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BRACHIOPODS FROM THE TYPE-SECTION OF THE BITHYNIAN SUBSTAGE (ANISIAN, MIDDLE TRIASSIC, NORTHWESTERN TURKEY)

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Key words: Brachiopoda, Nodular Limestone, biostratigraphy, chronostratigraphy, paleobiogeography.

Abstract. The Bithynian substage of the Anisian stage (Middle Triassic) was established by Assereto in the Gebze area (Kocaeli peninsula, northwestern Turkey), within the middle member of Nodular Limestone formation, now included in the Tepeköy Formation. The rich fauna, represented by conodonts, foraminifera and ammonoids, was described since a long time. The brachiopod fauna occurring in the Bithynian type-section is here revised. It consists of four species: *Austriellula kavakensis* (Arthaber, 1914), *Holchorhynchella edhemi* (Toula, 1896), *Ptychomentzelia propontica* (Toula, 1896), and *Angustothyris angustaeformis* (Böckh, 1872). The fauna is mostly endemic, with high number of specimens for the first three quoted species. Rare specimens of *P. propontica* occur also in the lower member of the Nodular Limestone, who delivered the conodont *Neogondolella regalis*, suggesting an Aegean age. The brachiopod fauna of the Bithynian substage continues upward with rare specimens in the lowermost part of the overlying Pelsonian succession. In the Illyrian, very rare *"Rhynchonella" tscharkensis* Arthaber, 1914, and *Koeveskallina koeveskalyensis* (Stur, 1865) were found. The Bithynian brachiopod fauna from Gebze has no counterpart in the Europe and in the surrounding regions, like Northern Caucasus and Aghdarband in Iran, even if some of the ammonoids found in Gebze are also present in these areas.

Introduction

The Middle Triassic fauna from Bithynia was first discovered around the turn of XIX and XX centuries by Toula (1896) and Endriss (1910). Later, Arthaber (1914) illustrated the invertebrate fauna collected by Endriss in the localities near Dil-il-Iskelesi (now Diliskelesi) and Tepeköy.

After this first set of papers, no information on the biostratigraphy of this succession was provided for years. Riccardo Assereto (Milano University) carried out new field work in the area in 1968 and 1971 with a bed by bed sampling approach, producing a preliminary note in 1972, followed by the proposition of two new substages for the Anisian stage: Aegean and Bithynian (Assereto 1974). The Bithynian was established with type section from the area of Gebze and the Aegean in the Island of Chios (Greece). The section was measured between Diliskelesi and Hereke (Gebze is the main town, whilst Diliskelesi is a smaller village to the East) in Northwestern Turkey. Tepeköy is a village in the interior, from which part of the material described by Arthaber originates (Fig. 1).

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Due to the premature death of Assereto in 1976, the palaeontological data were published mostly later on benthic foraminifera (Nicora & Premoli Silva 1976), conodonts (Nicora 1977), and ammonoids (Fantini Sestini 1988). Additional biostratigraphic data were given by Gedik (1975), who studied the conodont content of the whole Triassic succession, and by Zaninetti & Dağer (1978) on the foraminiferal biostratigraphy of the Triassic.

In this paper, I describe the brachiopods collected by Assereto from the type section of the Bithynian, and a few specimens collected upwards in the Pelsonian-Illyrian part of the succession. Most of the studied brachiopods come from the Nodular Limestone of Assereto (1972) which is now considered part of the Tepeköy Formation sensu Tuyuz et al. (2004).

Stratigraphy

Assereto (1972) described the Triassic succession, without introducing formal lithostratigraphic terms. Several papers introduced this kind of classification, starting with Altinli (1968), followed by Yurtsever (1976), Zaninetti & Dağer (1978), and

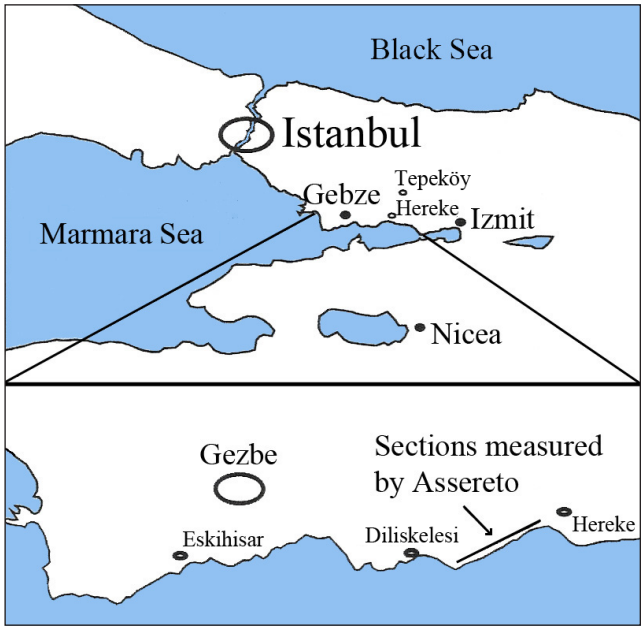


Fig. 1 - Index map of the area of Gebze, with position of the section measured by Assereto.

summarized by Tüysüz et al. (2004). However, it is worthy of note that the description of the sedimentary succession made by Assereto (1972) is still in use, as testified by the recent paper of Okay & Nikishin (2015, fig. 6).

Bottom to top, the succession is as follows:

- Poorly sorted conglomerate (Kapaklı Formation) with abundant matrix, dark red in colour, deposited in a fluvial setting. It is transgressive with angular unconformity on sedimentary rocks of Devonian age (100 to 300 m thick). Age: Early Triassic according to Gedik (1975).

- Variegated sandstone and marlstone (Erikli Formation). The conglomerate is unconformably overlain by well-sorted quartzarenite, yellow shale, and silty shale, overlain by varicoloured fossiliferous marlstone with rare bivalve and gastropod (less than 90 m thick). Age: Early Triassic.

- Grey limestone and dolostone (Ballıkaya Formation). The lower unit consists of burrowed wackestone to packstone intercalated with crinoidal packstone/grainstone (about 200 m thick). The upper unit consists of light grey, burrowed dolostone intercalated with massive limestone (more than 100 m thick). Age: latest Early Triassic based on the foraminiferal content in the upper member, where Gedik (1975) reported the occurrence of *Neospathodus triangularis*.

- Nodular Limestone [Ubeyli Formation according to Yurtsever (1978) or lower part of the Tepeköy Formation according to Tüysüz et al. (2004)]. Assereto divided the Nodular Limestone in three members. The lower member consists of black nodular wackestone, with chert in nodules and bands (35 m thick). The middle member consists of very nodular grey wackestone/packstone and it is capped by a thick bed of monogenic calcareous conglomerate (31 m thick). The upper member consists of nodular wackestone, separated by red or yellowish marlstone (about 50 m thick). The brachiopod fauna here described originates almost exclusively from the Nodular Limestone. Age: large part of the Anisian, and not only its topmost part as reported by Tüysüz et al. (2004).

- "Ammonitico Rosso" (Tepeköy Formation), red nodular ammonitic facies (about 15 m thick). Age: Late Anisian-Ladinian.

- Grey-green marlstone (Tepeköy Formation). Green-grey marlstone alternating with thin wackestone. Age: Carnian.

- Thick-bedded limestone overlying with angular unconformity the Triassic succession. Age: Cretaceous.

