flanks, spines along the hinge, and rarely on the ventral corpus where they are finer than the ribs. The fine ribs, small number of spines with blister-like swollen bases and the combination of strongly curved juvenile shell and less curved adult shell are typical of *Linoproductus*.

Linoproductus antonioi n. sp.

Pl. 2, figs 28-39

1999 *Linoproductus* sp. aff. *L. kaseti* Grant, 1976 – Angiolini & Bucher, p. 687, pl. 15, figs 1-14.

Holotype: TUV5-5, ventral valve, from the Pamuçak Fm., Çürük Dağ section 3, bed TUV5.

Derivation of name: in honour of Antonio Manzari.

Material: One figured articulated specimen: MPUM10356 (TUV9-2); 5 articulated specimens: MPUM10357 (TUV5-28, TUV9-14, TUV9-46, TUV9-57, TUV10-4); 8 figured ventral valves: MPUM10346 (BAUD06-1A), MPUM10347 (TUV1D-4), MPUM10348 (TUV5-5), MPUM10355 (TUV5-12), MPUM10349 (TUV5D-4), MPUM10350 (TUV11-1), MPUM10352 (TUV11-5), MPUM10351 (TUV11-19); 50 ventral valves: MPUM10358 (Baud6-1(C-D), TK8-41, TK8-42, TU11-12, TU16-1, TU17D-5, TU17D-6, TUV5-7A, TUV5-9, TUV5-11A, TUV5-20, TUV5-72(A-B), TUV5D-3, TUV9-1, TUV9-29, TUV9-30(A-B), TUV9-33A, TUV9-37, TUV9-39, TUV9-41, TUV9-43, TUV9-44, TUV9-48, TUV9-51, TUV9-59, TUV10-1, TUV10-2, TUV10-3, TUV10-4, TUV10-5, TUV10-9, TUV11-3, TUV11-4, TUV11-6, TUV11-7, TUV11-8, TUV11-9, TUV11-10, TUV11-11, TUV11-12, TUV11-13, TUV11-14, TUV11-15, TUV11-16, TUV11-18, TUV11-20, TUV11-22; 1 figured dorsal valve: MPUM10354 (TUV8D-3); 1 dorsal valve: MPUM10359 (Baud6-1E); 3 external casts of ventral valves: MPUM10360 (TUV9-38(A-B), TUV5-11B); 1 figured external cast of dorsal valve: MPUM10353 (BAUD06-1B); 11 external casts of dorsal valves: MPUM10361 (TUV5D-5, TUV9-4, TUV9-6, TUV9-7, TUV9-8, TUV9-11, TUV9-15, TUV9-31, TUV9-35, TUV9-49, TUV11-2; 14 fragments: MPUM10362 (TU7/3, TU7/36, TUV5-10, TUV5-13, TUV5-14, TUV5-15, TUV9-28, TUV9-34, TUV9-42, TUV10-7, TUV10-8, TUV11-17, TUV11-23, TUV11-24).

Occurrence: Turkey, Pamuçak Fm., Çürük Dağ section 1 (TU17D); Çürük Dağ section 2 (TU11, TU16, TK8); Çürük Dağ section 3 (06Br, TUV1D, TUV5, TUV5D, TUV8D, TUV9, TUV10, TUV11).

Diagnosis*:* Medium sized *Linoproductus* with fine costellae, shallow ventral sulcus, and swollen spine bases causing both deflection and coalescence of costellae.

Description. Medium sized, concavo-convex shell, with subrectangular to elongated oval outline; maximum width: 24-48 mm; corresponding length: 22-45 mm. Anterior commissure rectimarginate. Ventral valve strongly convex, with long trail; maximum convexity near the umbonal region; the transverse profile generally shows a median flattening, but a very weak median sulcus can be present; umbo large, wide, rounded and gently recurved on the dorsal valve. Ears rugose, expanded in some specimens. Ornamentation of numerous costellae, numbering 10-14 per 5 mm at 10 mm from the umbo and 8-10 per 5 mm at the anterior margin; rugae on flanks and ears, sometimes crossing the venter; few drop-like and swollen spine bases, 0.4-1.8 mm wide. The spines are randomly arranged on the venter; a longitudinal row of spine bases is present in one specimen and several transverse rows of spine bases near the anterior margin have been observed in a few specimens. The spine bases cause either the deflection of the lateral costellae or their coalescence to the spine bases. Dorsal valve slightly concave and geniculated, with oval to subrectangular outline. Median fold often present. Ornamentation of costellation similar to that of the ventral valve and concentric, coarse rugae present on both the visceral disk and trail.

Dimensions (in mm)

Specimen	Width	Length	W/L	N. costellae per 5 mm on the anterior margin	N. costellae per 5 mm at 10 mm from the umbo
Baud6-1A	~44.0	46.4	0.9	9	12
Baud6-1B	44.5	>44.5	<1.0	8	/
Baud6-1C	/	43.7	/	8	/
TK8-41	~28.0	/	/	/	13
TK8-42	30.0	/	/	9	12
TU16-1	33.2	36.9	0.9	9	9
TU17D-5	~28.0	~33.0	~0.8	/	12
TU17D-6	36.3	35.5	1.0	9	10
TUV1D-4	27.5	23.7	1.2	9	13
TUV5-5	39.4	40	1.0	8	12
TUV5-7A	/	/	/	9	13
TUV5-9	33.4	36.2	0.9	9	13
TUV5-12	37.0	40.0	0.9	9	
TUV5D-3	/	44.0	/	9	/
TUV5D-4	43.0	50.4	0.8	10	/
TUV5-11	/	/	/	10	12
TUV5-12	36.4	41.5	0.9	10	13
TUV9-14	24.0	>22	/	9	13
TUV9-18	>30	31.5	/	9	12
TUV9-29	/	/	/	/	13
TUV9-30A	39.5	/	/	/	11
TUV9-30B	37.3	/	/	/	/
TUV9-33A	>31.0	34.0	/	9	11
TUV9-43	>31.0	>28.0	/	/	11
TUV10-1	26.5	/	/	8	12
TUV10-2	/	/	/	/	12
TUV10-4	/	37	/	9	12
TUV11-1	~42.5	48.1	0.9	9	13
TUV11-3	43.3	>42.2	/	8	12
TUV11-4	38.0	39.2	1.0	9	13
TUV11-5	43.5	43.6	1.0	8	/
TUV11-6	38.7	43.0	0.9	9	14
TUV11-7	39.5	41.5	0.9	9	11
TUV11-8	40.0	42.4	0.9	9	/
TUV11-9	41.3	45.4	0.9	10	11
TUV11-10	44.0	47.0	0.9	8	/
TUV11-11	~38.0	39.0	~1.0	10	13
TUV11-12	48.0	>45.0	/	/	13
TUV11-13	45.4	>42.5	/	8	14
TUV11-15	/	39.0	/	10	/
TUV11-16	41.3	/	/	/	11
TUV11-18	~37.0	41.5	~0.9	9	11
TUV11-19	34.0	32.2	1.0	9	14
TUV11-20	33.0	35.5	0.9	9	14

Discussion. *Linoproductus antonioi* n. sp. is characterized by its medium size and comparatively fine costellae which are either deflected around the swol-

len spine bases or coalesce with them. The direct comparison of the Turkish material with the specimens from Oman, named as *Linoproductus* sp. aff. *L. kaseti* Grant, 1976 by Angiolini & Bucher (1999, p. 687, pl. 9, figs 15.1-

PLATE 3

Fig. 1 - *Perigeyerella miriae* n. sp. Ventral valve. MPUM10363 (TK70-17), x1.

Fig. 2 - *Perigeyerella miriae* n. sp. Ventral view of an articulated specimen. Holotype MPUM10364 (TK72-217), x1.

Fig. 3 - *Perigeyerella miriae* n. sp. Dorsal view of an articulated specimen. Holotype MPUM10364 (TK72-217), x1.

Fig. 4 - *Perigeyerella miriae* n. sp. Ventral view of an articulated specimen. MPUM10365 (TK139BIS-67), x1.

Fig. 5 - *Perigeyerella miriae* n. sp. Ventral view of an articulated specimen. MPUM10366 (TUV8D-1), x1.

Fig. 6 - *Perigeyerella miriae* n. sp. Ventral valve. MPUM10367 (TU7.3aB), x1.

Fig. 7 - *Perigeyerella miriae* n. sp. Dorsal view of an articulated specimen. MPUM10368 (TK72-179), x1.

Fig. 8 - *Perigeyerella* aff. *P. raffaellae* Angiolini in Angiolini & Bucher, 1999. Ventral view of an articulated specimen. MPUM10373 (TK72-163), x2.

Fig. 9 - *Perigeyerella* aff. *P. raffaellae* Angiolini in Angiolini & Bucher, 1999. Dorsal view of an articulated specimen. MPUM10373 (TK72-163), x2.

Fig. 10 - *Perigeyerella* aff. *P. raffaellae* Angiolini in Angiolini & Bucher, 1999. Ventral view of an articulated specimen. MPUM10374 (TU17D-1), x1.

Fig. 11 - *Perigeyerella* aff. *P. raffaellae* Angiolini in Angiolini & Bucher, 1999. Ventral valve. MPUM10375 (TU11D-1), x1.

Fig. 12 - *Perigeyerella* aff. *P. raffaellae* Angiolini in Angiolini & Bucher, 1999. Ventral valve. MPUM10376 (TUV11-21), x1.

Fig. 13 - *Perigeyerella* aff. *P. raffaellae* Angiolini in Angiolini & Bucher, 1999. Dorsal valve. MPUM10377 (TU63D-4), x1.

Fig. 14 - *Perigeyerella* aff. *P. raffaellae* Angiolini in Angiolini & Bucher, 1999. Dorsal view of an articulated specimen. MPUM10378 (TK72-176), x1.

Fig. 15 - *Enteletes* sp. ind. Fragment. MPUM10383 (TK8-48), x2.

Fig. 16 - *Enteletes* sp. ind. Ventral view of an articulated specimen. MPUM10384 (TU62D-2), x2.

Fig. 17 - *Kotlaia* sp. ind. Ventral view of an articulated specimen. MPUM10385 (TK72-48), x2.

Fig. 18 - *Kotlaia* sp. ind. Dorsal view of an articulated specimen. MPUM10385 (TK72-48), x2.

Fig. 19 - *Kotlaia* sp. ind. Ventral view of an articulated specimen. MPUM10386 (TU5D-1), x2.

Fig. 20 - *Kotlaia* sp. ind. Dorsal view of an articulated specimen. MPUM10386 (TU5D-1), x2.

Fig. 21 - *Curuckamara globosa* n. gen. n. sp. Ventral view of an articulated specimen. Holotype MPUM10389 (TU18-2), x1.

Fig. 22 - *Curuckamara globosa* n. gen. n. sp. Dorsal view of an articulated specimen. Holotype MPUM10389 (TU18-2), x1.

Fig. 23 - *Curuckamara globosa* n. gen. n. sp. Lateral view of an articulated specimen. Holotype MPUM10389 (TU18-2), x1.

Fig. 24 - *Curuckamara globosa* n. gen. n. sp. Posterior view of an articulated specimen. Holotype MPUM10389 (TU18-2), x1.

Fig. 25 - *Curuckamara globosa* n. gen. n. sp. Ventral view of an articulated specimen. MPUM10390 (TU18-1), x1.

Fig. 26 - *Curuckamara globosa* n. gen. n. sp. Dorsal view of an articulated specimen. MPUM10390 (TU18-1), x1.

Fig. 27 - *Pontisia* sp. ind. Ventral view of an articulated specimen. MPUM10391 (TK139-1), x2.

Fig. 28 - *Pontisia* sp. ind. Dorsal view of an articulated specimen. MPUM10391 (TK139-1), x2.

Fig. 29 - *Pontisia* sp. ind. Anterior view of an articulated specimen. MPUM10391 (TK139-1), x2.

Fig. 30 - *Cleiothyridina* sp. ind. Ventral view of an articulated specimen. MPUM10392 (TK9-44), x2.

Fig. 31 - *Cleiothyridina* sp. ind. Dorsal view of an articulated specimen. MPUM10392 (TK9-44), x2.

Fig. 32 - *Cleiothyridina* sp. ind. Ventral view of an articulated specimen. MPUM10393 (TK72-66), x2.

Fig. 33 - *Cleiothyridina* sp. ind. Dorsal view of an articulated specimen. MPUM10393 (TK72-66), x2.

Fig. 34 - *Cleiothyridina* sp. ind. Ventral view of an articulated specimen. MPUM10394 (TK72-120), x2.

Fig. 35 - *Cleiothyridina* sp. ind. Dorsal view of an articulated specimen. MPUM10394 (TK72-120), x2.

Fig. 36 - *Hustedia* aff. *H. ratburiensis* Waterhouse & Piyasin, 1970. Ventral view of an articulated specimen. MPUM10396 (TUSEZ3-1), x2.

Fig. 37 - *Hustedia* aff. *H. ratburiensis* Waterhouse & Piyasin, 1970. Dorsal view of an articulated specimen. MPUM10396 (TUSEZ3-1), x2.

Fig. 38 - *Hustedia* aff. *H. stataria* Cooper & Grant, 1976b. Ventral view of an articulated specimen. MPUM10398 (TU7D-1), x2.

Fig. 39 - *Hustedia* aff. *H. stataria* Cooper & Grant, 1976b. Dorsal view of an articulated specimen. MPUM10398 (TU7D-1), x2.

Fig. 40 - *Hustedia* sp. ind. Ventral valve. MPUM10400 (TK70-26), x2.

Fig. 41 - *Orbicoelia* sp. ind. Ventral valve. MPUM10404 (TK72-140), x1.

Fig. 42 - *Martinia* sp. ind. Ventral view of an articulated specimen. MPUM10405 (TK72-95), x2.

Fig. 43 - *Martinia* sp. ind. Dorsal view of an articulated specimen. MPUM10405 (TK72-95), x2.

Fig. 44 - *Martinia* sp. ind. Ventral view of an articulated specimen. MPUM10406 (TK139bis-5), x2.

Fig. 45 - *Martinia* sp. ind. Dorsal view of an articulated specimen. MPUM10406 (TK139bis-5), x2.

Fig. 46 - *Squamularia dieneri* Gemmellaro, 1899. Ventral view of an articulated specimen. MPUM10407 (TK8-38), x2.

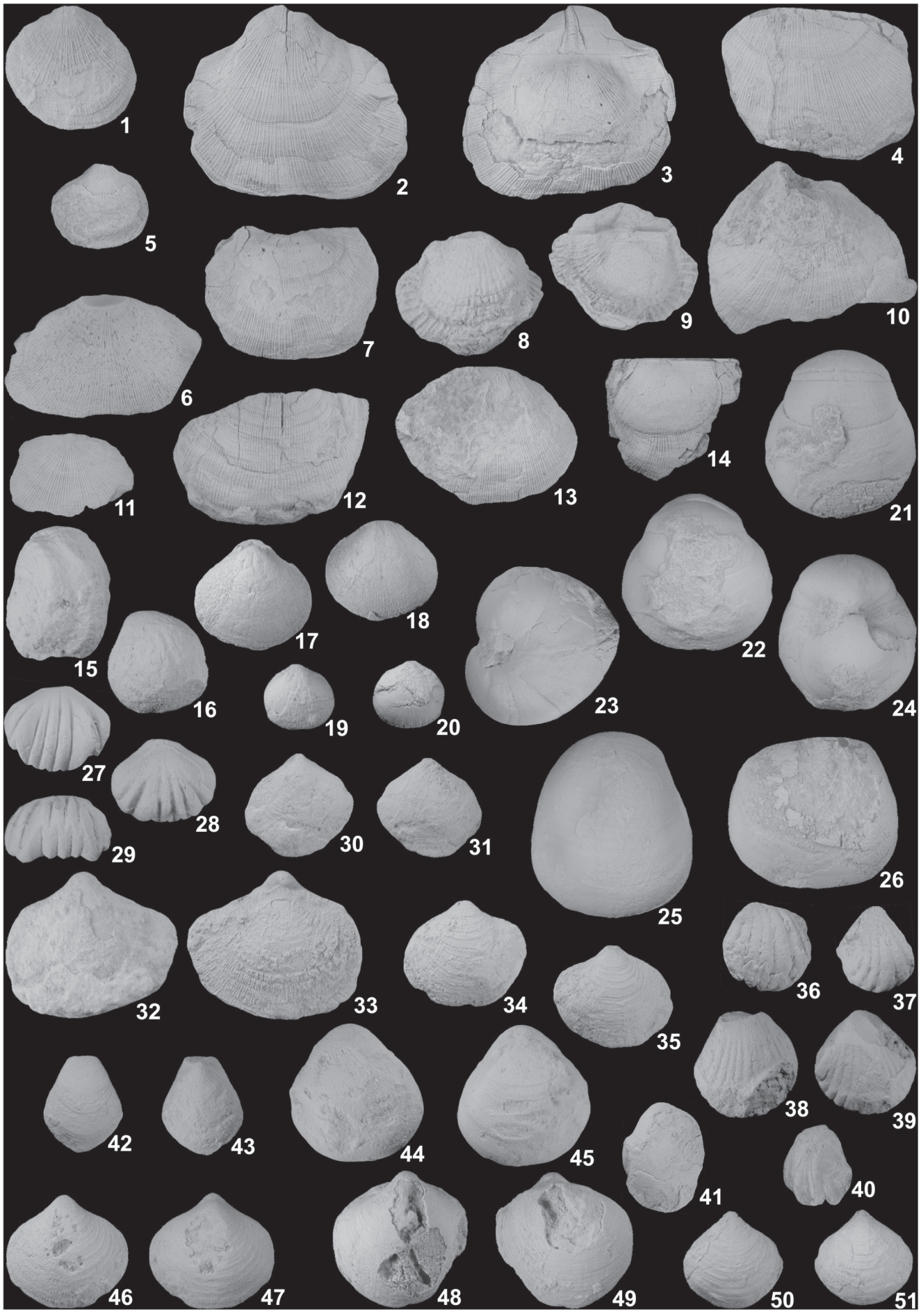
Fig. 47 - *Squamularia dieneri* Gemmellaro, 1899. Dorsal view of an articulated specimen. MPUM10407 (TK8-38), x2.

Fig. 48 - *Squamularia dieneri* Gemmellaro, 1899. Ventral view of an articulated specimen. MPUM10408 (TK139 BIS-57), x2.

Fig. 49 - *Squamularia dieneri* Gemmellaro, 1899. Dorsal view of an articulated specimen. MPUM10408 (TK139 BIS-57), x2.

Fig. 50 - *Squamularia dieneri* Gemmellaro, 1899. Ventral view of an articulated specimen. MPUM10409 (TU17D-10), x2.

Fig. 51 - *Squamularia dieneri* Gemmellaro, 1899. Dorsal view of an articulated specimen. MPUM10409 (TU17D-10), x2.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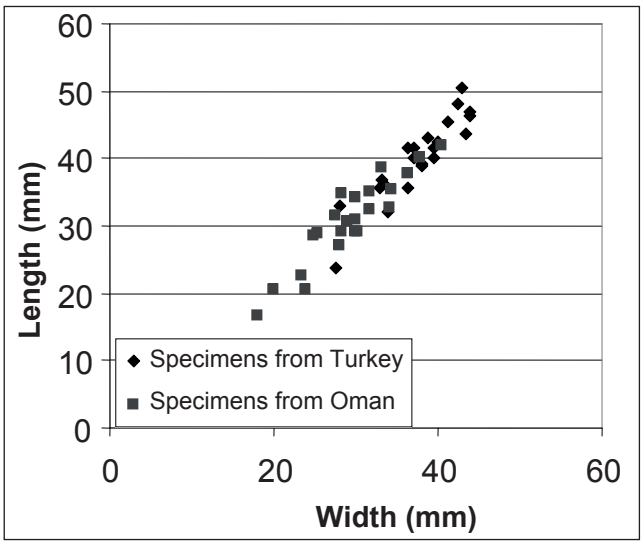


Fig. 9 - Width vs. length diagram of the specimens of *Linoproductus antonioi* n. sp. from Turkey and those described as *Linoproductus* sp. aff. *L. kaseti* Grant, 1976 by Angiolini in Angiolini & Bucher (1999) from Oman. It supports inclusion of all the specimens in the same species.

14) indicate that they belong to the same species (Fig. 9), even though the Turkish specimens have slightly larger dimensions and less neatly arranged spine bases.

Linoproductus antonioi n. sp. differs from *Linoproductus kaseti* Grant, 1976 by its finer and more numerous costellae and greater average dimensions. *Linoproductus antonioi* n. sp. differs from *Productus lineatus* Waagen (1884, pl. 66, figs 1-2) because of a different degree of deflection of the costellae around the spine bases. The specimens described as *L.* cf. *lineatus* by Angiolini et al. (2005) from the Guadalupian of Chios are larger and have a shallow median sulcus and fewer costellae. *Linoproductus antonioi* n. sp. differs from the specimens described as *Productus cora* d'Orbigny, 1842 by Waagen (1884, pl. 66, fig. 3 and pl. 67, figs 1-2) because of the more numerous costellae and a greater degree of deflection of the costellae around the spine bases; from *L. semisulcatus* Cooper & Grant (1975, p. 1148, pl. 431, figs 7-12) because of its very shallow median sulcus.

According to Grant (1976) there is an important change in size and ornamentation of *Linoproductus* species through the Guadalupian-Lopingian with Guadalupian species being smaller and having coarser spine bases than the Lopingian ones. Therefore, *Linoproductus antonioi* n. sp. could represent a step in the evolution towards an increase in dimensions and in the fineness of the ornamentation with respect to *L. kaseti*.

Stratigraphic and geographic occurrence. *Linoproductus antonioi* n. sp. occurs in the Guadalupian Khuff Formation of southeastern Oman (Angiolini & Bucher 1999).

Order **Orthotetida** Waagen, 1884

Suborder **Orthotetidina** Waagen, 1884

Superfamily Orthotetoidea Waagen, 1884

Family Meekellidae Stehli, 1954

Subfamily Meekellinae Stehli, 1954

Genus *Perigeyerella* Wang, 1955

Type species: *Perigeyerella costellata* Wang, 1955, from the Lopingian of South China

Remarks. *Perigeyerella* is based on the combination of a non-plicate shell with dental plates meeting at the apex, but then extending separately and parallel along the floor (Grant 1976, p. 63). *Perigeyerella* can be described as having dental plates beginning in the umbonal region with an elevated spondylium, like *Ombonia* Caneva, 1906 and *Geyerella* Schellwien, 1900, but passing anteriorly to a sessile spondylium, like *Sicelia* Gortani & Merla, 1934, and terminating with parallel plates along the floor of the valve, like *Meekella* White & John, 1867 and *Orthothetina* Schellwien, 1900. *Sicelia* also differs because of its conical ventral valve which resembles that of *Geyerella*.

Meekella can be distinguished from *Perigeyerella* by its distict plicate shell and two divergent dental plates which never meet to form a spondylium. *Ombonia* is different in showing a broadly uniplicate shell.

According to Shen & Shi (2007, p. 25), some species of *Orthothetina*, such as *O. triangularis* Tong, 1978 and *O. elongata* Nakamura, 1972, show transitional features to *Perigeyerella*. They seem to have the dental plates joined in the apex to form a pseudospondylium which however is not elevated on a median septum as in typical *Perigeyerella*.

Perigeyerella miriae n. sp.

Pl. 3, figs 1-7; Pl. 6, figs 5-6

Holotype: TK72-217, an articulate specimen from the Pamuçak Fm., Kemer Gorge locality, bed TK72.

Derivation of name: in honour of Miria Carmela Verna.

Material: Four figured articulated specimens: MPUM10368 (TK72-179), MPUM10364 (TK72-217), MPUM10365 (TK-139BIS-67), MPUM10366 (TUV8D-1); 2 articulated specimens: MPUM10369 (TK72-111, TK72-134); 3 figured ventral valves: MPUM10363 (TK70-17), MPUM10367 (TU7.3aB), MPUM10458 (TU7/3aA); 3 ventral valves: MPUM10370 (TK72-59, TK72-81, TU63D-2); 1 dorsal valve: MPUM10371 (TU7/3-100); 6 fragments: MPUM10372 (TK72-113, TK72-123, TK72-175, TK138-205(A-B), TK139bis-68).

Occurrence: Turkey, Pamuçak Fm., Kemer Gorge locality (TK70, TK72, TK139bis); Çürük Dağ section 3 (TUV8D); Çürük Dağ section 5 (TU7, TU63D); top of Çürük Dağ section (TK138).

Diagnosis: Species of *Perigeyerella* characterized by a flat to weakly concave ventral valve, wide and high orthocline interarea and ornamented by two different orders of costellae.

Description. Medium sized, convex-plane to convex-concave shell, with drop-like to subpentagonal outline; maximum width: 18-43 mm, length: 16-38 mm; hinge wide; anterior commissure rectimarginate or slightly unisulcate. Ventral valve flat or weakly concave, with a very wide and rather high, orthocline interarea, transversally and longitudinally striated; triangular and narrow pseudodeltidium bearing a monticulus with a median shallow and narrow concavity; umbo elongated and pointed, slightly erect. Ornamentation of numerous, fine and flabellate costellae of two orders: 1) first order costellae numbering 4-8 per 5 mm at the anterior margin; 2) second order costellae numbering 1-2 between two costellae of the first order at the anterior margin; concentric delicate rugae. Dorsal valve with suboval or subrectangular outline, strongly convex, with the maximum convexity in the umbonal region. Shallow dorsal sulcus often present, widening anteriorly. Ornamentation of concentric and thin rugae and costellae similar to the ventral valve.

Interior of ventral valve with two thin dental plates converging into a spondylium in the apex whose ontogenetic development is typical for the genus.

Dimensions (in mm)

Specimen	Width	Length	W/L	Thickness	N. costellae of first order per 5 mm on the anterior margin	N. costellae of second order between two costellae of first order
TK70-17	24.0	24.0	1	/	6	1
TK72-81	/	25.4	/	/	4	1-2
TK72-111	/	31.0	/	/	6	1
TK72-123	/	/	/	/	5	1-2
TK72-175	/	/	/	/	4	1-2
TK72-179	34.0	/	/	13.3	11	
TK72-217	41.5	38.0	1.1	14.0	4	1
TK138-205B	/	/	/	/	5	1
TK139bis-67	35.0	28.0	1.2	12.9	10	
TU7/3Aa	/	/	/	/	8	1
TU7/3Ab	~43.0	>33.0	/	/	7	1
TU7/3-100	35.0	24.0	1.4	/	6	1
TUV8D-1	18.0	16.0	1.1	8.5	7	1

Discussion. *Perigeyerella miriae* n. sp. is characterized by its very wide and considerably high interarea, with nearly orthocline inclination and by the number and pattern of the costellae which are of two orders and not numerous.

Perigeyerella miriae n. sp. differs from *Perigeyerella tricosa* Grant, 1976 (p. 63, pl. 11, figs 1-30) by the lower number of costellae at the anterior margin, the greater dimensions and the higher interarea; from *Perigeyerella costellata* Wang, 1955, described by Shen & Shi (2007, p. 25, pl. 8, figs 1-16), because of its much smaller size, flat to concave ventral valve, wide and orthocline interarea, and the lower number of costellae; from *P. raffaellae* by its outline, the pattern and the lower number of costellae, the finer rugae.

Perigeyerella aff. **P. raffaellae** Angiolini in Angiolini & Bucher, 1999

Pl. 3, figs 8-14

Material: Three figured articulated specimens: MPUM10373 (TK72-163), MPUM10378 (TK72-176), MPUM10374 (TU17D-1); 2 figured ventral valves: MPUM10375 (TU11D-1), MPUM10376 (TUV11-21); 6 ventral valves: MPUM10379 (TK9-45, TK115-200A, TK115-202C, TU1-2, TU62D-5, TUV7D-4); 1 figured dorsal valve: MPUM10377 (TU63D-4); 7 dorsal valves: MPUM10380 (TK2-30D, TK72-37, TK115-202A, TUV4-3, TUV7D-3, TUV9-32, TUV9-47); 2 external casts of dorsal valves: MPUM10381 (TK2-30C, TU63BD-1); 7 fragments: MPUM10382 (TK115-200B, TK115-202B, TK139bis-46, TU9D-1, TU9D-2, TUV9-23, TUV9-45).

Occurrence: Turkey, Pamuçak Fm., Çürük Dağ Kemer Gorge locality (TK72, TK139bis); section 1 (TU1, TU17D); Çürük Dağ section 2 (TU9D, TU11D); Çürük Dağ section (TUV4, TUV7D, TUV9, TUV11); Çürük Dağ section 5 (TU62D, TU63BD, TU63D); Çürük Dağ section about 70 m above section 5 (TK115); coal mine section (base of the section (TK2); coal mine section (TK9).

Description. Small to medium sized, convex-plane or dorso-biconvex shell, with a drop-like to subtriangular outline; maximum width at shell midlength: 7.2-37.5 mm, length: 5.4-31 mm; anterior commissure unisulcate or rectimarginate. Ventral valve flat or weakly convex with pointed and slightly erect beak; apsacline interarea relatively high, triangular and flat with a shallow pseudodeltidium and a monticulus. Ornamentation of flabellate and fine costellae, numbering 8-23 per 5 mm at the anterior margin, increasing by intercalation. Strong concentric rugae can be present. Dorsal valve with subcircular outline, more convex than the ventral one with occasionally a weak dorsal sulcus. Ornamentation as per the ventral valve.

Interior of ventral valve with dental plates forming a Y-shape spondylum posteriorly, then merging directly on the valve floor, and finally separating and

extending parallelly along the valve floor. Interior of the dorsal valve with slender socket plates diverging anteriorly.

Dimensions (in mm)

Specimen	Width	Length	W/L	Thickness	N. costellae per 5mm at the anterior margin
TU1-2	7.2	~5.4	~1.3		23
TU11D-1	24.0	>16.2	/		12
TU17D-1	37.0	/	/	19.0	11
TU62D-5	/	/	/		14
TU63BD-1	>17.5	16.0	/		20
TU63D-4	35.0	28.8	1.2		12
TUV4-3	19.5	14.0	1.4		17
TUV11-21	37.5	/	/		9
TK2-30C	/	18.0	/		17
TK72-37	/	/	/		13
TK72-163	13.8	11.7	1.17	5.8	8
TK72-176	~34.0	~31.0	~1.1	12.6	9
TK115-200A	/	/	/		12
TK115-202A	18.0	12.0	1.5		12

Discussion. The specimens from Turkey are very similar to the specimens named *Perigeyerella raffaellae* Angiolini in Angiolini & Bucher (1999, p. 676, figs 12.1-6). However, they differ by the flat ventral and by the anterior commissure which can be not only rectimarginate, but also unisulcate. Therefore, we consider our specimens as belonging to *Perigeyerella* aff. *P. raffaellae* Angiolini in Angiolini & Bucher, 1999.

The Turkish specimens are similar to *Perigeyerella altilosina* Xu & Grant (1994, p. 26, figs 14.10-14), considered a synonym of *Perigeyerella fastigata* Liao & Meng, 1986 by Shen & Shi (2007, p. 26). They are similar in the size, the number of costellae, the weak depression on the ventral valve, and the nature of the ventral umbo. They differ however by the presence of a sulcus in the dorsal valve and the absence of the shell asymmetry typical of the Chinese species.

Class **Rhynchonellata** Williams et al., 1996

Order **Orthida** Schuchert & Cooper, 1932

Suborder **Dalmanellidina** Moore, 1952

Superfamily Enteletoidea Waagen, 1884

Family Enteletidae Waagen, 1884

Genus *Enteletes* Fischer de Waldheim, 1825

Type species: *Enteletes glabra* Fischer de Waldheim, 1830, from the Namurian of Russia

Remarks. The genus *Enteletes* differs from the genera *Peltichia* Jin & Liao in Jin & Sun, 1981, *Enteletina* Schuchert & Cooper, 1931 and *Mapintichia* Li in Li, Yang & Feng, 1986 because of its uniplicate anterior commissure. It also differs from the genus *Entelella* Licharev, 1926, because the latter has a spondylium simplex inside the ventral valve. *Parenteletes* King, 1931 is similar, but bears an unisulcate anterior commissure and a Λ-shaped chamber under the anterior extension of the ventral median septum.