The succession is displaced by numerous faults. Therefore, the Nodular Limestone formation is repeated several times along the trench of the old railway. Assereto kept separate the different displaced parts of the section and details are reported by Nicora (1977) to which reference is made.

Provenance and age of the fossil material

When introducing the fossiliferous succession with the name of Nodular Limestone formation, Assereto (1972) initially identified 9 units, grouped in three members. Later on, in his 1974 paper, unit 9 was merged with unit 8. Based on the scheme published by Nicora (1977) and Fantini Sestini (1988), the material here described was collected from units 3 to 8 of Assereto (1974), but for two specimens of *Koeveskallina koeveskalyensis* found in the "Ammonitico Rosso" (Assereto 1972).

Units 1-4 are part of the lower member, which is poor of brachiopods and did not yield any ammonoids. Units 5-7 belong to the middle member, which is the richest in brachiopods as well as in ammonoids. Unit 8 is part of the upper member, where brachiopods are very rare.

In the highest part of unit 8, out of the me-

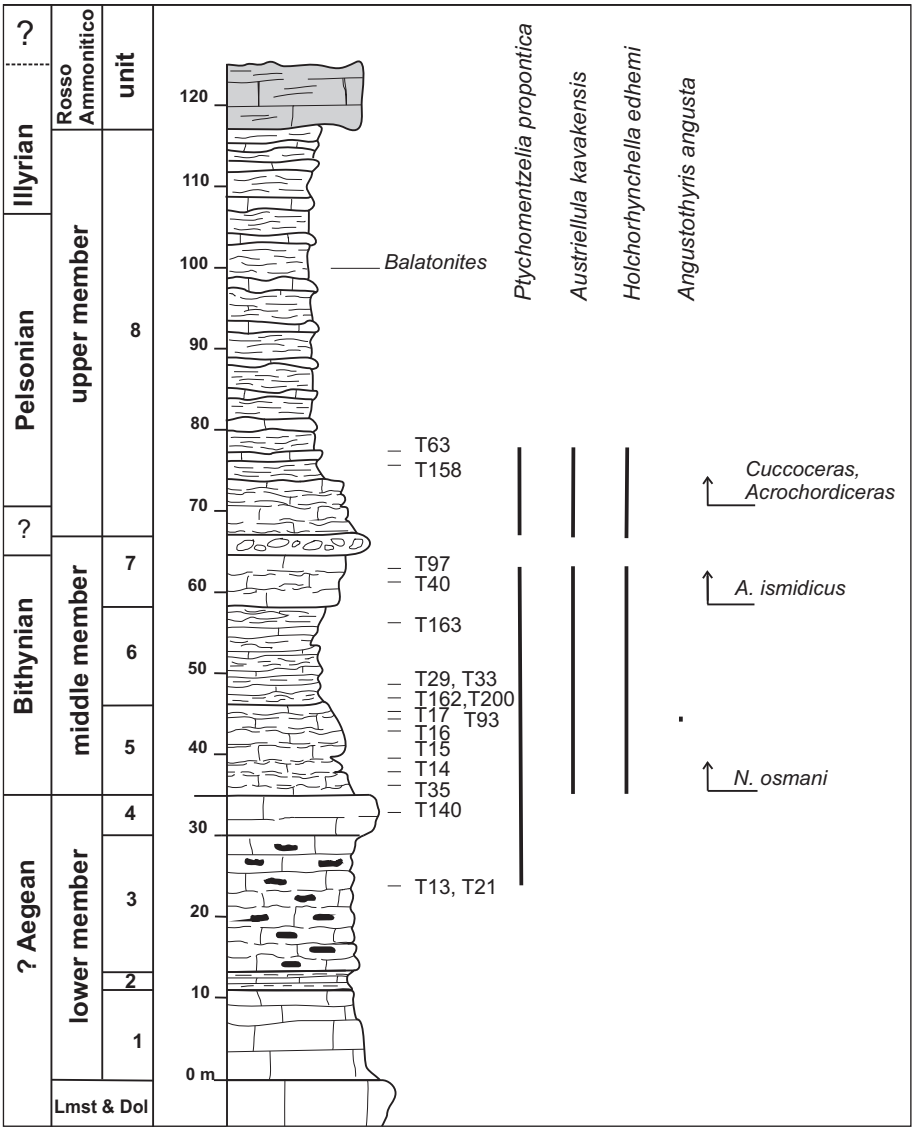


Fig. 2 - Composite stratigraphic log of the Gebze section [drawn from Assereto (1974, figs 3-4)], and the Assereto's field notes] with the ranges of the four brachiopod species collected in the Bithynian strato-type.
K. koeveskalyensis originates from the "Rosso Ammonitico" unit. Assereto originally measured several partial sections, which were assembled in the composite log shown here, where the relevant brachiopod samples are indicated. The partial sections are reported in Nicora (1977) and Fantini Sestini (1988).

asured sections, two specimens of "*Rhynchonella*" *tscharkensis* were collected (Assereto 1972: 441).

Outside the measured sections, near Eskihisar, *Holchorhynchella edhemi* (1 spec.) and *Ptychomentzelia propontica* (2 spec.) were found in the Nodular Limestone formation.

Unit 4 did not deliver ammonoids, but it contains *Neogondolella regalis* and *Neogondolella constricta*, suggesting a possible early Anisian age (Nicora 1977). *Ptychomentzelia propontica* rarely appears in units 3 and 4. Assereto (1974) and Fantini Sestini (1988) referred the units 5 and 6 to the Osmani Zone, and unit 7 to the Ismidicus Zone, based on their ammonoid fauna. Therefore, units 5 to 7 belong to Bithynian by definition. The bulk of the brachiopods was collected in these units, with *Holchorhynchella edhemi* (Toula, 1896), *Austriellula kavakensis* (Arthaber, 1914), *Ptychomentzelia propontica* (Toula, 1896), and *Angustothyris angustaeformis* (Böckh, 1872). Thus, most of the brachiopods under study comes from units 5 and 7 and are Bithynian. Even if much rarer, they continue up in the lower part of the Pelsonian (Fig. 2). Larger part of unit 8 is to be referred to the Pelsonian Balatonicus Zone. The highest part of unit 8 should be referred to the Trinodosus Zone, Illyrian (Fig. 2).

In the Illyrian, only *Koeveskallina koeveskalyensis* was collected, and "*Rhynchonella*" *tscharkensis* was found, but outside the section.

Table 1 summarizes the range and abundance of the brachiopods collected by Assereto, here described and housed in the Paleontological Museum of the University of Milano with museum numbers MPUM. The letter T (Turkey) followed by a number indicates the original field number given by Assereto.

Lithostratigraphy		Brachiopods						
		Rhynchonellida			Spiriferida		Terebratulida	
	unit	*Austriellula kavakensis*	*Holcorhynchella edhemi*	*Rhynchonella tscharkensis*	*Ptychomentzelia propontica*	*Koeveskallina koeveskalyensis*	*Angustothyris angustaeformis*	TOTAL
"Rosso Ammonitico"	–					2		
upper	8	3	8	2	2	-	=	7,1%
middle	7	22	21	=	12	=	=	25,9%
	6	8	2	–	15	–	–	11,8%
	5	25	47	-	39	-	1	53,2%
lower	4	-	-	-	1	-		0,5%
	3				3			1,5%
	1–2							
TOTAL		58 27,3%	78 36.6%	2 0.9%	72 33.8%	2 0.9%	1 0.5%	

Tab. 1 - Distribution pattern of the brachiopods in the Bithynian type-area of Gebze.