Enteletes sp. ind.

Pl. 3, figs 15-16

Material: One figured articulated specimen: MPUM10384 (TU62D-2); 1 figured fragment: MPUM10383 (TK8-48).

Occurrence: Turkey, Pamuçak Fm., Çürük Dağ section 5 (TU62D); coal mine section (TK8).

Description and discussion. These specimens can be ascribed to the genus *Enteletes*, because of their sharp plicae, numerous and fine costellae and their zig-zagged uniplicate anterior commissure. However, their state of preservation and the incompleteness of diagnostic characters do not allow a specific determination.

Family Schizophoriidae Schuchert & LeVene, 1929

Genus *Kotlaia* Grant, 1993

Type species: *Kotlaia capillosa* Grant, 1993, from the Lopingian of Salt Range, Pakistan

Remarks. *Kotlaia* has been widely discussed by Grant (1993, p. 4) and by Angiolini et al. (2005, p. 178). The latter wrote that among the Schizophoriidae, the Guadalupian genus *Kotlaia* is very close both to *Orthotichia* Hall & Clarke, 1892 and to *Acosarina* Cooper & Grant, 1969. More specifically, the Cisuralian genus *Acosarina* shows intermediate features between *Orthotichia* and *Kotlaia*. In fact, the oldest species of *Acosarina* shows a rectimarginate anterior commissure that becomes sulcate in the younger species of middle Cisuralian age. Its ornamentation consists of tubular costellae on the ventral valve; its dental plates are divergent and arcuate (as in *Kotlaia*), and the ventral median septum is low and usually extends to midvalve; interiorly, the dorsal valve bears long and parallel brachiophore plates surrounding a trilobate muscle field (as in *Orthotichia*). Angiolini et al. (2005) thus suggested an evolutionary trend from the Carboniferous *Orthotichia*, through the intermediate Cisuralian genus *Acosarina*, to the Guadalupian *Kotlaia*.

Kotlaia sp. ind.

Pl. 3, figs 17-20

Material: Two figured articulated specimens: MPUM10385 (TK72-48), MPUM10386 (TU5D-1); 2 articulated specimens: MPUM10387 (TK8-49, TUV2D-15); 1 ventral valve: MPUM10388 (TK72-31).

Occurrence: Turkey, Pamuçak Fm, Çürük Dağ section 1 (TU5D); Kemer Gorge locality (TK72); Çürük Dağ section 3 (TUV2D); Çürük Dağ section 5 (TK8).

Description. Small sized, biconvex shell with suboval transverse outline; maximum width around shell midlength: 6.6-12.6 mm, length: 6.1-11.3 mm; anterior commissure fairly unisulcate, but rectimarginate in the juveniles. Ventral valve with pointed, wide and slightly incurved umbo; interarea rather high, concave, almost catacline and subtriangular; ventral fold low, visible only along the anterior commissure. Ornamentation of numerous, tubular and fine costellae, numbering 8-11 per 2 mm at the anterior commissure, separated by narrow interspaces; few and relatively strong growth lamellae. Dorsal valve more convex than ventral valve, with a slightly more swollen and more incurved umbo and a lower interarea; dorsal sulcus very shallow, corresponding to the fold on the ventral valve. Ornamentation as per the ventral valve.

Interior of ventral valve with a long median septum, extending beyond midlength of the valve. Interior of dorsal valve with a low and short myophragm.

Dimensions (in mm)

Specimen	Width	Length	W/L	Thickness
TK8-49	9.2	7.9	1.1	6.4
TK72-31	12.6	~11.3	>1.0	/
TK72-48	10.4	10.1	1.0	7.7
TU5D-1	6.6	6.1	1.1	4.0
TU17D-14	9.6	8.8	1.1	/
TUV2D-15	10.7	10.2	1.0	6.6

Discussion. The Turkish specimens are similar to *Kotlaia aethopa* Grant, 1993, from Chios Island, Greece (Guadalupian), but differ in in having a less incurved ventral umbo, fewer costellae opening as small tubes, and the occurrence of a dorsal myophragm. The Turkish specimens differ from *K. capillosa* Grant, 1993 (p. 5, figs 4.1-4.6), from the Lopingian Chhidru Formation, Khishor Range, Pakistan, by their subovate outline, and a concave ventral interarea.

Angiolini et al. (2005, p.180) reassigned *Orthotichia waterhousei* Grant, 1976 from the Roadian-Wordian Rat Buri Limestone (South Thailand) to the genus *Kotlaia*, because of their dental plates, brachiophore plates and median septum that are typical features of this genus. The specimens from Turkey differs from *K. waterhousei* (Grant, 1976, p. 35, pl. 2, figs 16-30) by their smaller dimensions, more transverse outline, and their median septum extending beyond midvalve.

The determination is left open because of the poor state of preservation and the low number of specimens. One additional specimen from Turkey (TU17D-14 from section 1) could belong to another unidentifiable species of *Kotlaia*, based on the lower number of costellae.

Order **Rhynchonellida** Kuhn, 1949

Superfamily Stenoscismatoidea Oehlert, 1887 (1883)

Family Psilocamaridae Grant, 1965

Subfamily Cyrolexinae Williams et al., 2002

Curuckamara n. gen.

Type species: *Curuckamara globosa* n. gen. n. sp. from the Guadalupian of Çürük Dağ, Antalya, Turkey

Diagnosis: Medium to large sized and moderately ventribiconvex, globose shell, with spatuliform, elongated outline; anterior commissure rectimarginate; wide and evident umbos, strongly recurved towards each other; flanks steep; palintropes very concave and no sulcus or fold. Microornamentation reticulated, consisting of fine growth lines crossed by radial striae; costae absent; growth lamellae strong. Interior of ventral valve with sessile spondylium; interior of dorsal valve with camarophorium with intercamarophorial plate; base of septum with lateral buttress plates forming a trifurcating structure.

Derivation of name: *Curuckamara* from the union of *Çürük*, the type locality with *camera,* which refers to the internal characters of the dorsal valve.

Assigned species: *Curuckamara globosa* n. gen. n. sp. from the Guadalupian of Çürük Dağ, Antalya, Turkey.

Discussion. Among the Cyrolexinae *Curuckamara* n. gen. is most close to *Ussuricamara* Koczyrkevicz, 1969, from eastern Russia, but it differs from it in having a more globose shell, an intercamarophorial plate, and a trifurcating structure at the base of the dorsal septum.

Curuckamara n. gen. differs from *Psilocamara* Cooper, 1956 because of its larger size, globose shell, spatuliform outline, rectimarginate anterior commissure, sessile spondylium and a trifurcating structure at the base of the dorsal septum. *Psilocamara* has a flatter umbonal region and reaches its maximum convexity towards midvalve; furthermore it shows a strong angular uniplication which is absent in *Curuckamara* n. gen.

Although represented by one species and few specimens, the combination of internal and external characters makes *Curuckamara* n. gen. very distinctive and supports the erection of a new genus.

Curuckamara globosa n. gen. n. sp.

Pl. 3, figs 21-26

Holotype: TU18-2 an articulate specimen from Pamuçak Fm., Çürük Dağ section 1, bed TU18.

Material: Two figured articulated specimens: MPUM10390 (TU18-1), MPUM10389 (TU18-2).

Occurrence: Turkey, Pamuçak Fm., Çürük Dağ section 1 (TU18).

Description. Medium to large sized, biconvex and globose shell, showing a spatuliform and elongated outline; maximum width: 27-32 mm; corresponding length: 30.4-37 mm, with maximum width anteriorly; anterior commissure rectimarginate, slightly undulated. Ventral valve very convex with wide and strongly recurved umbo, projecting towards the dorsal one; palintrope narrow, concave. Ventral sulcus absent, but a median flattening occurs anteriorly. Ornamentation of fine growth lines and radial and interrupted striae, imparting a reticulate micrornamentation; strong growth lamellae, irregularly spaced posteriorly. Dorsal valve slightly less convex, with an evident, strongly recurved, and wide umbo. Ornamentation as the ventral one.

Interior of ventral valve having an U-shaped sessile spondylium. Interior of dorsal valve with camarophorium with intercamarophorial plate; base of septum with two lateral buttress plates forming a trifurcating structure.

Dimensions (in mm)

Specimen	Width	Length	W/L	Thickness
TU18-1	32.0	>37.0	<1.0	32.2
TU18-2	27.8	30.4	0.9	30.5

Discussion. The specimens under study are externally close to the ones considered by Shen et al. (2000, p. 747, figs 13.19-21) as belonging to the genus *Psilocamara*, from the Wuchiapingian-early Changhsingian of Tibet; however, in terms of the internal features, the Tibetan specimens differ having the spondylium supported by a low median septum, an uniplicate anterior commissure and a dorsal valve without an intercamarophorial plate.

Superfamily Wellerelloidea Licharew, 1956

Family Pontisiidae Cooper & Grant, 1976a

Subfamily Pontisiinae Cooper & Grant, 1976a

Genus *Pontisia* Cooper & Grant, 1969

Type species: *Pontisia stehlii* Cooper & Grant, 1976a, from the upper Cisuralian of the Glass Mountains, Texas, USA

Remarks. Records of this genus are rare in Asia and chiefly consist of the findings of Grant (1976, p. 173) in the Guadalupian of South Thailand, and Shen et al. (2003, p. 1132) from the Late Guadalupian of Tibet.

According to Grant (1976, p. 173), *Pontisia* resembles *Wellerella* Dunbar & Condra, 1932 and *Tautosia* Cooper & Grant, 1969, from which it differs by its lack of a median septum in the dorsal valve.

Pontisia sp. ind.

Pl. 3, figs 27-29

Material: One figured articulated specimen: MPUM10391 (TK139-1).

Occurrence: Turkey, Pamuçak Fm., Kemer Gorge locality.

Description. Small sized shell with fan-shaped outline; maximum width: 10 mm, corresponding length: 9 mm, thickness: 6.35 mm; widest around shell midlength. Anterior commissure paraplicate. Ventral valve slightly convex with pointed and small umbo; ventral palintrope visible only at the sides of the umbo, where, with the dorsal palintrope, forms two elongated and oval depressions. Ventral sulcus starting at umbo, widening anteriorly and becoming deepest in the median region, forming a moderately geniculated tongue. Ornamentation of costae, 0.8-2 mm wide anteriorly, starting at a short distance from the umbo; three costae in sulcus starting at 2.5 mm from the umbo, widening anteriorly, sharp in the median region, but rounded both anteriorly and posteriorly; three pairs of lateral costae present on flanks, well separated from the ones in sulcus, wider and stronger anteriorly, and starting more anteriorly than those in sulcus, at 4 mm from the umbo; a fourth costa may be present on the right flank. Fine growth lines developed on the surface, parallel to the zig-zagged anterior commissure and crossed by interrupted, short radial elements, especially posteriorly, giving the surface a reticulated aspect. Dorsal valve fairly convex up to two thirds of the length, then sharply geniculated; dorsal fold wide anteriorly. Ornamentation consisting of four costae on the fold, which are sharp, widen anteriorly, and start from the midvalve; three pairs of lateral costae developed on each side of the fold, the distal one is just perceptible; they start from midvalve and become wider anteriorly. The width of the median and lateral costae at the anterior commissure is 0.8-2.1 mm.

Interior of ventral valve with dental plates almost subparallel and closely set.

Discussion. The Turkish specimen is rather distinctive from the species described by Cooper & Grant (1976a) from the Permian of West Texas. It is similar to *P. wolfcampensis* Cooper & Grant, 1976a, but differs in having no truncated anterior margin, a greater number

of costae in the sulcus and ventral costae starting more posteriorly. It resembles *P. kingi* Cooper & Grant, 1976a, but it differs by the more numerous costae in the sulcus and the smaller size. It is also similar to *P. nana* (Stehli, 1954) from which it differs by the greater number of costae in the sulcus, the larger size, the ventral costae starting posteriorly and the absence of a low median costa on the fold.

The diagnostic characters of this species, such as the usually sharp costae, the ventral costae starting posteriorly, the deep sulcus, and the transversally fan-shaped outline, do not allow to us to allocate it to any known species of *Pontisia*.

Order **Athyridida** Boucot, Johnson & Staton, 1964

Suborder **Athyrididina** Boucot, Johnson & Staton, 1964

Superfamily Athyridoidea Davidson, 1881

Family Athyrididae Davidson, 1881

Subfamily Cleiothyridininae Alvarez, Rong & Boucot, 1998

Genus *Cleiothyridina* Buckman, 1906

Type species: *Atrypa pectinifera* de Sowerby, 1840 in 1840-1846, from the Guadalupian of Durham, United Kingdom

Cleiothyridina sp. ind.

Pl. 3, figs 30-35

Material: Three figured articulated specimens: MPUM10392 (TK9-44), MPUM10393 (TK72-66), MPUM10394 (TK72-120); 1 articulated specimen: MPUM10395 (TK72-23).

Occurrence: Turkey, Pamuçak Fm., coal mine section (TK9); Kemer Gorge locality (TK72).

Description. Small to medium sized, weakly to moderately equally biconvex shell, with maximum convexity posteriorly; suboval to subtriangular outline; maximum width near shell midlength: 10.3-16 mm; corresponding length: 9.5-13.7 mm; anterior commissure slightly uniplicate. Ventral valve, with a small and pointed umbo, slightly larger than the dorsal one; ventral sulcus shallow anteriorly. Ornamentation of imbricate growth lamellae bearing irregularly arranged solid, flat spines. Dorsal valve with a weak fold anteriorly. Ornamentation of irregularly wide growth lamellae showing solid spines.

Interior of ventral valve with dental plates.

Dimensions (in mm)

Specimen	Width	Length	W/L	Thickness
TK9-44	10.3	9.5	1.1	4.3
TK72-66	16.0	13.7	1.2	6.4
TK72-120	11.3	9.9	1.1	6.0

Discussion. The relative paucity and the poor state of preservation of the specimens under study do not allow specific determination.

Suborder **Retziidina** Boucot, Johnson & Staton, 1964

Superfamily Retzioidea Waagen, 1883

Family Neoretziidae Dagys, 1972

Subfamily Hustediinae Grunt, 1986

Genus *Hustedia* Hall & Clarke, 1893

Type species: *Terebratula mormoni* Marcou, 1858, from the Pennsylvanian of Nebraska, USA

Remarks. According to Cooper & Grant (1976b, p. 2762) one general trend in the evolution of *Hustedia* is an increase in size throughout the Permian, varying from less than 10 mm in length to nearly 20 mm. Another feature that shows a progressive development is the median septum of the dorsal valve. Its relative height is generally greater in Guadalupian than in Cisuralian species.

Hustedia aff. **Hustedia ratburiensis** Waterhouse & Piyasin, 1970

Pl. 3, figs 36-37

Material: One figured articulated specimen: MPUM10396 (TUSEZ3-1); 1 articulated specimen: MPUM10397 (TUSEZ3-2).

Occurrence: Turkey, Pamuçak Fm., Çürük Dağ section 3 (TUSEZ3).

Description. Small sized, biconvex shell with subtriangular outline; maximum width anterior to shell midlength: 8.4 mm; corresponding length: 8.9 mm; thickness: 7.2 mm; short cardinal margin; anterior commissure zig-zagged. Ornamentation of ventral valve of relatively high costae, with narrow interspaces, starting from the umbonal region and reaching the anterior commissure where they become weakly wider; the two median plicae are more evident. Fine growth lamellae are visible. Dorsal valve with a long and pointed umbo, fairly incurved. Ornamentation similar to that of the ventral valve; the three median plicae are slightly wider than the lateral ones and correspond to the two wider costae on the ventral valve. Thin growth lamellae are present.