The brachiopod fauna and its palaeogegraphic significance

The brachiopods collected by Assereto from the type-Bithynian and here described are as follows: *Holchorhynchella edhemi* (Toula, 1896), *Austriellula kavakensis* (Arthaber, 1914), *Ptychomentzelia propontica* (Toula, 1896), and *Angustothyris angustaeformis* (Böckh, 1872). "*Rhynchonella*" *tcharkensis* Arthaber, 1914 and *Koeveskallina koeveskalyensis* (Stur, 1865), also collected by Assereto, originate from the Illyrian (upper Anisian). *P. propontica* rarely appears in the lower member, considered of Aegean age according to the conodonts.

The knowledge of Aegean and Bithynian brachiopods is scanty, because their occurrence is spotty and the assemblages are represented by few species, at least in the western Tethys (Siblík 1991). This is in contrast with the more abundant conodont and ammonoid occurrences, on which the concept of these two Tethyan substages was established. The Bithynian brachiopod fauna can be considered an oligotypic assemblage characterized by species as *A. kavakensis, H. edhemi,* and *P. propontica*, which gradually disappear during the early Pelsonian. *A. angustaeformis* is a long range and widespread species, known from the Anisian of Central Europe, the Mediterranean region and China (Chen et al. 2015), whilst "*Rhynchonella*" *tcharkensis* and *Koeveskallina koeveskalyensis* were recovered from beds of Illyrian age. More specifically, "*Rhynchonella*" *tcharkensis* is known so far only by three specimens in the Gebze area. *K. koeveskalyensis* is a widely distributed species in the Pelsonian and in the Illyrian of the Southern and Northern Alps, Balaton, Dobrogea, the Balkans and Dinarids, and Caucasus (Bittner 1890, 1903; Dagys 1974; Iordan 1993; Benatov 2001; Pálfy 2003; Gaetani & Mantovani 2015).

The Anisian succession of the Gebze area belongs to the İstanbul Terrane. There is a consensus that the İstanbul Terrane rifted off from an area south of the Odessa Shelf and was translated southward opening the West Black Sea basin during the Cretaceous (Okay 1989; Okay et al. 1994, 1999; Yanev et al. 2006; Okay & Nikishin 2015). It was accreted to the Sakarya Terrane during the Early Cretaceous (Akbaryama et al. 2013). Therefore, affinities for this fauna should be first searched along the southern shore of Laurasia.

A potential extension of the Odessa shelf to the west, in North Dobrogea, does not record any similar Bithynian fauna. The ammonoids listed by Gradinaru & Sobolev (2006) are largely different from the Gebze ammonoids, and no brachiopod is recorded in the equivalent beds in Dobrogea (Mirauta et al. 1984; Iordan 1993).

Bithynian brachiopods are virtually unknown from continental Europe. Only the lowest fauna from Monte Rite in the Southern Alps may be doubtfully referred to the Bithynian, but it does not share any taxon with the Gebze Bithynian fauna (Neri et al. 2007; Gaetani & Mantovani 2015).

Eastwards, along the northern shores of the Tethys, sparse occurrences are reported from Aghdarband in Iran (Siblík 1991). The Bithynian brachiopod assemblage of Aghdarband is composed of *Costirhynchia ruttneri* Siblík, 1991, *Punctospirella* aff. *P. fragilis* (Schlotheim, 1814), *Dareithyris vulgaris* Siblík, 1991, and it contains a stratigraphically doubtful occurrence of *Tetractinella trigonella* (Schlotheim, 1820). In the Naklak area of central Iran, *Tethyspira persis* and a large undescribed Athyridoid (M. Balini, pers. comm. 2015) have been found in the debris of the Alam Formation, which is possibly Bithynian in age (Balini et al. 2009; Berra et al. 2013). According to Krystyn & Tatzreiter (1991), some Bithynian ammonoids are also present in western Caucasus, but no brachiopod is known from that area. Dagys (1974) reported the presence of Anisian brachiopods in the mudstone/wackestone of the Malyi Tchak unit. The quoted assemblage is typical for the Pelsonian-Illyrian, with *Decurtella* ?*tommasii*, *Koeveskallina koeveskalyensis*, *Punctospirella fragilis*, *Spirigerellina sturi* and *Sulcatinella sulcata*.

Along the southern shore of the Tethys, in Himalaya and in the nearby (during Triassic) Socotra Island, Yemen, the assemblage *Nudirostralina*, *Guseriplia*, *Tulongospirifer*, and *Adygella* is present in the Bithynian-Illyrian (Bittner 1899; Siblík 1975; Ching et al. 1976; Gaetani 2016). This seems to be a typical Gondwanan assemblage, very different from the coeval European and Mediterranean records.

Therefore, it clearly appears that the oligotypic brachiopod assemblage from Gebze is unique for the Western Tethys. In the southern China Block, the recovery pattern of brachiopods was analysed in several papers (Shen et al. 2006; Chen et al. 2015; Ke et al. 2016). The Aegean and Bithynian brachiopods are represented by more than 30 species. However, only a couple of these species is shared with the Western Tethys faunas, i.e. *Mentzelia mentzeli* and *Angustothyris angustaeformis*, which are long- and wide range taxa.

As for the palaoecological significance, most of the brachiopods here studied are smooth forms, which are found in nodular limestone probably deposited at depth below the storm wave base. The small foramen of the two main rhynchonellid species also suggests a reduced functionality of the pedicle in the adults. Almost all the specimens of the rhynchonellid species are articulated, whereas the 15% of specimens of the spiriferinid species are represented by disarticulated valves, mostly ventral valves. This may be due to the weaker articulation of the group. Vörös (2005) evaluated the connection between deep water and smooth shell amongst brachiopods. In addition, the smooth shelled taxa may suggest low predation pressure (Vörös 2010). This is in agreement with the inferred evolution of the succession, recording a deepening from the shallow water carbonates of the Ballikaya Formation to the open and deeper water sediments of the Tepeköy Formation (Zaninetti & Dağer 1978).

Systematic palaeontology

Phylum **Brachiopoda** Duméril, 1806
Subphylum **Rhynchonelliformea** Williams, Carlson, Brunton, Holmer & Popov, 1996
Class **Rhynchonellata** Williams, Carlson, Brunton, Holmer & Popov, 1996
Order **Rhynchonellida** Kuhn, 1949
Superfamily Norelloidea Ager, 1959
Family Norellidae Ager, 1959
Subfamily Norellinae Ager, 1959
Genus *Austriellula* Strand, 1928

[nom. subst. pro *Austriella* Bittner, 1890] [praeocc. Tenison-Woods 1881]
[=*Austriellina* Schuchert & LeVene, 1929 obj. syn.]
[=*Jacobella* Patte, 1926] [praeocc. Jeannet 1908]

Austriellula kavakensis (Arthaber, 1914)

Figs 3, 4; Pl. 1, figs 1-11

1914 *Rhynchonella kavakensis* Arthaber: 196, pl. 18, figs 18-20.

Lectotype: The specimen depicted at pl. 18, fig. 18 and housed in the Stuttgart Museum, Catalogue Number 12871/75 is designated here as lectotype. Other paralectotypes belong to the Endriss collection stored in the Stuttgart Museum, with Catalogue Numbers 12871/75-87 from Diliskelesi and 12871/88-90 from Tepeköy.

Material: Fifty-eight articulated specimens in rather good state of preservation, but often slightly squeezed. They originate from:

unit 5, MPUM 11372 - 25 specimens: T15 (1 spec.), T 16 (2 spec.), T17 (1 spec.), T22 (10 spec.), T23 (4 spec.), T36 (5 spec.), T93 (2 spec.);

unit 6, MPUM 11375 - 8 specimens: T20 (1 spec.), T37 (1 spec.), T59 (3 spec.), T125 (1 spec.), T200 (2 spec.);

unit 7, MPUM 11378 - 22 specimens: T39 (1 spec.), T40 (1 spec.), T42 (2 spec.), T45 (1 spec.), T47 (1 spec.), T61 (1 spec.), T73 (1

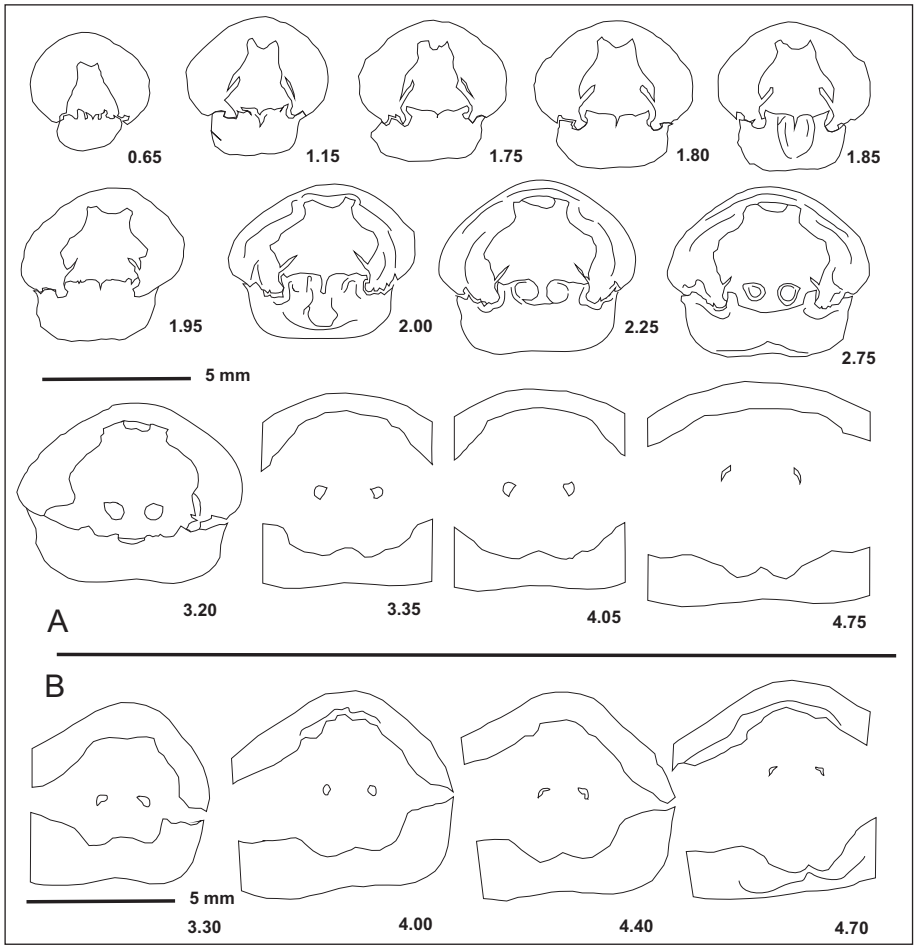


Fig. 3 - *Austriellula kavakensis* (Arthaber, 1914). Serial sections of the specimen MPUM11379 T63/1 (total length 18.85 mm) (top) and the specimen T23 (total length 17.20 mm), bottom. Distance from the umbo in mm.

spec.), T74 (1 spec.), T75 (4 spec.), T76 (1 spec.), T97 (2 spec.), T108 (2 spec.), T157 (3 spec.), T 215 (1 spec.);

unit 8, MPUM 11379 - 3 specimens: T63 (2 spec.), T158 (1 spec.).

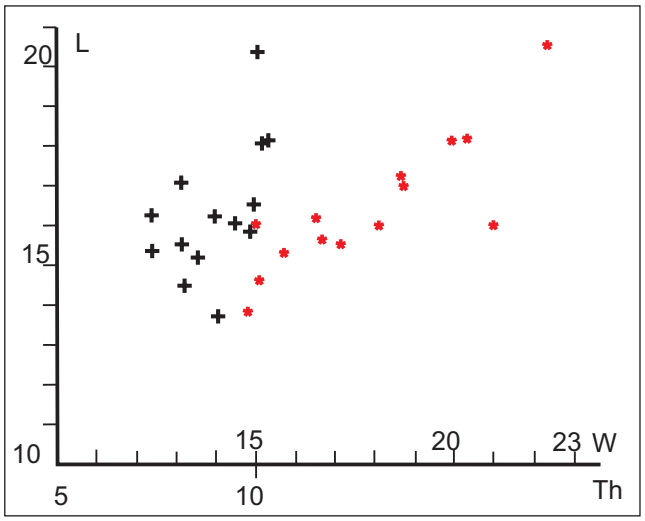


Fig. 4 - *Austriellula kavakensis* (Arthaber, 1914). Plot in mm of the Length (L) versus Width (W) (red *) and of Length versus Thickness (Th) (black +).

Description. Biconvex, medium sized shell, subpentagonal in outline; width slightly exceeding length; shell substance very thick. Maximum thickness at about mid-length. Ventral valve with small umbo, pierced by a very small foramen; in juvenile specimens a small delthyrium is visible. Dorsal valve usually slightly thicker than the ventral valve, with rectimarginate to gently unisulcate commissure. Shell smooth with marked growing lamellae, more prominent near the front.

Interior of ventral valve (Fig. 3) with umbonal cavities filled with secondary shell material. Dental lamellae very short, incomplete, convergent towards the valve floor or fused with the lateral wall. Lateral denticula occasionally developed. Teeth massive, dorsally expanded and crenulated. Interior of dorsal valve with subhorizontal, short hinge plates, partly subdivided by aV-shaped sulcus. Sockets large, in some specimens crenulated. Crural base round, stout. Crura arcuiform, terminally turning towards the interior of the ventral valve. Muscle scar not visible, hidden by thick shell in the posterior part of the specimen.