Discussion. The generic assignment of the Turkish specimens to the genus *Hustedia* is based on the evident radial ornamentation, the relatively strong convexity of both valves, the small size and the nature of the cardinal margin.

They are similar to *Hustedia ratburiensis* Waterhouse & Piyasin, 1970, for the arrangement and the rather high number of plicae on both valves, as well as for the strength of the plicae and the narrow

interspaces. Nevertheless, due to the small number of specimens, their incompleteness, and deformation the nomenclature determination is left open.

The present specimens differ from *Hustedia funaria* Grant, 1976, because they are less elongated, and have a shorter beak and no sulcus.

Geographic and stratigraphic occurrence. *Hustedia ratburiensis* comes from the Guadalupian Rat Buri Limestone of South Thailand (Waterhouse & Piyasin 1970; Grant 1976).

Hustedia aff. **Hustedia stataria** Cooper & Grant, 1976b

Pl. 3, figs 38-39

Material: One figured articulated specimen: MPUM10398 (TU7D-1); 1 articulated specimen: MPUM10399 (TU62Dbis-2).

Occurrence: Turkey, Pamuçak Fm., Çürük Dağ section 5 (TU7Det, TU62Dbis).

Description. Small sized, biconvex shell, with suboval to subpentagonal outline; maximum width at shell midlength: 10 mm, corresponding length: >10 mm, thickness: 8.5 mm; short cardinal margin; anterior commissure zig-zagged. Ventral valve with a very weak median fold. Ornamentation of 12-16 low, rounded and thin plicae, with narrow interspaces, starting from the umbonal region and ending at the anterior commissure; fine concentric growth lamellae and pitting. Dorsal valve slightly more convex, with a wide beak, fairly curved; very weak sulcus, corresponding to the fold of the ventral valve. Ornamentation of about 15 low, thin plicae, separated by narrow interspaces; fine growth lamellae visible only anteriorly and pitted surface.

Discussion. The Turkish specimens resemble *Hustedia stataria* Cooper & Grant, 1976b with the presence of numerous, thin and low plicae, the small dimensions, the almost suboval outline, the degree of the convexity, and the W/L ratio. In comparison to the West Texas material, they have a very weakly perceptible fold on the ventral valve, and not on the dorsal valve. The incompleteness and alteration of the Turkish specimens do not allow observation of the cardinal margin and the exact number of plicae, hence the caution in the specific determination.

The present specimens are similar to *Hustedia hapala* Cooper & Grant (1976b, p. 2781, pl. 736, figs 46-60), but the latter species differs by having fewer plicae and the weakly serrated anterior commissure.

Geographic and stratigraphic occurrence. Specimens of *Hustedia stataria* have been found in the lower part of the Guadalupian Cathedral Mountain Formation, West Texas (Cooper & Grant 1976b).

Hustedia spp. ind.

Pl. 3, fig. 40

Material: One articulated specimen: MPUM10401 (TU62-1); 1 figured ventral valve: MPUM10400 (TK70-26); 1 ventral valve: MPUM10402 (TK70-13b); 1 external cast of ventral valve: MPUM10403 (TK70-13a).

Occurrence: Turkey, Pamuçak Fm., Kemer Gorge locality (TK70); Çürük Dağ section 5 (TU62).

Description. Small sized, comparable to that of the above studied specimens, but not precisely measurable. Biconvex shell, with subtriangular to suboval outline; short cardinal margin; anterior commissure zig-zagged, almost rectimarginate. Ventral valve with pointed, small and weakly incurved umbo. Ornamentation of 5-6 wide plicae, relatively high, sometimes angular, arranged along the total length of valve, and separated by moderately wide interspaces; fine concentric ornamentation seems to be present.

Interior of ventral valve with elongated teeth. Interior of dorsal valve with a long median septum, extending beyond midvalve, very high in the umbonal region, but decreasing progressively in height anteriorly, dividing the cavity into two parts; robust cardinal process; fragments of spiralia.

Discussion. We considered that these specimens belong to the genus *Hustedia* because of the ornamentation and the presence of a long median septum in the dorsal valve; this septum is high in the umbonal region, but decreases anteriorly as described by Alvarez & Rong (2002, p. 1591). However, the state of preservation of the material is poor and the specific determination is left open.

Order **Spiriferida** Waagen, 1883

Superfamily Ambocoelioidea George, 1931

Family Ambocoeliidae George, 1931

Subfamily Ambocoeliinae George, 1931

Genus *Orbicoelia* Waterhouse & Piyasin, 1970

Type species: *Orbicoelia fraterculus* Waterhouse & Piyasin, 1970, from the Guadalupian of South Thailand

Remarks. *Orbicoelia* resembles *Cruricella* Grant, 1976, but it differs in having a larger size, a smaller umbo, a comparatively lower ventral interarea, and a different ornamentation consisting of spinules. Waterhouse & Piyasin (1970) described the microornamentation of *Orbicoelia* as consisting of dense uniramous spinules over 1 mm long, where well preserved, 12-15 unities per millimetre, more or less concentrically arranged in close-set rows on both valves. According to Grant (1976, p. 193), the wide outline of *Orbicoelia* suggests a spire with several volutions in contrast

to the one or two in *Cruricella*, although the spires of *Orbicoelia* have not been observed in the specimens of Grant (1976) or by Waterhouse & Piyasin (1970).

Orbicoelia is also similar to *Crurithyris* George, 1931, from which it differs by the absence of a median sulcus in both valves and by its higher ventral interarea. In addition, according to Chen et al. (2006, p. 316), *Orbicoelia* differs from *Crurithyris* in the possession of a relatively more strongly inflated dorsal valve and more rounded cardinal extremities. Also, *Crurithyris* includes species with concentrically arranged and very distinct spines (George 1931; Veevers 1959; Waterhouse & Piyasin 1970). According to Grant (1976, p. 190), the shape of the interarea and also differences in the cardinal process are reliable characters to distinguish the two genera.

Orbicoelia sp. ind.

Pl. 3, fig. 41

Material: One figured ventral valve: MPUM10404 (TK72-140).

Occurrence: Turkey, Pamuçak Fm., Kemer Gorge locality (TK72).

Description. Convex ventral valve, with drop-like outline; maximum longitudinal convexity in the posterior part, but lower than the transverse convexity; maximum width: 15 mm, corresponding length: 21.5 mm. Narrow and pointed umbo, curved over a rather high, triangular, narrow and concave interarea; cardinal extremities rounded; anterior commissure rectimarginate; ventral sulcus absent. Microornamentation, even if abraded, appears to consist of very fine growth lamellae and of very tiny, elongated spinules, roughly concentrically arranged on the growth lamellae.

Discussion. The Turkish specimen clearly belongs to the genus *Orbicoelia* based on the absence of a sulcus, the high, narrow interarea and the microornamentation of fine, elongated spinules. However, the state of preservation does not allow a specific determination.

Superfamily Martinioidea Waagen, 1883

Family Martiniidae Waagen, 1883

Subfamily Martiniinae Waagen, 1883

Genus *Martinia* M'Coy, 1844

Type species: *Spirifer glaber* Sowerby, 1820 in 1818-1821, from the Visean of England

Remarks. *Martinia* is similar to *Spinomartinia* Waterhouse, 1968 from the Cisuralian-Lopingian of Thailand and Australia and the Lopingian of New Zealand, but the latter differs in having fine erect spines. *Postmartinia* Wang & Yang, 1993 from the Sakmarian of China (Xinjiang) is also similar, but differs by the low ventral interarea and the lateral slopes bearing 3 to 4 smooth, low, broad plicae.

Martinia sp. ind.

Pl. 3, figs 42-45

Material: Two figured articulated specimens: MPUM10405 (TK72-95), MPUM10406 (TK139bis-5).

Occurrence: Turkey, Pamuçak Fm., Kemer Gorge locality (TK72, TK139).

Description. Small sized, biconvex shell with rounded to subpentagonal profile, longer than wide; maximum width: 7.4-12.5 mm, corresponding length: 10-13.2 mm. Anterior commissure rectimarginate or weakly uniplicate. Ventral valve convex posteriorly with elongated, pointed umbo; ventral interarea subtriangular and flat to concave; ventral sulcus absent or very shallow. Ornamentation of very fine growth lamellae. Dorsal valve with median fold absent or very weak, ornamented by barely visible growth lamellae.

Dimensions (in mm)

Specimen	Width	Length	W/L	Thickness
TK72-95	7.4	~10.0	~0.7	4.5
TK139bis-5	12.5	13.2	0.9	10.0

Discussion. The absence of a distinct sulcus, the shape and the small size, and the rectimarginate anterior commissure of the Turkish specimens are also typical of *Martinia semiplana* Waagen, 1883 (p. 536, pl. 43, fig. 4), from the Wargal Formation, Salt Range, Pakistan. However, the difference in convexity between the ventral valve and the dorsal one, which characterizes Waagen's specimen, is not recorded by the Turkish ones. Therefore, we prefer to leave the nomenclature open.

The specimens under examination are very similar to the one described by Campi et al. (2005) as *Martinia semiplana* Waagen, 1883, because of the small dimensions, the circular to subpentagonal outline and the absence of an evident sulcus; however the specimen studied by Campi et al. (2005) has more alate cardinal extremities than our specimens.

The specimens under study are also similar to the specimens named by Gemmellaro (1899) *Martinia pusilla*, because they also have a small size, almost pentangonal outline and length greater than the width. However, *Martinia pusilla* differs from the Turkish specimens in having an anteriorly uniplicate commissure, instead of an almost rectimarginate one, and it also is much more inflated. Finally, the Turkish speci-

mens resemble *Martinia ceres* Gemmellaro, 1899, because of the pointed umbo and the subpentangonal outline, but they differ in having smaller dimensions and lacking an evident ventral sulcus.

Suborder **Delthyridina** Ivanova, 1972

Superfamily Reticularioidea Waagen, 1883

Family Elythidae Frederick, 1924

Subfamily Phricodothyridinae Caster, 1939

Genus *Squamularia* Gemmellaro, 1899

Type species: *Squamularia rotundata* Gemmellaro, 1899, from the Guadalupian of Sosio, Sicily

Diagnosis (emended): Medium size; almost equally biconvex; outline subovate; ventral umbonal region broad, beak incurved; ventral interarea indistinct; ornament lamellose with widely spaced, undulating, squamose growth lamellae fringed with closely spaced, fine, biramous spines; ventral interior simple, dental adminicula and septa absent; spiralia directed laterally or posterolaterally, forming cones with wide bases and short axes.

Remarks. *Squamularia* Gemmellaro, 1899 is a very debated genus, discussed mainly for the nature of its spines and the direction of coiling of the axes of the spiralia. In the original description of the genus, Gemmellaro (1899) did not describe the spines in details, but most subsequent reports suggest the presence of biramous spines. Grant (1993, p. 17) affirmed that the concentric lamellae bear double-barrelled spine bases; Xu & Grant (1994, p. 58) showed in the species *Squamularia formilla* Xu & Grant, 1994 the presence of two rows of rarely preserved double-barrelled spines at edge of the growth lamellae; Shi et al. (2002, p. 374) described biramous spines, but not elaborate. However, Carter & Gourvennec (2006, p. 1848) reported in the diagnosis of *Squamularia*: "closely spaced, fine, uniramous spines". We had the opportunity to study the type-material of *Squamularia rotundata* Gemmellaro, 1899 which is housed at the Museum G. Gemmellaro of Palermo, Italy. According to our inspection, the spines of *Squamularia rotundata* are made of primary layer and are biramous with a diamond-shaped base, concentrically arranged on the growth lamellae in alternating rows; however, they are difficult to observe as a consequence of the frequent alteration and abrasion of the primary layer. When the primary layer is entirely abraded, the spines appear as just elongated ridges and the fabric below shows the crest of the keels of the secondary layer fibres (Pl. 5).

An important consequence of the observation that the spines of *Squamularia* are biramous is the revaluation of the family position of *Squamularia*, which should be assigned to the Family Elythidae Frederick, 1924, because of the microornament of fine biramous spines, and to the Subfamily Phricodothyridinae Caster, 1939, because of the absence of dental adminicula and ventral median ridge. It should be thus removed from the Family Reticulariidae Waagen, 1883 and the Subfamily Reticulariinae Waagen, 1883 (generally ornamented by uniramous spinules or tubercles), where it was placed in the revised Treatise classification (Carter & Gourvennec 2006, p. 1848).

According to Gemmellaro (1899, p. 325 pl. 33, figs 44-45), Grant (1993, p. 17), Shi et al. (2002, p. 374, fig 4) and Shen et al. (2003, p. 247), the axes of coiling of the spiralia of *Squamularia* are directed laterally, as indicated also by the fact that the maximum width of the shell is placed at midvalve (Cooper & Grant 1976a, p. 2248; Angiolini 2001, p. 340). However, Carter & Gourvennec (2006, p. 1848) described the spiralia as being directed posterolaterally and in fact in some specimens we have observed a slightly postero-laterally tilted direction.

Even if Shen et al. (2003, p. 247) affirmed that the direction of the spiral axes is critical for discriminating *Squamularia* from a similar genus *Permophricodothyris* Pavlova, 1965, we suggest that the discriminating feature characterising *Squamularia* is not merely the direction of the axes of spiralia (which can be laterally or posterolaterally directed), but the conical shape of the spiralia themselves, which show a wide base and even have a diameter longer than the relative axis, a low number of coils (ca. 8) and almost entirely fill the mantle cavity; characteristic are also the short and closely set crura starting from the dorsal cardinal margin, first diverging and then later converging to meet along the median line. *Permophricodothyris* on the contrary has spindle-shaped spiralia, with posteriorly or posterolaterally directed axes, a narrow diameter of the base of the cone with respect to the length of the axis and a high number of coil (> 28); also it has long and straight crura, which start from cardinal loci more distantly apart than in *Squamularia* and weakly convergent towards the median line. Other important differences between these two very similar genera are the dimensions, that are (usually) greater in *Permophricodothyris*, and the nature of the spines; the biramous spines in *Permophricodothyris* are more elaborate (Shi et al. 2002, p. 374), more densely spaced and more elongated. In addition, the spines of *Permophricodothyris* are of two types: biramous and uniramous ones, whereas the spines of *Squamularia* are of one type only, that is biramous.

According to Gemmellaro (1899, p. 325), *Squamularia* is also similar to *Martinia* M'Coy, 1844, but the latter differs by having a pitted surface, lack of spines and crura converging towards the median line and generating small spiral cones.

Squamularia dieneri Gemmellaro, 1899

Pl. 3, figs 46-51

1899 *Squamularia dieneri* Gemmellaro, p. 327, pl. 34, figs 1-4.

Material: Three figured articulated specimens: MPUM10407 (TK8-38), MPUM10408 (TK139 BIS-57), MPUM10409 (TU17D-10).

Occurrence: Turkey, Pamuçak Fm., Çürük Dağ section 1 (TU17D); Kemer Gorge locality (TK139bis); coal mine section (TK8).

Description. Small to medium sized, biconvex shell with subpentangonal outline; slightly dilated on the flanks and showing a narrow front; maximum width: 9.6-12.7 mm, length: 9.4-12.9 mm; anterior commissure uniplicate to rectimarginate, with the valves meeting to form an angle <90°. Ventral valve subpentangonal, moderately or strongly convex, with pointed, weakly recurved umbo, higher than the dorsal one, or nearly equally high; ventral sulcus, when present, evident only anteriorly. Ornamentation of fine, scaly, and imbricate growth lamellae; fine and irregularly arranged pustules; elongated, ≤ 0,1 mm wide spine bases anteriorly. Dorsal valve with subpentagonal outline, smaller than the ventral one, as convex or slightly less convex than the ventral valve; a dorsal fold is evident only anteriorly. Ornamentation as in the ventral valve.