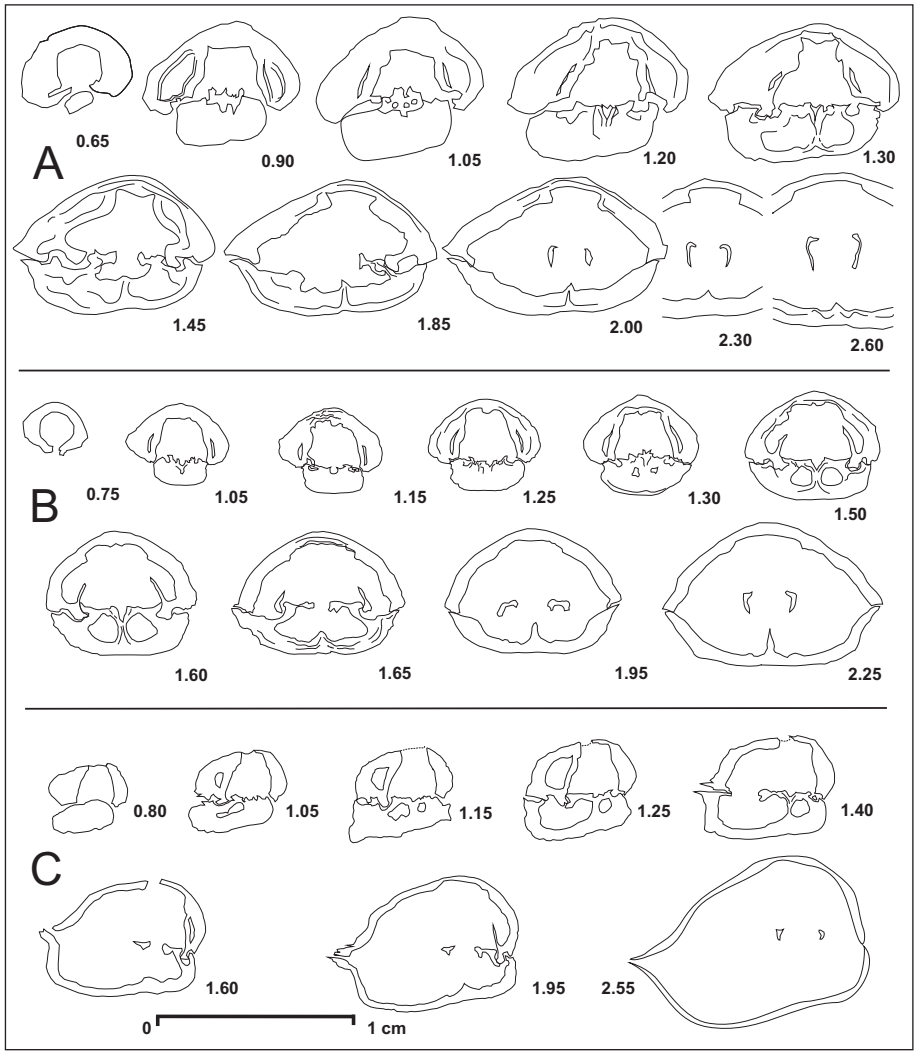


Fig. 5 - *Holchorhynchella edhemi* (Toula, 1896). Serial sections of the specimens: MPUM 11373 T93/2 (A, total length 17.25 mm), T36/11 (B, total length 14.45 mm), T6/2 (C, total length 14.10 mm). Distance from the umbo in mm.

Dimensions (in mm) (Fig. 4). L = Length; W = Width: Th = Thickness.

specimen	L	W	Th
T75/1	14.4	15.1	8.2
T36/1	15.2	15.8	8.6
T16/1	18.0	19.9	10.1
T158/1	16.2	18.7	8.6
T22/1	20.3	22.4	>9.6
T22/2	18.0	20.6	10.1
T37/1	15.3	17.2	7.3
T42/1	17.1	19.0	8.1
T47/1	16.5	16.4	9.9
T59/1	15.5	16.6	8.1
T93/1	15.9	15.0	10.1
T97/1	16.2	18.1	>7.3
T200/1	13.7	14.8	9.0

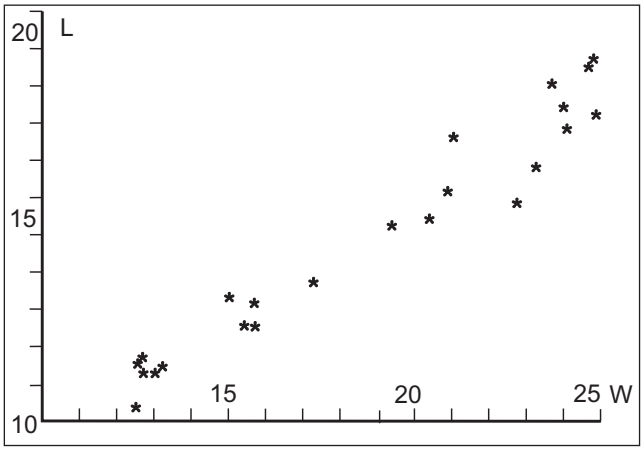


Fig. 6 - *Holchorhynchella edhemi* (Toula, 1896). Plot in mm of Length (L) versus Width (W).

Remarks. *A. kavakensis* has all the characters of the genus *Austriellula*, a genus widely distributed in the Carnian and Norian (Siblík 1982). According to Savage et al. (2002) and Manceñido & Owen (2001), the occurrence of the genus in the Middle Triassic is doubtful.

A. kavakensis is the most ancient species so far known for this stock of smooth brachiopods.

Occurrence. At present it is known only from the Gebze area (Tepeköy Formation), mostly from the Bithynian, both from the Osmani and Ismidicus zones, and it is very rare in the early Pelsonian Balatonicus Zone.

Subfamily Holchorhynchellinae Xu, 1990

Holchorhynchella edhemi (Toula, 1896)
Figs 5, 6, Pl. 2, figs 1- 9

1896 *Rhynchonella Edhemi* Toula: 158, pl. 18, figs 8-10, 12.
1896 *Rhynchonella Edhemi* n. sp. var. *plicata* Toula: 159, pl. 18, fig. 11.
1914 *Rhynchonella edhemi* – Arthaber: 195, pl. 18, figs 12-13.
1914 *Rhynchonella edhemi* var. *robusta* Arthaber: 195, pl. 18, fig. 14.
1914 *Rhynchonella edhemi* var. *plana* Arthaber: 195, pl. 18, fig. 15.
1914 *Rhynchonella protractifrons* – Arthaber: 19, pl. 18, fig. 11,
1974 *Holchorhynchella edhemi* - Dagys: 110.
2010 *Holchorhynchella edhemi plicata* – Siblík: 66, pl. 2, fig. 2.

Lectotype: Toula 1896, pl. 18, figs 8, housed in Vienna in the collections of the Geologische Bundesanstalt No. GBA 1896/002/0003/02. Other paralectotypes: Pl. 18, Fig. 9, GBA 1896/002/0003/03; Pl. 18, Fig. 10GBA 1896/002/0003/04: Pl. 18, Fig. 12 - GBA 1896/002/0003/05, and two specimens no figured: GBA 1896/002/0003/06, and GBA 1896/002/0003/07. Further nine specimens are stored in Vienna under the number GBA 1896/002/0003. The specimen described by Toula (1896) as *Rhynchonella edhemi* var. *plicata* is housed in Vienna, collection GBA 1896/002/0003/1.

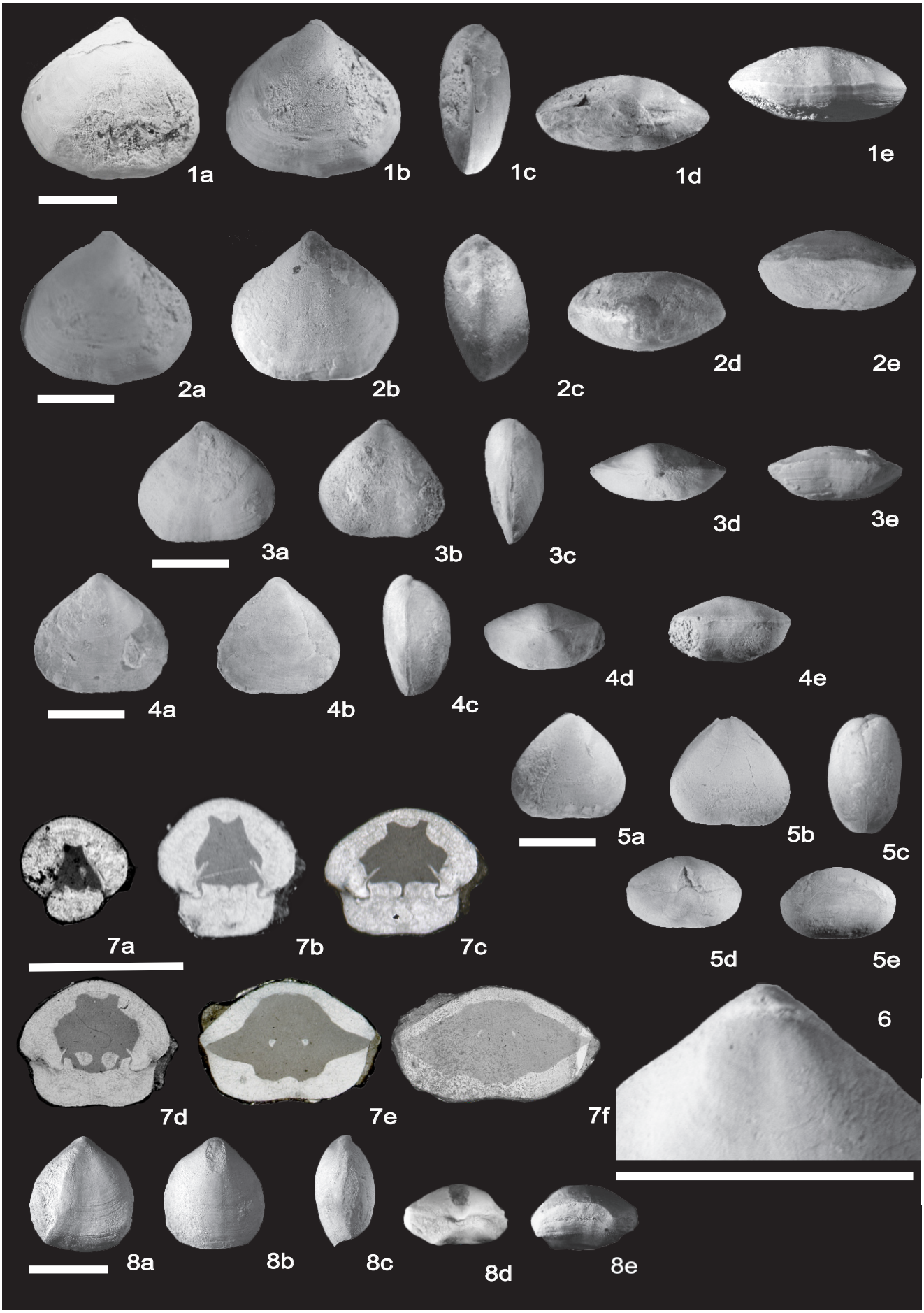
Material: Eighty articulated specimens originating from:
unit 5, MPUM 11373 - 47 specimens: T14 (5 spec.), T15 (2 spec.), T17 (1 spec.), T22 (5 sp.), T23 (10 spec.), T25 (1 spec.), T35 (2 spec.); T36 (7 spec.), T93 (14 spec.);
unit 6, MPUM 11376 - 2 specimens: T29 (1 spec.), T163 (1 spec.);
unit 7, MPUM 11377 - 21 specimens: T42 (1 spec.), T61 (1 spec.), T62 (3 spec.), T76 (1 spec.), T126 (1 spec.), T157 (4 spec.), T159 (7 spec.) T161 (3 spec.);
unit 8, MPUM 11380 - 7 specimens: T6 (1 spec.), T 63 (4 spec.), T158 (2 spec.);
near Eskihisar, MPUM 11406 T 217 (1 spec.).

Description. Medium sized biconvex shell; width exceeds length; thickness is about ½ of the width; anterior commissure markedly uniplicate. The ventral valve has a small umbo, with a small foramen in the adults, while it is larger and with a pedicle collar in the juveniles, and closed by triangular deltidial plates. Sulcus well defined by lateral shoulders with a frontal linguiform extension. The dorsal valve may have in its posterior part a weak depression that gives origin to a fold at about 2/3 of the valve length. Shell smooth or rarely with 2-3 very gentle undulations in the median part of the frontal commissure. Flanks usually smooth, but few specimens show 1-2 faint costae near the commissure. Growth lines often well defined, especially near the anterior part. Micrornament consisting of prostrate spines.

Interior of ventral valve (Fig. 5) with lateral umbonal cavities filled by a secondary callus; dental plates obliquely directed and poorly expressed for most of their development, because of callus infilling. Teeth massive, laterally inserted in large sockets, weakly crenulated; large and rounded diductor muscle scars, sorrounding a narrow and elongate adductor field. Interior of dorsal valve with horizontal hinge plates well separated from inner socket ridges. Fairly deep V-shaped septalium, posteriorly connected with thick, but short median septum. Broad falcifer-like crura, initially semicircular and concave towards each other in cross section, terminally flattened and dorsally converging or subparallel, best classified as of calcariform-type according to Savage et al. (2002, fig. 702/4); weakly pronounced adductor field, divided by a myophragm.

PLATE 1

Austriellula kavakensis (Arthaber, 1914).
Fig. 1 - a-e - MPUM 11372 T22/1. Dorsal, ventral, lateral, posterior and frontal views, respectively.
Fig. 2 - a-e - MPUM 11372 T16/1. Dorsal, ventral, lateral, posterior and frontal views, respectively.
Fig. 3 - a-e - MPUM 11375 T37/1. Dorsal, ventral, lateral, posterior and frontal views, respectively.
Fig. 4 - a-e - MPUM 11378 T75/1. Dorsal, ventral, lateral, posterior and frontal views, respectively.
Fig. 5 - a-e - MPUM 11375 T 200/1. Dorsal, ventral, lateral, posterior and frontal views, respectively.
Fig. 6 - MPUM 11378 T74. The small foramen denotes the poorly efficient pedicle attachment.
Fig. 7 - a-f - MPUM 11379 T63/4. Serial sections. Distance from the umbo in mm. 7a) 0.65; 7b) 1.15; 7c) 2.00; 7d) 2.75; 7e) 3.35; 7f) 4.75.
Scale bar 5 mm.
Angustothyris angustaeformis (Böckh, 1872).
Fig. 8 - a-e - MPUM 11405 T93. Dorsal, ventral, lateral, posterior and frontal views, respectively.
Scale bar 10 mm, unless otherwise indicated.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Dimensions, in mm (Fig. 6). L= Length; W= Width; Th = Thickness; WS = Width of the sulcus.

specimen	L	W	Th	WS
T14/2	18.4	24.0	9.9	14.2
T15/1	15.7	22.8	8.5	12.8
T15/2	15.2	19.3	9.4	11.3
T22/1	18.2	24.9	8.6	13.4
T22/2	19.1	23.7	11.3	13.9
T22/3	15.4	20.4	7.9	7.7
T25/1	17.6	24.2	9.4	12.9
T35/1	12.5	15.6	6.3	8.5
T35/2	19.6	24.6	11.9	15.1
T42	17.6	21.0	13.5	12.8
T62/1	13.4	15.0	9.1	8.2
T63/1	11.4	12.7	4.9	9.0
T63/2	11.5	13.2	7.1	7.8
T63/3	13.1	15.6	6.6	9.9
T63/4	11.6	12.4	5.7	8.0
T93/1	19.6	24.8	10.7	15.5
T93/3	16.7	23.4	10.8	13.7
T159/1	12.6	14.6	8.3	9.4
T161/1	11.8	13.1	6.1	9.2
T163	12.3	13.9	-	8.9

Remarks. The presence of a pedicle collar in the juveniles and the reduced size of foramen in the adults suggests that the pedicle was functional in the juveniles, while gradually reducing its function with the growth.