Dimensions (in mm)

Specimen	Width	Length	W/L	Thickness
TK8-38	11.7	10.9	1.1	5.9
TK139bis-57	12.7	12.9	1.0	7.7
TU17D-10	9.6	9.4	1.0	5.3

Discussion. *Squamularia dieneri* is similar to *S. rotundata* (Fig. 10), but differs by its typical subpentagonal outline, with the valves meeting at an acute angle and having more dilated flanks. Also, *S. dieneri* has a longer cardinal margin, moderate convexity and a lower ventral umbo with respect to the dorsal one (Gemmellaro 1899, p. 328).

The present specimens are similar to one described by Angiolini (2001, p. 340, pl. 2, fig. 23), from Karakorum, but the latter is different in having a more triangular and slender profile.

Geographic and stratigraphic occurrence. *S. dieneri* comes from the allochthonous limestones of Rocca di San Benedetto near Palazzo Adriano of Sosio Valley, Sicily, Italy.

Squamularia marcouxi n. sp.

Pl. 4, figs 1-10; Pl. 5, figs 1-5; Pl. 6, figs 1-4, 8, 10-11

Holotype: TK72-12 an articulate specimen, from the Pamuçak Fm., Kemer Gorge locality, bed TK72.

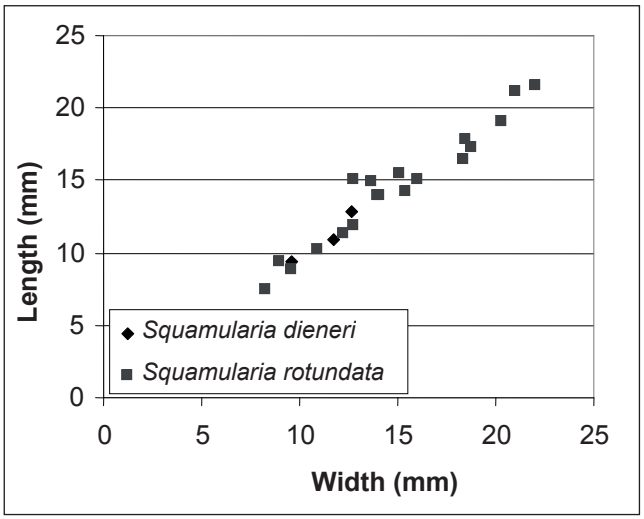


Fig. 10 - Width vs. length diagram of *Squamularia dieneri* Gemmellaro, 1899 and *Squamularia rotundata* Gemmellaro, 1899.

Derivation of name: In honour of the late Jean Marcoux, who unraveled the geology of the Antalya region.

Material: Six figured articulated specimens: MPUM10414 (TK72-183B), MPUM10410 (TK72-12), MPUM10411 (TK72-54), MPUM10415 (TK72-92), MPUM10454 (TK139BIS-63), MPUM10460 (TK-139); 91 articulated specimens: MPUM10417 (TK8-47, TK9-32, TK9-33, TK9-34, TK9-35, TK70-21, TK72-4, TK72-7, TK72-10, TK72-14, TK72-15, TK72-16, TK72-17, TK72-19, TK72-20, TK72-25, TK72-27, TK72-33, TK72-34, TK72-38, TK72-39, TK72-41, TK72-42, TK72-51, TK72-57, TK72-58, TK72-68, TK72-70, TK72-74, TK72-76, TK72-88, TK72-98, TK72-99, TK72-101, TK72-103, TK72-116, TK72-117, TK72-119, TK72-133, TK72-136, TK72-148, TK72-149, TK72-154, TK72-155, TK72-160, TK72-163, TK72-165, TK72-172, TK72-185, TK72-187, TK72-205, TK72-209, TK139-0, TK139-98, TK139bis-13, TK139bis-19, TK-139bis-23, TK139bis-24, TK139bis-25, TK139bis-26, TK139bis-31, TK139bis-32, TK139bis-33, TK139bis-36, TK139bis-41, TK-139bis-44, TK139bis-50, TK139bis-52, TK139bis-53, TK139bis-54, TK139bis-55, TK139bis-56, TK139bis-58, TK139bis-64, TK-139bis-69, TK139bis-72, TK139bis-73, TK139bis-74, TK139bis-75, TK139bis-76, TK139bis-78, TK139bis-82, TK139bis-86, TK-139bis-88, TK139bis-89, TK147-3, TK147-5, 148-3, TU2-2, TU2-4, TU2-5, TU13-2); 1 figured ventral valve: MPUM10412 (TK72-183C); 21 ventral valves: MPUM10418 (TK9-36, TK70-7(A-B), TK70-11, TK70-15E, TK70-16B, TK70-24, TK70-27A, TK72-6, TK72-46, TK72-53, TK72-106, TK72-171, TK139-14, TK139-26A, TK-139bis-16, TK139bis-20, TK139bis-21, TK139bis-39, TK139bis-69, TK139bis-83C, TUV1D-8); 2 figured dorsal valves: MPUM10413 (TK72-183A), MPUM10416 (TK72-174), 11 dorsal valves: MPUM10419 (TK70-4C, TK72-8, TK72-184, TK72-198, TK72-199, TK72-208, TK72-210, TK139-3, TK139-26B, TK139bis-14, TK139bis-83D); 12 fragments: MPUM10420 (TK70-3A, TK70-23B, TK72-29, TK72-36, TK72-93, TK72-135, TK72-142, TK72-167, TK72-186, TK72-188, TK139bis-35, TK139bis-85).

Occurrence: Turkey, Pamuçak Fm., Kemer Gorge locality (TK70, TK72, TK139, TK139bis); Çürük Dağ section 1 (TU2); Çürük Dağ section 2 (TU13); Çürük Dağ section 3 (TUV1D); isolate locality TK147 at Kopuk Dağ , stratigraphically corresponding to Çürük Dağ section 2; coal mine section (TK8, TK9).

Diagnosis: Species of *Squamularia* with a marked difference between the subriangular outline of the ventral valve and that of the dorsal valve, which is transversally subrectangular.

Description. Small to medium sized, biconvex shell with subtriangular to subrectangular outline; maximum width: 9.4-24.8 mm, length: 8.6-21.5 mm (Fig. 11); anterior commissure uniplicate; lateral commissure undulate (S-like) or straight. Ventral valve moderately to strongly convex, with a concave distinct area in some specimens; umbo narrow, pointed, recurved on the dorsal valve; ventral sulcus very shallow, visible only anteriorly, or almost absent. Ornamentation of fine, scaly, imbricate growth lamellae, numbering 7-8 per 5 mm, bearing two alternate rows of biramous spines, with diamond-shaped bases, 30-100 µm wide, longitudinally elongated, whose opposite apexes become thin crests placed between two adjacent spine bases of the next row (Pl. 5, fig. 5). Dorsal valve less convex than the ventral one, with a distinct subrectangular outline, expanded transversally, much more than that of the ventral valve; median fold absent or only barely observable anteriorly. Ornamentation as per the ventral valve; in one specimen (MPUM10417 (TK139bis-74)) swollen spine bases, 0,1-0,5 mm wide, irregularly arranged on the umbonal region.

Interior of dorsal valve with short and closely set

PLATE 4

Fig. 1 - *Squamularia marcouxi* n. sp. Ventral view of an articulated specimen. Holotype MPUM10410 (TK72-12), x2.

Fig. 2 - *Squamularia marcouxi* n. sp. Dorsal view of an articulated specimen. Holotype MPUM10410 (TK72-12), x2.

Fig. 3 - *Squamularia marcouxi* n. sp. Ventral view of an articulated specimen. MPUM10411 (TK72-54), x1.

Fig. 4 - *Squamularia marcouxi* n. sp. Dorsal view of an articulated specimen. MPUM10411 (TK72-54), x1.

Fig. 5 - *Squamularia marcouxi* n. sp. Ventral valve. MPUM10412 (TK72-183C), x2.

Fig. 6 - *Squamularia marcouxi* n. sp. Dorsal valve. MPUM10413 (TK72-183A), x1.

Fig. 7 - *Squamularia marcouxi* n. sp. Dorsal view of an articulated specimen. MPUM10414 (TK72-183B), x1.

Fig. 8 - *Squamularia marcouxi* n. sp. Ventral view of an articulated specimen. MPUM10415 (TK72-92), x2.

Fig. 9 - *Squamularia marcouxi* n. sp. Dorsal view of an articulated specimen. MPUM10415 (TK72-92), x2.

Fig. 10 - *Squamularia marcouxi* n. sp. Dorsal valve. MPUM10416 (TK72-174), x1.

Fig. 11 - *Squamularia rotundata* Gemmellaro, 1899. Ventral view of an articulated specimen. MPUM10421 (TK72-132), x2.

Fig. 12 - *Squamularia rotundata* Gemmellaro, 1899. Ventral view of an articulated specimen. MPUM10422 (TK72-107), x2.

Fig. 13 - *Squamularia rotundata* Gemmellaro, 1899. Dorsal view of an articulated specimen. MPUM10422 (TK72-107), x2.

Fig. 14 - *Squamularia rotundata* Gemmellaro, 1899. Ventral valve. MPUM10423 (TK72-180-B), x2.

Fig. 15 - *Squamularia rotundata* Gemmellaro, 1899. Ventral valve. MPUM10424 (TK72-86), x2.

Fig. 16 - *Squamularia rotundata* Gemmellaro, 1899. Ventral valve. MPUM10425 (TK72-180C), x2.

Fig. 17 - *Squamularia* sp. ind. Fragment. MPUM10430 (TK70-25), x2.

Fig. 18 - *Squamularia* sp. ind. Ventral valve. MPUM10431 (TK70-258), x1.

Fig. 19 - *Squamularia* sp. ind. Dorsal valve. MPUM10432 (TK72-45), x1.

Fig. 20 - *Permophricodothyris affinis* (Gemmellaro, 1899). Ventral valve. MPUM10436 (TU2-1), x1.

Fig. 21 - *Permophricodothyris caroli* (Gemmellaro, 1899). Ventral valve. MPUM10439 (TK72-147), x1.

Fig. 22 - *Reticulariina* sp. ind. Ventral view of an articulated specimen. MPUM10440 (TK139bis-42a), x1.

Fig. 23 - *Reticulariina* sp. ind. Dorsal view of an articulated specimen. MPUM10440 (TK139bis-42a), x1.

Fig. 24 - *Reticulariina* sp. ind. Anterior view of an articulated specimen. MPUM10440 (TK139bis-42a), x1.

Fig. 25 - *Reticulariina* sp. ind. Ventral view of an articulated specimen. MPUM10441 (TK139bis-42b), x2.

Fig. 26 - *Reticulariina* sp. ind. Dorsal view of an articulated specimen. MPUM10441 (TK139bis-42b), x2.

Fig. 27 - *Callispirina* sp. ind. Ventral view of an articulated specimen. MPUM10442 (TK139bis-4), x2.

Fig. 28 - *Callispirina* sp. ind. Dorsal view of an articulated specimen. MPUM10442 (TK139bis-4), x2.

Fig. 29 - *Callispirina* sp. ind. Anterior view of an articulated specimen. MPUM10443 (TK72-31), x2.

Fig. 30 - *Spiriferellina* aff. *Spiriferellina tricosa* Cooper & Grant, 1976b. Ventral view of an articulated specimen. MPUM10444 (TU62D-1), x2.

Fig. 31 - *Spiriferellina* aff. *Spiriferellina tricosa* Cooper & Grant, 1976b. Dorsal view of an articulated specimen. MPUM10444 (TU62D-1), x2.

Fig. 32 - *Metriolepis* sp. ind. Ventral view of an articulated specimen. MPUM10445 (TK9-38), x2.

Fig. 33 - *Metriolepis* sp. ind. Dorsal view of an articulated specimen. MPUM10445 (TK9-38), x2.

Fig. 34 - *Metriolepis* sp. ind. Anterior view of an articulated specimen. MPUM10445 (TK9-38), x2.

Fig. 35 - *Chondronia* aff. *C. obesa* Cooper & Grant, 1976b. Ventral view of an articulated specimen. MPUM10446 (TU10D-1), x2.

Fig. 36 - *Dielasma* sp. ind. Ventral view of an articulated specimen. MPUM10447 (TK72-89), x2.

Fig. 37 - *Dielasma* sp. ind. Dorsal view of an articulated specimen. MPUM10447 (TK72-89), x2.

Fig. 38 - *Dielasma* sp. ind. Ventral view of an articulated specimen. MPUM10448 (TUV9-16), x2.

Fig. 39 - *Dielasma* sp. ind. Dorsal view of an articulated specimen. MPUM10448 (TUV9-16), x2.

Fig. 40 - *Dielasma* sp. ind. Ventral view of an articulated specimen. MPUM10449 (TUV2d-2), x2.

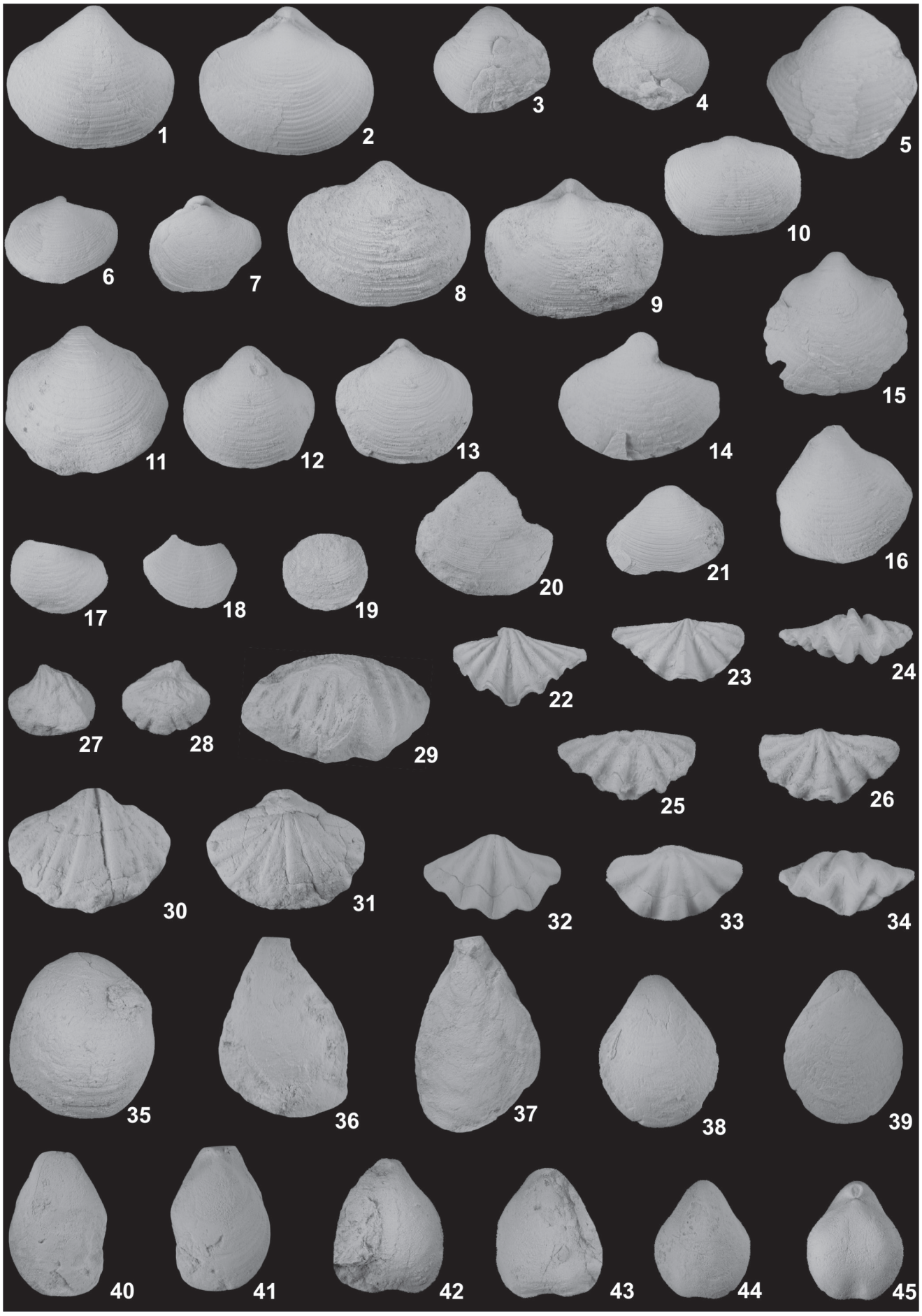
Fig. 41 - *Dielasma* sp. ind. Dorsal view of an articulated specimen. MPUM10449) TUV2d-2, x2.