The fairly large collection enable to consider the lateral plications that occasionally occur near the front in some specimens from units 7 and 8, as a variabile feature of the species. These specimens match the var. *plicata* of Toula (1896, fig. 11). The internal features agree with those of the nominative species (Fig. 5, C). The varieties *plana* and *robusta* of Arthaber (1914) simply represent different ontogenetic stages of the species.

Some differences occur in comparison to the type species of the genus, *H. delicatula* (Bittner, 1890). In *H. edhemi,* the pedicle collar occurs in the juveniles and the delthydial plates are not disjunct. The crura are different in the terminal stage, being arcuate (prefalciform according to the classification of Savage et al. 2002) and not calcariform as reported in Dagys (1974, fig. 74). *Uniplicatorhynchia* Sun & Ye, 1982 is somewhat similar, but it does not have the initial depression in the dorsal valve and it differs in having a less deep sulcus and apparently smaller crura.

Occurrence. *H. edhemi* is known only from the Gebze area, from unit 5 to the lowermost part of unit 8 of the Nodular Limestone (Tepeköy Formation).

Superfamily, family, and genus unknown

"Rhynchonella" tscharkensis Arthaber, 1914
Pl. 2, figs 10 a-d, 11 a-b.

1914 *Rhynchonella tscharkensis* Arthaber, 195, pl. 18, fig. 16

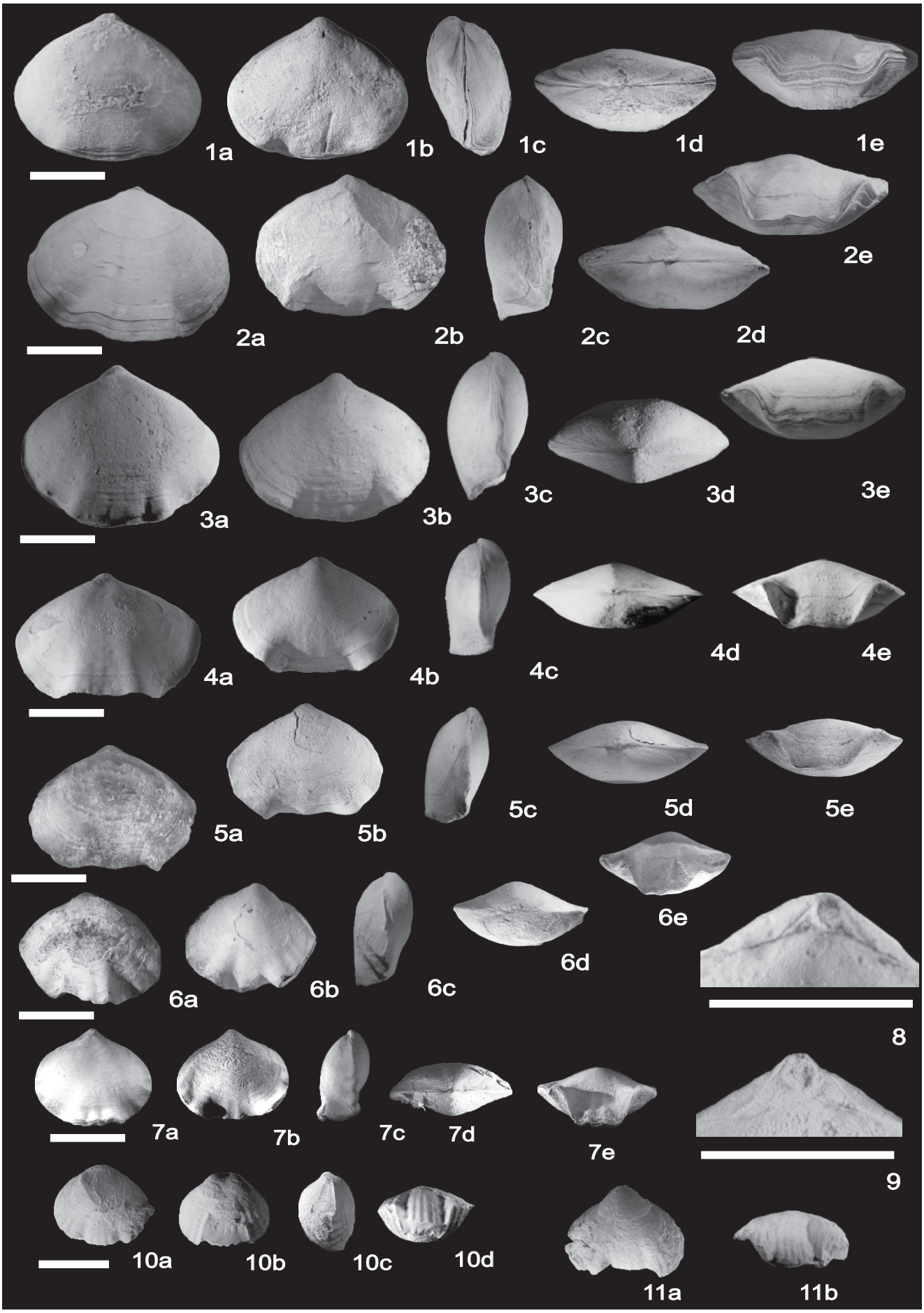
Material: Two articulated specimens MPUM 11374 (T5 - 1 spec., T6 - 1 spec.) (Assereto 1972: 441).

Description. Small sized, biconvex rhynchonellids, with strongly uniplicate anterior commissure; outline slightly larger than long. Ventral beak small and curved on the hinge; sulcus of ventral valve starting at mid-length. Dorsal valve slightly depressed near the umbo, then gradually transformed into a fold anteriorly.

Shell smooth up to 2/3 of the length, then 4-5 fine costae appear in the median part and 4-5 on each flank.