Fig. 42 - *?Qinglongia* sp. ind. Ventral view of an articulated specimen. MPUM10452 (TK9-43), x2.

Fig. 43 - *?Qinglongia* sp. ind. Dorsal view of an articulated specimen. MPUM10452 (TK9-43), x2.

Fig. 44 - *?Qinglongia* sp. ind. Ventral view of an articulated specimen. MPUM10453 (TK72-5), x2.

Fig. 45 - *?Qinglongia* sp. ind. Dorsal view of an articulated specimen. MPUM10453 (TK72-5), x2.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crura, diverging at their base; spiralia conical and posterolaterally directed, with 9-12 coils.

Dimensions (in mm)

Specimen	Width	Length	W/L	Thickness	Specimens	Width	Length	W/L	Thickness
TK8-47	14.0	12.5	1.1	8.7	TK72-160	18.0	15.2	1.2	9.4
TK9-33	20.9	19.8	1.0	14.0	TK72-163	17.5	13.8	1.3	10.0
TK9-35	21.4	16.1	1.3	12.4	TK72-171	22.3	18.0	1.2	/
TK70-21	17.3	15.2	1.1	9.4	TK72-172	15.9	13.0	1.2	8.7
TK72-4	16.2	11.8	1.4	9.0	TK72-183	21.6	19.2	1.1	16. 0
TK72-7	16.7	14.0	1.2	9.0	TK72-185	18.0	15.4	1.2	10.3
TK72-10	22.0	18.0	1.2	12.0	TK72-187	19.8	18.0	1.1	13.3
TK72-12	16.4	14.0	1.2	9.2	TK72-205	18.8	17.4	1.1	11.8
TK72-15	14.2	13.0	1.2	8.8	TK139bis-13	17.7	16.4	1.1	11.6
TK72-19	17.7	14.7	1.2	9.6	TK139bis-19	14.0	12.3	1.1	8.2
TK72-25	13.4	12.8	1.0	8.5	TK139bis-24	22.3	17.5	1.3	/
TK72-34	11.5	10.5	1.1	7.0	TK139bis-31	14.3	11.3	1.3	7.0
TK72-39	11.8	10.2	1.1	6.8	TK139bis-32	17.0	14.0	1.2	9.6
TK72-41	22.0	17.5	1.2	12.0	TK139bis-33	20.0	16.0	1.2	10.0
TK72-46	22.0	16.4	1.3	/	TK139bis-36	19.0	15.0	1.3	11.0
TK72-51	18.0	13.5	1.3	9.3	TK139bis-41	18.3	17.2	1.1	12.5
TK72-57	19.5	18.0	1.1	11.0	TK139bis-44	17.1	12.0	1.4	/
TK72-58	19.7	14.8	1.3	10.5	TK139bis-50	18.2	15.3	1.1	10.8
TK72-68	22.8	18.2	1.2	14.4	TK139bis-54	20.7	18.9	1.1	12.0
TK72-70	18.8	14.5	1.3	9.3	TK139bis-55	16.0	15.0	1.1	7.5
TK72-74	16.0	12.9	1.2	7.0	TK139bis-56	18.8	15.0	1.2	11.4
TK72-76	19.2	15.8	1.2	11.0	TK139bis-58	20.5	18.9	1.1	12.9
TK72-88	12.4	11.6	1.1	6.7	TK139bis-63	21.2	21.5	1.0	15.0
TK72-92	17.6	14.0	1.2	10.0	TK139bis-64	21.3	19.8	1.1	14.2
TK72-98	14.2	11.8	1.2	8.0	TK139bis-69	18.4	15.6	1.2	10.5
TK72-99	11.2	8.6	1.3	5.9	TK139bis-72	19.8	15.0	1.3	11.0
TK72-101	18.0	16.4	1.1	11.0	TK139bis-74	24.2	20.3	1.1	14.8
TK72-103	16.7	14	1.2	9.0	TK139bis-75	19.0	17.3	1.1	/
TK72-116	19.9	16.4	1.2	12.3	TK139bis-78	16.2	14.0	1.1	10.4
TK72-119	9.4	9.0	1.0	6.2	TK139bis-82	19.0	15.5	1.2	11.1
TK72-133	12.6	11.3	1.1	7.3	TK139bis-89	22.0	17.5	1.2	11.3
TK72-148	17.2	12.5	1.4	11.5	TU2-2	24.0	19.6	1.2	13.0
TK72-149	13.3	11.3	1.2	7.6	TU2-4	16.6	13.2	1.2	9.0
TK72-154	24.8	~17.0	~1.4	15.3	TU2-5	18.2	15.0	1.2	9.4
TK72-155	13.8	13.0	1.1	8.5	TU13-2	13.0	10.5	1.2	9.4

Discussion. The Turkish specimens belong to a new species characterized by a distinct transversely expanded dorsal valve which can be readily distinguished from any other species of the genus. The ornamentation of characteristic diamond-shaped spine bases is another important character to erect a new species.

Our specimens are similar to those named as *Reticularia elegantula* by Waagen (1883, pl. 44, figs 1a-d), but the latter differs because the outline of the dorsal valve is suboval, instead of subrectangular, it does not show the contrast in outline between the two valves, and it has a hook-like umbo.

Squamularia rotundata

Gemmellaro, 1899

Pl. 4, figs 11-16; Pl. 5, figs 6-10; Pl. 6, figs 7, 9

1899 *Squamularia rotundata* Gemmellaro, p. 326, pl. 33, figs 38-45.

Material: Five figured articulated specimens: MPUM10422 (TK72-107), MPUM10421 (TK72-132), MPUM10455 (TK139bis-77), MPUM10456 (TK72-104), MPUM10459 (TK72-63); 10 articulated specimens: MPUM10426 (TK9-42, TK9-46, TK72-18, TK72-109, TK72-110, TK72-197, TK139bis-51, TK139bis-65, TU63AD-1, TUV5D-2); 2 figured ventral valves: MPUM10423 (TK72-180B), MPUM10425 (TK72-180C), 7 ventral valves: MPUM10427 (TK70-18b, TK72-125, TK72-201, TK72-202, TK139-215, TK139bis-62, TK139bis-66); 1 figured dorsal valve: MPUM10424 (TK72-86); 2 dorsal valves: MPUM10428 (TK72-91, TU3D-1); 3 fragments: MPUM10429 (TK72-40, TK72-127, TK72-203).

Occurrence: Turkey, Pamuçak Fm., Kemer Gorge locality (TK70, TK72, TK139, TK139bis); Çürük Dağ section 1 (TU3D, TUV5D); Çürük Dağ section 5 (TU63AD); coal mine section, (TK 9).

Description. Biconvex shell with subcircular, subpentagonal or subtriangular profile; width: 8.3-22 mm, length: 7.5-24 mm; anterior commissure slightly uniplicate, except for few specimens presenting a strong uniplication; lateral commissures straight. Ventral valve with pointed, swollen and hook-like umbo, much higher than the one on the dorsal valve, and with an indistinct interarea; ventral sulcus very weak, visible only anteriorly. Ornamentation of fine, flaky and imbricate growth lamellae, each bearing two alternating rows of biramous spines, with diamond-shaped bases, 50-150 µm wide, longitudinally elongated, whose opposite apexes become thin crests placed between the two adjacent spine bases of the next row (Pl. 5, figs 7-9). Dorsal valve with orbicular outline, less convex than the ventral valve; small, pointed

and wide umbo; fold absent; ornamentation as per the ventral valve.

Interior of dorsal valve with closely set and initially divergent crura; spiralia conical with 9 coils, wide bases and posterolaterally directed axes.

Dimensions (in mm)

Specimen	Width	Length	W/L	Thickness
TK9-42	10.9	10.2	1.1	6.0
TK9-46	9.0	9.4	0.9	5.4
TK72-18	18.4	16.4	1.1	10.0
TK72-86	13.7	14.9	0.9	/
TK72-91	12.8	15.0	0.8	/
TK72-104	14.1	13.9	1.0	9.8
TK72-107	12.8	11.9	1.1	8.2
TK72-109	15.1	15.5	1.0	9.2
TK72-110	20.3	19.0	1.0	/
TK72-125	22.0	21.5	1.0	/
TK72-132	15.4	14.2	1.0	10.2
TK72-180C	14.0	14.0	1.0	/
TK72-197	18.8	17.3	1.1	9.1
TK72-201	2.01	21.2	1.0	/
TK72-202	18.5	17.8	1.0	/
TK139bis-51	9.6	8.9	1.1	5.2
TK139bis-65	/	24.0	/	15.9
TK139bis-77	/	19.7	/	14.0
TU3D-1	8.3	7.5	1.1	/
TU63AD-1	16.0	15.0	1.1	9.5
TUV5D-2	12.2	11.3	1.1	6.1

Discussion. The specimens under examination fall in the specific variability of *Squamularia rotundata* Gemmellaro, 1899.

Stratigraphic and geographic occurrence. *Squamularia rotundata* comes from the allochthonous limestones of Rocca di San Benedetto near Palazzo Adriano of Sosio Valley, Sicily, Italy.

Squamularia sp. ind.

Pl. 4, figs 17-19

Material: Seven articulated specimens: MPUM10433 (TK70-9, TK72-43, TK72-65, TK72-79, TK72-137, TK72-158, TK139bis-40); 1 figured ventral valve: MPUM10431 (TK70-258); 15 ventral valves: MPUM10434 (TK70-18A, TK70-20, TK72-3, TK72-30, TK72-82, TK72-83, TK72-85, TK72-156, TK72-166, TK139-11, TK139-13, TK139-17, TK139bis-43, TU2-3, TU63AD-2); 1 figured dorsal valve: MPUM10432 (TK72-45); 1 figured fragment: MPUM10430 (TK70-25); 25 fragments: MPUM10435 (TK9-40, TK70-5(A-C), TK70-10, TK70-15, TK70-16, TK70-22, TK70-60, TK72-21, TK72-64, TK72-68, TK72-87, TK72-121, TK72-124, TK72-128, TK72-169, TK139-213, TK139bis-3, TK139bis-6, TK139bis-18, TK139bis-22, TK-139bis-49, TK139bis-79).

Occurrence: Turkey, Pamuçak Fm., Çürük Dağ section 1 (TU2); Kemer Gorge locality (TK70, TK72, TK139, TK139bis); Çürük Dağ section 5 (TU63AD); coal mine section (TK9).

Description and discussion. The presence of an ornamentation made of fine growth lamellae characterizes most of the present specimens, but the nature of these lamellae and their spines are mostly unknown as a consequence of alteration. Nevertheless, the general outline of the shell, the degree of convexity of the valves, the anterior commissure and the dimensions are diagnostic characters for the recognition of the genus *Squamularia*.

Dimensions (in mm)

Specimen	Width	Length	W/L	Thickness
TK70-18A	7.1	6.9	1.0	/
TK72-65	13.8	12.5	1.1	8.0
TK72-137	20.5	18.3	1.1	11.5
TK72-156	13.2	13.2	1.0	/
TK72-158	/	12.4	/	5.9
TK139bis-40	18.5	17.0	1.1	11.0
TU2-3	12.4	11.4	1.1	/

Genus *Permophricodothyris* Pavlova, 1965

Type species: *Permophricodothyris ovata* Pavlova, 1965, from the Lopingian of Transcaucasia

Remarks. Pavlova (1965) established the genus *Permophricodothyris* for those Permian forms that have the spiral axes pointing diagonally backward toward the hinge line, micrornamentation of double-barreled spines and a characteristic absence of internal plates.

Permophricodothyris affinis (Gemmellaro, 1899)

Pl. 4, fig. 20

1899 *Reticularia affinis* Gemmellaro, p. 330, pl. 34, fig. 5-8.

1934 *Reticularia lineata* var. *affinis* – Solignac, p. 13.

1957 *Reticularia affinis* – Termier & Termier, p. 209, text-pl. 5i-k, 6a-f.

1977 *Permophrycodothyris* (sic) *affinis* – Termier et al., p. 59.

2010 *Permophricodothyris affinis* – Verna et al., p. 336, pl. 2, figs 33-34; pl. 3, figs 25; pl. 4, figs 8-10; text-fig. 7.

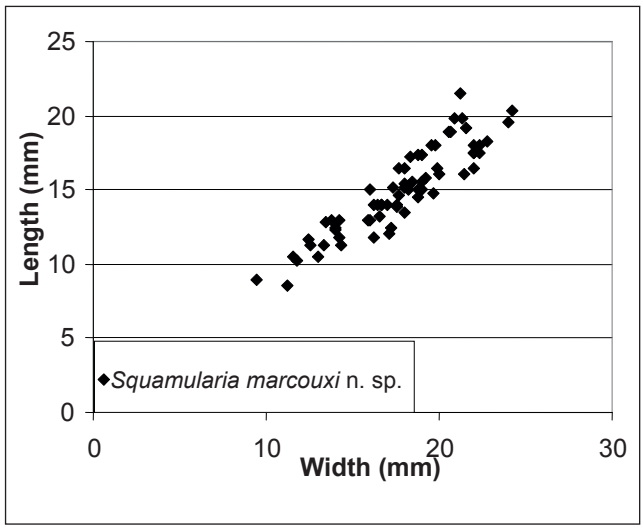


Fig. 11 - Width vs. length diagram of *Squamularia marcouxi* n. sp.

Material: 1 figured ventral valve: MPUM10436 (TU2-1); 3 ventral valves: MPUM10437 (TU18-3, TU23-1, TU59D-100); 2 fragments: MPUM10438 (TK72-13, TK139bis-37).

Occurrence: Turkey, Pamuçak Fm., Çürük Dağ section 1, (TU2, TU18); Kemer Gorge locality, (TK72, TK139bis); Çürük Dağ section 3, (TU23); Çürük Dağ section 5, (TU59D).

Description. Medium to large sized, convex ventral valve with subcircular to oval outline; maximum width at shell midlength: 30- >60 mm, length: 27- >56 mm. Cardinal extremities generally rounded; anterior commissure rectimarginate or slightly uniplicate with valves meeting at a variable angle; ventral umbo large and recurved. Ornamentation of regular concentric growth lamellae, 400-500 µm wide bearing two orders of long, dense spine bases, concentrically arranged: one kind of spines bifid, the other smaller and uniramous.

Interior of ventral valve with no plates supporting robust teeth. Interior of dorsal valve with spiral brachidium, with cones directed posterolaterally towards the cardinal region.

Dimensions (in mm)

Specimen	Width	Length	W/L
TU2-1	~32.0	27.0	>1.0
TU18-3	30.0	30.5	1.0
TU23-1	>60.0	>56.0	/

Discussion. The specimens under examination are similar to *Permophricodothyris affinis* Gemmellaro, 1899 from the Gaudalupian of Sosio, Palermo, Sicily. Gemmellaro (1899) described the species spiral cones of the brachidium as having extremities directed towards the lateral regions. However, when we studied the collection of Gemmellaro at the Museum G. Gemmellaro of Palermo, we noticed that the type material of *P. affinis* is comprised of six specimens, none of which have been sectioned to see the direction of the spiral cones.

Stratigraphic and geographic occurrence. *Permophricodothyris affinis* (Gemmellaro, 1899) has been found in the allochthonous limestones of Pietra di Salomone, of Rocca di San Benedetto and of Rupe del Passo del Burgio of Sosio Valley, Sicily, Italy (Gemmellaro 1899), in the Bellerophon limestone of Oudjah el Rhar, Tunisia (Termier et al. 1977), and in Halq Jemel section, Djebel Tebaga de Medenine, Southern Tunisia (Verna et al. 2010).

PLATE 5

Fig. 1 - *Squamularia marcouxi* n. sp. Overview of fine growth lamellae bearing two alternate rows of biramous spines, with diamond-shaped, longitudinally elongated bases; dorsal valve, MPUM10454 (TK139BIS-63).

Fig. 2 - *Squamularia marcouxi* n. sp. Enlargement of previous dorsal valve, showing alternate rows of biramous spines, with diamond-shaped longitudinally elongated bases; MPUM10454 (TK139BIS-63).

Fig. 3 - *Squamularia marcouxi* n. sp. Single biramous spine, with diamond-shaped, longitudinally elongated base; dorsal valve, MPUM10454 (TK139BIS-63).

Fig. 4 - *Squamularia marcouxi* n. sp. Alternate rows of biramous spines, with diamond-shaped, longitudinally elongated bases; ventral valve, MPUM10454 (TK139BIS-63).

Fig. 5 - *Squamularia marcouxi* n. sp. Biramous spine, with diamond-shaped, longitudinally elongated base; ventral valve, MPUM10454 (TK139BIS-63).

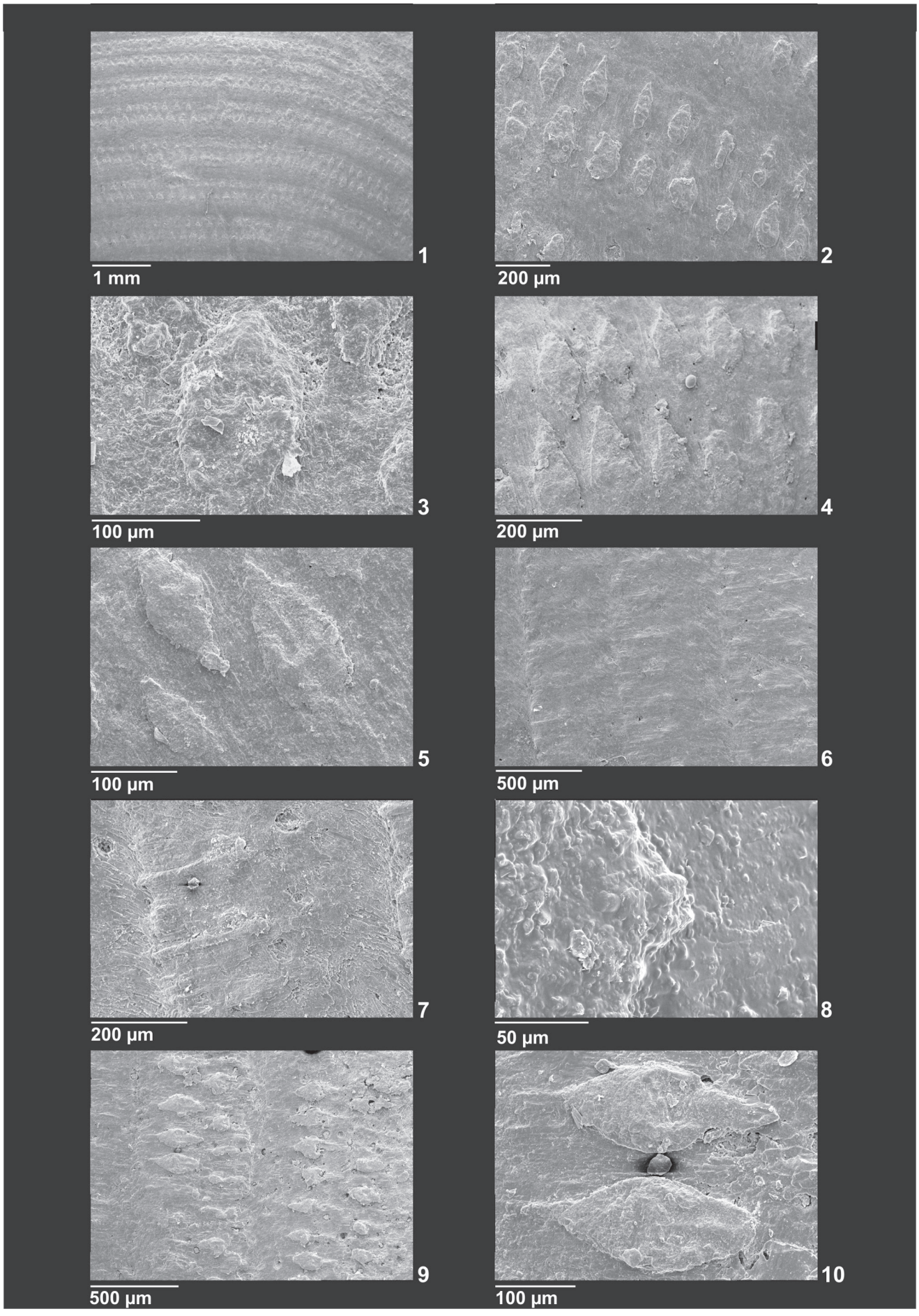
Fig. 6 - *Squamularia rotundata* Gemmellaro, 1899. Fine growth lamellae, each bearing two alternating rows of biramous spines of different size; ventral valve, MPUM10455 (TK-139BIS-77).

Fig. 7 - *Squamularia rotundata* Gemmellaro, 1899. Enlargement of previous ventral valve showing alternating rows of biramous spines of different size; MPUM10455 (TK-139BIS-77).

Fig. 8 - *Squamularia rotundata* Gemmellaro, 1899. Enlargement of a single biramous spine; dorsal valve, MPUM10456 (TK72-104).

Fig. 9 - *Squamularia rotundata* Gemmellaro, 1899. Overview of alternating rows of biramous spines, with diamond-shaped, longitudinally elongated bases of different size; ventral valve, MPUM10456 (TK72-104).

Fig. 10 - *Squamularia rotundata* Gemmellaro, 1899. Two biramous diamond-shaped spine bases; ventral valve, MPUM10456 (TK72-104).


1
1 mm
2
200 µm
3
100 µm
4
200 µm
5
100 µm
6
500 µm
7
200 µm
8
50 µm
9
500 µm
10
100 µm

Permophricodothyris caroli (Gemmellaro, 1899)

Pl. 4, fig. 21

1899 *Reticularia caroli* Gemmellaro, p. 334, pl. 34, figs 11-20; pl. 35, fig. 1.

1969 *Permophricodothyris caroli* – Pavlova, p. 103, pl. 10, fig. 1.

2010 *Permophricodothyris caroli* - Verna et al., p. 339, pl. 3, figs. 1-6; pl. 4, figs 1-5; text-fig. 8.

Material: One figured ventral valve: MPUM10439 (TK72-147).

Occurrence: Turkey, Pamuçak Fm., Kemer Gorge locality, (TK72).

Description. Single convex valve, 22 mm wide and 19.5 mm long, with a subtriangular outline, widest at shell midlength, cardinal extremities weakly angular; anterior commissure probably uniplicate. Umbo prominent, narrow, recurved and strongly pointed; it is not symmetrical but slightly tilted towards a side; interarea high, large and concave. Ventral sulcus shallow, widening and deepening towards the anterior margin. Ornamentation of narrow, unequal, imbricate and very fine lamellae bearing two orders of long, dense, concentrically arranged spine bases: one spine type bifid, the other smaller and uniramous.

Discussion. The ornamentation of *Permophricodothyris caroli* is close to that one of *Permophricodothyris affinis.* The two species mainly differs because of the asymmetrical umbo and the very high and large ventral interarea of *Permophricodothyris caroli*. *P. caroli* is similar to *P. pulcherrima* (Gemmellaro, 1899), but the latter differs because it is more elongated and less subtriangular and it has a lower interarea.

Stratigraphic and geographic occurrence. *Permophricodothyris caroli* has been found in the allochthonous limestones of Pietra di Salomone and of Rocca di San Benedetto of Sosio Valley, Sicily, Italy, and in Halq Jemel section, Djebel Tebaga de Medenine, Southern Tunisia (Verna et al. 2010).

Order **Spiriferinida** Ivanova, 1972

Suborder **Spiriferinidina** Ivanova, 1972

Superfamily Pennospiriferinoidea Dagys, 1972

Family Reticulariinidae Waterhouse, 1975

Genus *Reticulariina* Fredericks, 1916

Type species: *Spirifer spinosus* Norwood & Pratten, 1855, from the Mississippian of Illinois, USA

Remarks. *Reticulariina* Frederick, 1916 is similar to *Arionthia* Cooper & Grant, 1976b, differing by its smaller size, less transverse outline, bifurcating costae, and generally smooth sulcus and fold. According to Cooper & Grant (1976b, p. 2670), *Reticulariina* is characterized by a variable size, usually transverse outline and a microornamentation of numerous large hollow spines.

Reticulariina sp. ind.

Pl. 4, figs 22-26

Material: Two figured articulated specimens: MPUM10440 (TK139bis-42a), MPUM10441 (TK139bis-42b).

Occurrence: Turkey, Pamuçak Fm., Kemer Gorge locality (TK139).

Description. Small to medium sized, biconvex shell with asymmetric, strongly transverse, subtriangular outline; maximum width at hinge: 13.5 and 24.5 mm, length: 7 and 13.5 mm, and thickness: 5 and 10 mm. Cardinal extremities very elongated and pointed; anterior commissure uniplicate and zig-zagged. Surface densely covered by bases of hollow spines. Ventral valve with wide and small umbo, weakly projecting on a wide, subtriangular, concave, apsacline to nearly catacline, longitudinally and transversally striated interarea. Ventral sulcus V-shaped with narrow flat bottom, around 0.8 mm wide. Ornamentation of 8 sharp and almost flat topped costae, widening anteriorly; the two median costae are separated by 3.5 and 7 mm wide interspaces, and the lateral ones by 1.5-2 mm wide interspaces; interspaces slightly wider than costae; growth lines fine; few strong concentric lamellae. Dorsal valve with very small umbo, slightly incurved on the interarea; median fold higher and stronger than the lateral costae. Ornamentation of 6-7 evident rounded costae, widening anteriorly, with interspaces along the anterior commissure of 1-3 mm. The first ribs have a distance from the median fold of 7 mm; concentric ornamentation similar to ventral one.

Discussion. The present specimens resemble four species from the Permian of West Texas (Cooper & Grant 1976b): *R. craticula* Cooper & Grant, 1976b, from the Cisuralian Cathedral Mountain (Wedin Member) and Road Canyon formations, from which it differs by its more transverse profile, the ventral convexity equal to the dorsal one, and the less rounded costae; *R. senticosa* Cooper & Grant, 1976b, from the Guadalupian Road Canyon and Word formations, from which it differs in having sharper costae and a rather short dorsal umbo; *R. strigosa* Cooper & Grant, 1976b, from the Cisuralian Neal Ranch Formation, from which it differs by its equally convex valves and the lower thickness; *R. tetrica* Cooper & Grant, 1976b, from the Cisuralian Bone Spring Formation and Skinner Ranch Formation, from which it differs in having stronger growth lamellae, equally convex valves, and a weaker dorsal fold. Nevertheless, the material is not suitable for a specific determination due to its paucity and poor preservation.

Family Paraspiriferinidae Cooper & Grant, 1976b

Genus *Callispirina* Cooper & Muir-Wood, 1951

Type species: *Spiriferina ornata* Waagen, 1883, from the Guadalupian of Salt Range, Pakistan

Remarks. *Callispirina* Cooper & Muir-Wood, 1951 is similar to *Paraspiriferina* Reed, 1944, but it differs in having higher and sharper plications and fine regularly spaced growth lines.

Callispirina sp. ind.

Pl. 4, figs 27-29

Material: Two figured articulated specimens: MPUM10442 (TK139bis-4), MPUM10443 (TK72-31).

Occurrence: Turkey, Pamuçak Fm., Kemer Gorge locality (TK72, TK139).

Description. Small sized, biconvex shell, showing a bulbous shape and a transverse subovate to fan-shaped outline; maximum width at shell midlength: 8.3 and 19 mm, length: 6.5 and 14 mm, thickness: 6 and 10.5 mm. Cardinal extremities rounded; anterior commissure uniplicate and zig-zagged. Ventral valve with pointed and quite elevated umbo; concave, triangular and quite high interarea; ventral sulcus deep and V-shaped, much deeper and wider than the intercostal sulci. Ornamentation of about 10-12 sharp and high costae, starting at umbo and widening anteriorly; the width of the V-shaped interspaces between adjacent costae along the anterior commissure is 0.5-1.9 mm; interspaces as wide as costae; lamellose growth lines, fine and closely and regularly arranged. Dorsal valve with small umbo, lower than the ventral one; dorsal fold strong, high, more evident but less sharp than the lateral costae. Ornamentation of 8-10 high and sharp costae, starting from the umbo and slightly widening anteriorly; V-shaped interspaces, as wide as the costae; concentric ornamentation as per the ventral valve.

Discussion. We consider the specimens under examination as belonging to *Callispirina* because of the sharp costae and fine, regularly spaced growth lines. These specimens differ from *Callispirina ornata* Waagen, 1883 by their less evident, narrower and shallower fold and sulcus. The Turkish specimens differ from *Callispirina*? *rotundella* Xu & Grant (1994, p. 47, pl. 36, figs 24-30) from the Lopingian Changxing Formation of South China, because the latter shows interspaces narrower than the costae, a shorter ventral interarea, and stronger growth lamellae. The specimens under study are also different from *Callispirina austrina* Grant, 1976 (p. 231, pl. 63, figs 1-37), from the Guadalupian Rat Buri Limestone of South Thailand, because of their shorter ventral umbo, and their lower ventral interarea. They differ from *Callispirina rotunda* Cooper & Grant, 1976b (p. 2743, pl. 705, figs 66-82), from the Guadalupian Bell Canyon Formation, West Texas, because of their smaller dimensions, non-truncate anterior margin, apsacline ventral interarea, and the absence of a narrow depression bearing one low costa inside the sulcus. However, due to preservation of the specimens, the specific determination is left open.

Family Spiriferellinidae Ivanova, 1972

Genus *Spiriferellina* Frederiks, 1924

Type species: *Terebratulites cristatus* von Schlotheim, 1816, from the Guadalupian of Germany

Remarks. *Spiriferellina* Frederiks, 1924 differs from *Paraspiriferina* Reed, 1944 because of its shallower sulcus, wider lateral costae, and less regularly spaced concentric ornamentations. It also differs from *Callispirina* Cooper & Muir-Wood, 1951, because it has a less globose shape, a shallower sulcus, and a smaller and less incurved ventral umbo.

Spiriferellina aff. **Spiriferellina tricosa** Cooper & Grant, 1976b

Pl. 4, figs 30-31

Material: One figured articulated specimen: MPUM10444 (TU62D-1).

Occurrence: Turkey, Pamuçak Fm., Çürük Dağ section 5 (TU62D).

Description. Large size for the genus, weakly biconvex shell with transverse and fan shaped outline; maximum width posterior to shell midlength: 15 mm, length: 11.8 mm, thickness: 9 mm; hinge relatively wide; anterior commissure zig-zagged, truncate and slightly uniplicate. Surface occasionally showing low pustules between punctae. Ventral valve with small and pointed umbo, projecting on the interarea; interarea concave, subtriangular and quite high; median sulcus 4.8 mm wide, slightly greater than the intercostal sulci. Ornamentation of 11 sharp costae, with width between their crests ranging from 4.8 mm medianly to around 1 mm laterally in the anterior region; interspaces wider than the plicae. No distinctive concentric ornamentation. Dorsal valve with a very small, weakly perceptible umbo. Ornamentation of 11 sharp costae. The anterior width between their crests ranges from 3.9 mm medianly to around 1 mm laterally. The median fold is slightly higher than the others. No concentric elements.

Discussion. The Turkish specimen is similar to *S. tricosa* Cooper & Grant, 1976b, but differs slightly in its sharper costae, lower ventral interarea, and less evident dorsal fold.

Our specimen differs from *S. adunctata* Waterhouse & Piyasin, 1970 chiefly because the Thai species has a higher, flat and nearly orthocline ventral interarea and has an evident concentric ornamentation, and from *S. nuda* Cooper & Grant, 1976b by its larger size, rounded cardinal extremities and more numerous costae.