PLATE 2

Holchorhynchella edhemi (Toula, 1896).
Fig. 1 - a-e - MPUM 11373 T22/2. Dorsal, ventral, lateral, posterior and frontal views, respectively.
Fig. 2 - a-e - MPUM 11373 T93/1. Dorsal, ventral, lateral, posterior and frontal views, respectively.
Fig. 3 - a-e - MPUM 11373 T35/1. Dorsal, ventral, lateral, posterior and frontal views, respectively.
Fig. 4 - a-e - MPUM 11373 T15/1. Dorsal, ventral, lateral, posterior and frontal views, respectively.
Fig. 5 - a-e - MPUM 11373 T22/3. Dorsal, ventral, lateral, posterior and frontal views, respectively.
Fig. 6 - a-e - MPUM 11377 T76. Dorsal, ventral, frontal, lateral and posterior views, respectively.
Fig. 7 - a-e - MPUM 11380 T63/3. Dorsal, ventral, frontal, lateral and posterior views, respectively.
Fig. 8 - MPUM 11380 T63/3. Detail of the foramen with pedicle collar and fused delthyrial plates.
Fig. 9 - MPUM 11377 T159. Detail of the foramen with pedicle collar and fused delthyrial plates.
"Rhynchonella" tscharkensis Arthaber, 1914.
Fig. 10 - a-d - MPUM 11374 T5. Ventral, dorsal, frontal and lateral views, respectively.
Fig. 11 - a-b - MPUM 11374 T6. Ventral and dorsal views.
Scale bar 10 mm.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11b

Occurrence. At present this species is known only from the upper part of the unit 8 (Tepeköy Formation) of the Gebze area, Illyrian in age. The specimen of Arthaber (1914) originates from the locality of Tepeköy.

Order **Spiriferinida** Ivanova, 1972
Suborder **Spiriferinidina** Ivanova, 1972
Superfamily Mentzelioidea Dagys, 1974 (nom. transl. Sun and Ye, 1982)
Family Mentzeliidae Dagys, 1974 (nom. transl. Sun and Ye, 1982)
Genus *Koeveskallina* Dagys, 1965

Koeveskallina koeveskalyensis (Stur, 1865)

Spiriferina Köveskályensis sp. nov. Stur: 245.
2015 *Koeveskallina koeveskalyensis* – Gaetani & Mantovani: 173, figs 2D, 7-B, pl. 2, figs 4-11 (cum syn.).

Material: Two disarticulated specimens (MPUM 8689 - T282) from the "Rosso Ammonitico" unit of Assereto (1972).

Remarks. For description and discussion see Gaetani & Mantovani (2015).

Occurrence. *K. koeveskalyensis* is a widespread species in the Pelsonian and Illyrian of Southern Alps (Bittner 1890; Gaetani & Mantovani 2015), Balaton (Pálfy 1993, 2003), Dinarids (Bittner 1903), Bulgaria (Benatov 2001), Dobrogea (Jordan 1993), Caucasus (Dagys 1974) and Himalaya (Bittner 1899).

Subfamily Tethyspirinae Carter in Carter et al., 1994
Genus *Ptychomentzelia* Gaetani & Mantovani, 2015

Ptychomentzelia propontica (Toula, 1896)

1896 *Spiriferina* (*Mentzelia*) *Mentzelii* var. *propontica* var. nov. Toula: 159, pl. 18, fig. 7a-e.
2015 *Ptychomentzelia propontica* – Gaetani & Mantovani: 178, figs 2G, 10, pl. 4, figs 4-8 (cum syn.).

Material: 60 articulated specimens and 11 disarticulated, (9 ventral and 2 dorsal valves) originating from:
unit 3, MPUM11407 - T9 (2 spec.); MPUM 8617 - T13 (1 spec.);
unit 4, MPUM 8625 - T140 (1 spec);
unit 5, MPUM 8617 - T14 (1 spec.); MPUM 11408 - T15 (3 spec.); MUPM 8617 - T17 (3 spec.); MUPM 8617 - T22 (7 spec.); MPUM 8619 - T23 (12 spec.); MPUM 11408 - T28 (1 spec.); MPUM 11408 - T35 (1 spec.); MPUM 11408 - T36 (4 spec.); MPUM 11408 - T55 (1 spec.); MPUM 11408 - T56 (4 spec.); MPUM 11408 - T57 (1 spec.); MPUM 11408 - T141 (1 spec.);
unit 6, MPUM 8617 - T29 (4 spec.); MPUM 8617 - T33 (1 spec.); MPUM 8617 - T75 (2 spec.); MPUM 8617 - T108 (1 spec.); MPUM 11409 - T123 (1 spec.); MPUM 8618 - T125 (1 spec.); MPUM 8617 - T126 (1 spec.); MPUM 8617 - T152 (2 spec.); MPUM 11409 - T162 (1 spec.); MPUM 8617 - T198 (1 spec.);
unit 7, MPUM 8615 - T40 (3 spec.); MPUM 11557 - T53 (1 spec.); MPUM 8620 - T76 (2 spec.); MPUM 8617 - T97 (2 spec.); MPUM 11557 - T129 (1 spec.); MPUM 8616 - T163 (3 spec.);
unit 8, MPUM 11558 - T63 (1 spec.); MPUM 11558 T64 (1 spec.).

Remarks. For description and discussion, see Gaetani & Mantovani (2015).

Occurrence. *P. propontica* is known only from the Gebze area (Tepeköy Formation). It is rare in the Aegean, is spread in the Bithynian, Osmani and Ismidicus zones and its last occurrence is in the basal Pelsonian, Balatonites Zone.

Order **Terebratulida** Waagen, 1883
Suborder **Terebratulidina** Waagen, 1883
Superfamily Dielasmatoidea Schuchert, 1913
Family Angustothyrididae Dagys, 1972
Genus *Angustothyris* Dagys, 1972

Angustothyris angustaeformis (Böckh, 1872)
Pl. 1, figs 8 a-e

1872 *Waldheimia angustaeformis* Böckh: 160, pl. 21, fig. 20.
1890 *Waldheimia angustaeformis* – Bittner: 8, 52, pl. 36, figs 37–40.
1914 *Waldhemia angustaeformis* – Arthaber: 194, pl. 18, fig. 10.
1983 *Angustothyris angustaeformis* – Popiel-Barczyk & Senkowiczowa: 87, pls. 1-4.
1997 *Angustothyris angustaeformis* - Torti & Angiolini: 168, pl. 1, figs 35–36, pl. 2, fig. 5.
2003 *Angustothyris ? angustaeformis* – Pálfy: 153, pl. 1, figs 32-33.

Material: One articulated specimen (MPUM 11405 T93) from unit 5 (Tepeköy Formation) of Assereto (1972).

Description. Medium-sized, biconvex shell, subpentagonal in outline. Ventral valve slightly more convex than the dorsal one. Greatest width of shell attained at mid-length. Beak erect; foramen circular, mesothyridid. Gently arched beak ridges reach the lateral margin. Greatest convexity in the middle part of the ventral valve. Dorsal valve with

broad rounded sulcus, developing near the umbo, bounded by rounded ridges. Smooth shell surface, with weak growth lines.

Dimensions (in mm). Length 14.20; width 13.15; thickness 7.70 mm.

Remarks. Due to the single available specimen, it is not possible to discuss the correct generic attribution, as also noted by Pálfy (2003).

Occurrence. *A. angustaeformis* is spread in the Pelsonian and Illyrian of Europe, Balaton (Pálfy 2003), Southern Alps (Torti & Angiolini 1997), Poland (Popiel-Barczyk & Senkowiczowa 1983), Bulgaria (Benatov 2001) up to South China, where is reported also in the Aegean and Bithynian (Chen et al. 2015).

Conclusions

The brachiopod fauna collected by Assereto (1972, 1974) in the Anisian succession of the Gebze area is here updated. The revised fauna is largely represented by an endemic assemblage, with two rhynchonellid species and one spiriferinid.

Most of the brachiopods here studied are smooth forms with a small foramen at the adult stage, which are found articulated in nodular limestone deposited at depth below the storm wave base.

The fauna is unique within the Bithynian brachiopod fauna described from localities in Western Tethys.

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