Stratigraphic and geographic occurrence. *S. tricosa* comes from the Cisuralian-early Guadalupian Cathedral Mountain Formation (Wedin Member) and Road Canyon Formation of West Texas (Cooper & Grant 1976b).

Genus *Metriolepis* Cooper & Grant, 1976b

Type species: *Metriolepis pulvinata* Cooper & Grant, 1976b, from the Guadalupian of West Texas, USA

Remarks. According to Cooper & Grant (1976b, p. 2717), the typical features of the genus *Metriolepis* are the generally transverse outline, somewhat conical ventral valve with flat or flatly concave interarea, moderately high fastigium, few, low and normally rounded lateral plications, broad, flattened or raised bottom of the sulcus, regularly spaced strong, imbricating growth lamellae and small pustules arranged parallel to the growth lamellae.

Metriolepis sp. ind.

Pl. 4, figs 32-34

Material: One figured internal mould of an articulated specimen: MPUM10445 (TK9-38).

Occurrence: Turkey, Pamuçak Fm., Kemer Gorge locality (TK9).

Description. Asymmetric, small sized biconvex shell, with transverse outline; maximum width at hinge: 13 mm, length: 8 mm and the thickness: 6 mm. Cardinal extremities asymmetric, one extremity being more pointed than the other; anterior commissure zigzagged and slightly uniplicate. Ventral valve conical, weakly convex, with high, wide and ventrally directed umbo; interarea catacline, flaty concave, triangular and high with wide delthyrium. Ventral sulcus V-shaped, 3.9 mm wide, slightly deeper and wider than the intercostal sulci. Ornamentation of 6 costae; the two median ones are sharp and almost flat-topped and the lateral ones are round-topped. The lateral costae are separated by 2.3-3.1 mm wide interspaces, which are moderately wider than the costae; few strong growth lamella present anteriorly. Dorsal valve less convex than the ventral one with small umbo. Dorsal fold fairly rounded, slightly higher and stronger than the lateral costae. Ornamentation of 5 round-topped costae, widening anteriorly, spaced along the anterior commissure at 1.8-3.5 mm intervals; interspaces wider than the costae; concentric ornamentation as per the ventral valve.

Interior of ventral valve with thin teeth, supported by dental plates with short adminicula; median septum. Interior of dorsal valve with rounded and shallow sockets delimited by socket ridges; wide ctenophoridium.

Discussion. The flatly concave catacline interarea, the transverse outline, the conical ventral valve and the few and rounded lateral costae, allow to us to assign the Turkish specimen to the genus *Metriolepis*. It is not possible to give a specific determination, based on an internal mould of a single specimen.

PLATE 6

Fig. 1 - *Squamularia marcouxi* n. sp. Longitudinal section near the commissure plane of a dorsal valve, showing spiralia. MPUM10457 (TK72-42).

Fig. 2 - *Squamularia marcouxi* n. sp. Longitudinal section near the commissure plane of a ventral valve, showing short and initially divergent crura. MPUM10457 (TK72-42).

Fig. 3 - *Squamularia marcouxi* n. sp. Detail of Fig. 1, showing several coils of spiralia. MPUM10457 (TK72-42).

Fig. 4 - *Squamularia marcouxi* n. sp. Longitudinal section near the commissure plane of a dorsal valve, showing conical spiralia with more than 9 coils and posterolaterally directed axes. MPUM10457 (TK72-42).

Fig. 5 - *Perigeyerella miriae* n. sp. Transverse section anterior to the umbo showing sessile spondylium. MPUM10458 (TU7/3aA), x2.

Fig. 6 - *Perigeyerella miriae* n. sp. Transverse section anterior to the umbo showing sessile spondylium, with plates starting to diverge along the floor of the valve. MPUM10367 (TU7.3aB), x2.

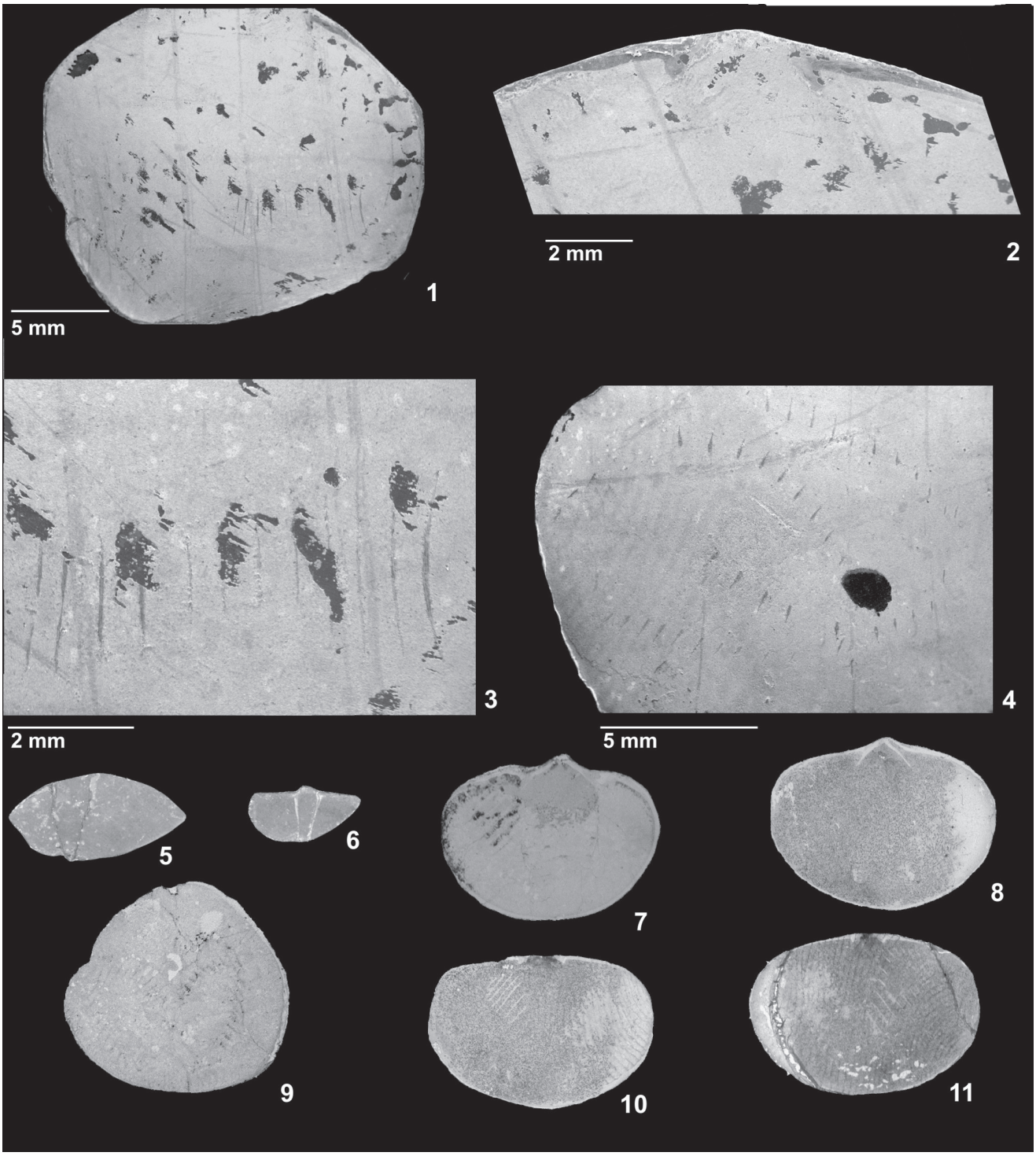
Fig. 7 - *Squamularia rotundata* Gemmellaro, 1899. Longitudinal section near the commissure plane of a dorsal valve, showing short and beginning divergent crura, and conical spiralia with posterolaterally directed axes. MPUM10459 (TK72-63), x2.

Fig. 8 - *Squamularia marcouxi* n. sp. Longitudinal section at 0,6 mm from the commissure plane of a dorsal valve, showing relatively elongate crura. MPUM10460 (TK-139), x2.

Fig. 9 - *Squamularia rotundata* Gemmellaro, 1899. Longitudinal section near the commissure plane of a ventral valve, showing conical spiralia with posterolaterally directed axes. MPUM10459 (TK72-63), x2.

Fig. 10 - *Squamularia marcouxi* n. sp. Longitudinal section at 1 mm from the commissure plane of a dorsal valve, showing short crura and coils of spiralia, with posterolaterally directed axes. MPUM10460 (TK-139), x2.

Fig. 11 - *Squamularia marcouxi* n. sp. Longitudinal section at 1,4 mm from the commissure plane of a dorsal valve, showing short crura and coils of spiralia, with posterolaterally directed axes. MPUM10460 (TK-139), x2.



Order **Terebratulida** Waagen, 1883

Suborder **Terebratulidina** Waagen, 1883

Superfamily Cryptonelloidea Thomson, 1926

Family Notothyrididae Licharew, 1960

Genus *Chondronia* Cooper & Grant, 1976b

Type species: *Chondronia bella* Cooper & Grant, 1976b, from the Guadalupian of West Texas, USA

Remarks. *Chondronia* Cooper & Grant, 1976b is similar to *Rostranteris* Gemmellaro, 1898, but it differs in having an anterior commissure commonly rectimarginate to paraplicate, being smooth or faintly costate anteriorly, and having a loop consisting of two broad, descending lamellae, with no median fold or plate. According to Cooper & Grant (1976b, p. 2854), *Chondronia* is close to the originating stock of the notothyridids, and has a simple, almost primitive loop.

Chondronia aff. **Chondronia obesa**
Cooper & Grant, 1976b
Pl. 4, fig. 35

Material: One figured articulated specimen: MPUM10446 (TU10D-1).

Occurrence: Turkey, Pamuçak Fm., Çürük Dağ section 2 (TU10).

Description. Medium sized, deeply biconvex shell, with elongated suboval outline; maximum width anterior to shell midlength: 13.5 mm, length: 15.6 mm, thickness: 12 mm; anterior commissure slightly paraplicate, with valves meeting at high angle. Ventral valve with very small palintrope and a small, pointed and slightly arcuate umbo, showing a median low groove; foramen open and relatively large. Ventral sulcus very shallow, observable only on the anterior region. Ornamentation of very fine growth lines, visible posteriorly, growth lamellae of which two, one anterior and the other posterior, are particularly strong; radial lirae thin, short and discontinual. Dorsal valve with a little beak pointed towards the ventral umbo. Ornamentation as per the ventral valve.

Discussion. The present specimen belongs to genus *Chondronia* based on its small size, paraplicate anterior commissure, and ornamentation of faint radial elements anteriorly. It is quite similar to *C. obesa* Cooper & Grant, 1976b (p. 2856), but it differs by its larger size and having a very shallow ventral sulcus anteriorly and thin, short and discontinual radial lirae anteriorly.

The specimen under examination differs from *C. bella* Cooper & Grant, 1976b by its larger size, the outline and the weak paraplication. It differs from *C. ningula* Cooper & Grant, 1976b by its shape and larger size, and from *C. rectimarginata* Cooper & Grant, 1976b, by its larger size, paraplicate anterior commissure and less elongated and more convex shape.

Geographic and stratigraphic occurrence. *Chondronia obesa* has been found in the Guadalupian Hueco Limestone Formation, West Texas (Cooper & Grant 1976b).

Superfamily Dielasmatoidea Schuchert, 1913
Family Dielasmatidae Schuchert, 1913
Subfamily Dielasmatinae Schuchert, 1913
Genus *Dielasma* King, 1859

Type species: *Terebratulites elongatus* Schlotheim, 1816, from the Guadalupian of Germany

Remarks. Angiolini & Zarbo in Angiolini et al. (2006, p. 9) described their genus *Omanilasma* as being externally very similar to *Dielasma* King, 1859, sharing its biconvex, elongated subovate shape with generally uniplicate anterior commissure and labiate foramen, but differing in its internal characters: i.e. the absence of dental plates inside the ventral valve. *Omanilasma* is in fact characterised by the occurrence of reduced dental flanges supporting the teeth, but not extending to the valve floor. Internally its dorsal valve shows the hinge plates forming an open 'V' between the socket ridges and the valve floor, as in *Dielasma*.

Dielasma sp. ind.
Pl. 4, figs 36-41

Material: Three figured articulated specimens: MPUM10447 (TK72-89), MPUM10449 (TUV2d-2), MPUM10448 (TUV9-16); 3 articulated specimens: MPUM10450 (TK72-9, TK72-159, TUV5-1); 1 ventral valve: MPUM10451 (TK139bis-67).

Occurrence: Turkey, Pamuçak Fm., Kemer Gorge locality (TK72, TK139); Çürük Dağ section 3 (TUV2D, TUV5, TUV9).

Description. Small to medium sized, biconvex shell, with spatuliform outline; maximum width anterior to shell midlength: 8.8-13.5 mm, length: 13-20 mm; anterior commissure weakly uniplicate; shell densely and finely endopunctate. Ventral valve more convex than the dorsal one, spatuliform, with an almost circular, slightly labiate or subtriangular foramen. Ornamentation of growth lines and widely spaced growth lamellae. Dorsal valve with less spatuliform outline than the dorsal one. Concentric ornamentation as on the ventral valve.

Interior of ventral valve with pedicle collar and dental plates. Interior of dorsal valve with hinge plates meeting on the valve floor.

Dimensions (in mm)

Specimen	Width	Length	W/L	Thickness
TK72-9	13.5	20.0	0.7	8.0
TK72-89	12.1	19.5	0.6	7
TUV2D-2	9.2	14.5	0.6	5.5
TUV5-1	8.8	13	0.7	7
TUV9-16	11.5	14.9	0.8	6.3
TK139bis-67	11.5	18.0	0.6	/

Discussion. The present specimens belong to *Dielasma*, and not to the similar genus *Omanilasma*, because of the occurrence of dental plates inside the ventral valve. The specific determination is left open because of the lack of specific diagnostic features.

Family Heterelasminidae Licharew, 1956

? Qinglongia Liao, 1980

Type species: *Q. zhongyingensis* Liao, 1980, from the Lopingian of Southwestern China

Remarks. *Qinglongia* differs from *Mimaria* Cooper & Grant, 1976b, from the Guadalupian of Sicily, because the latter genus has a larger size, concave ventral valve and small umbo. Jin et al. (2006, p. 2038) described the anterior commissure of *Qinglongia* as bisulcate and plicate, but judging from the illustrations it is sulciplicate. However, the identification of the genus *Qinglongia* is mainly based on its internal structure.

?Qinglongia sp. ind.

Pl. 4, figs 42-45

Material: Two figured articulated specimens: MPUM10452 (TK9-43), MPUM10453 (TK72-5).

Occurrence: Turkey, Pamuçak Fm., Kemer Gorge locality (TK72); coal mine section (TK9).

Description. Small sized, slightly ventribiconvex shell with elongated, drop-like to spatuliform outline; maximum width anterior to shell midlength: 9 and ~9.5 mm, length: 11.3 and 13 mm, thickness: 6.5 and 6.9 mm; anterior commissure sulciplicate; shell densely punctate. Ventral valve with conspicuous and pointed umbo, strongly recurved beyond the cardinal margin; ventral palintrope small, concave; foramen large, epithyrid, subcircular and weakly labiate. Surface smooth, except for some visible fine growth lines and few anterior strong lamellae; fold and lateral sulci imperceptible, and visible only at anterior commissure. Dorsal valve showing a median sulcus starting posteriorly only in MPUM10453 (TK72-5), where the sulcus shows a uniform width along all length, becoming deeper anteriorly. In the other specimen, the sulcus is visible only anteriorly. The lateral folds are visible both posteriorly and anteriorly only in MPUM10453 (TK72-5). Ornamentation as per the ventral valve.

Interior of dorsal valve with crural plates, subparallel in MPUM10453 (TK72-5) and slightly divergent in MPUM10452 (TK9-43).

Discussion. They differ from *Qinglongia,* as defined by Liao (1989) in having an epithyrid foramen and subparallel to slightly divergent crural plates (Jin et al. 2006, p. 2038). Therefore the uncertainty about the generic allocation of our specimens.

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