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Eocene micromorphic brachiopods from north-western Hungary

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Abstract: Seven micromorphic brachiopod species belonging to six genera are identified in Middle and Upper Eocene deposits from north-western Hungary. One species is new, namely *Argyrotheca tokodensis* sp. nov. The species *Novocrania bayaniana* (Davidson, 1870), *Orthothyris pectinoides* (von Koenen, 1894), *Argyrotheca michelottina* (Davidson, 1870) and *Lacazella mediterranea* (Risso, 1826) are reported for the first time from the Hungarian Eocene localities, while *Terebratulina tenuistriata* (Leymerie, 1846) and *Megathiris detruncata* (Gmelin, 1791) were already noted from the Eocene deposits of Hungary.

Key words: Hungary, Eocene, Tethys, Brachiopoda, *Novocrania*, *Terebratulina*, *Orthothyris*, *Megathiris*, *Argyrotheca*, *Lacazella*, new species.

Introduction

The Eocene brachiopods of Hungary are poorly known. Meznerics (1943), in her paper on Tertiary brachiopods, listed the following species from the Eocene deposits of Hungary: *Hemithiris polymorpha* (Massalongo, 1850), *Terebratulina striatula* Sowerby, 1829, *T. plana* Meznerics, 1943, *Megathiris decollata* (Chemnitz, 1785), *Magellania hilarionis* (Davidson ex Meneghini, 1870), *M. hilarionis* var. *novalensis* (Fabiani, 1913), *M.* (s.l.) *hantkeni* Meznerics, 1943 and *M.* ? *gibbosa* Meznerics, 1943. Since this publication, Hungarian Eocene brachiopods have never been re-described or revised. The aim of the present paper is to describe a new Eocene brachiopod fauna from north-western Hungary. This material contains only micromorphic forms.

It is worth mentioning that another Eocene brachiopod assemblage from the nummulitic limestones of the Bakony Mts, Transdanubian Central Range, Hungary now under study (Bitner, Dulai & Galácz, in preparation) has a quite different composition, characterized by larger-sized, smooth terebratulides.

Geological setting and the studied material

During the Early Paleogene, the Alcapa terrain (the area north of the Zagreb-Zemplén line, including the Alps, the Carpathians and the Pannonian Basin) was situated to the south-west of its present position (Kázmér et al. 2003). Four large basins (Outer Carpathian Flysch Basin, Inner Carpathian Flysch Basin, Transylvanian Basin and Hungarian Paleogene Basin) which existed within this terrain had connection with each other and the world oceans. One of these basins, the Hungarian Paleogene Basin, which included the present-day Transdanubian Central Range and Northern Hungarian Range, was connected to the northern Italian basins through the so-called Slovenian corridor, as proved by sedimentological and paleontological data (Báldi 1984, 1986). All the studied Eocene brachiopod-bearing deposits belong to the Transdanubian Central Range (Fig. 1). The Paleogene formations of this area were deposited during one large sedimentary cycle (Báldi-Beke & Báldi 1991).

The studied area became emergent after the Cretaceous and no marine sediments of the Paleocene and Early Eocene age are known. Several transgressive-regressive sequences characterize the Middle Eocene which attains a thickness of 200–400 m. The transgressions arrived from S-SW, therefore the sedimentation started at the Zala Basin and Southern Bakony during the early Lutetian (Császár 1997) (Fig. 2). The sea reached the NE-Bakony and Tatabánya Basin during the early Bartonian, while it reached the Buda Mountains and Northern Hungarian Range in the Priabonian (Báldi-Beke 1984).

The initial coal-bearing, terrigenous Darvastó Formation passes upward into the Middle Eocene Szőc Limestone, known from the Southern Bakony to the Vértes Mts. The grey or yellowish grey limestone is interpreted as having been deposited in shallow, warm water and under normal salinity conditions (sublittoral platform facies) (Kopek 1980). The large foraminifers (*Nummulites*, *Alveolina*, *Assilina*, *Discocyclina*) are often rock-forming. The Szőc Limestone also contains numerous but not diverse larger-sized brachiopods, which will be the subject of a separate paper (Bitner, Dulai & Galácz, in preparation). However, micromorphic brachiopods were also found in the marly layers of this formation, both in outcrops and boreholes (Magyarpolány-40, Ajka, Pénzesgyőr, Hárskút HKt/c, Dudar-218, Úrhida-1) (see Figs. 1, 2). The overlying (or sometimes interfingering) Middle and Upper Eocene Padrag Marl Formation is a grey, silty marl interpreted as shallow bathyal. In the Eastern Bakony Mts, this formation is present in the boreholes Balinka-224 and Balinka-239 but the same formation also crops out in the Gerecse Mts (Mogyorósbánya-87, Tokod) (see Figs. 1, 2). The Upper Eocene (Priabonian) Szépvölgy Limestone consists of grey limestone and calcareous marl interpreted as sublittoral platform facies. Brachiopods were found at several localities in this formation (Úrhida, Neszmély, Budapest, Csillag-hegy). Tectonically enhanced subsidence (Fodor et al. 1992) produced a thin limestone sequence, overlain by thick marl of shallow bathyal origin. The Upper Eocene–Lower Oligocene Buda Marl can be observed in the Buda Hills and the Northern Hungarian Range. The lower part of the formation consists of marl of shallow bathyal origin, and sometimes contains a large amount of bryozoans. One specimen comes from the Buda Marl of the Buda Hills, but the exact locality is unknown.

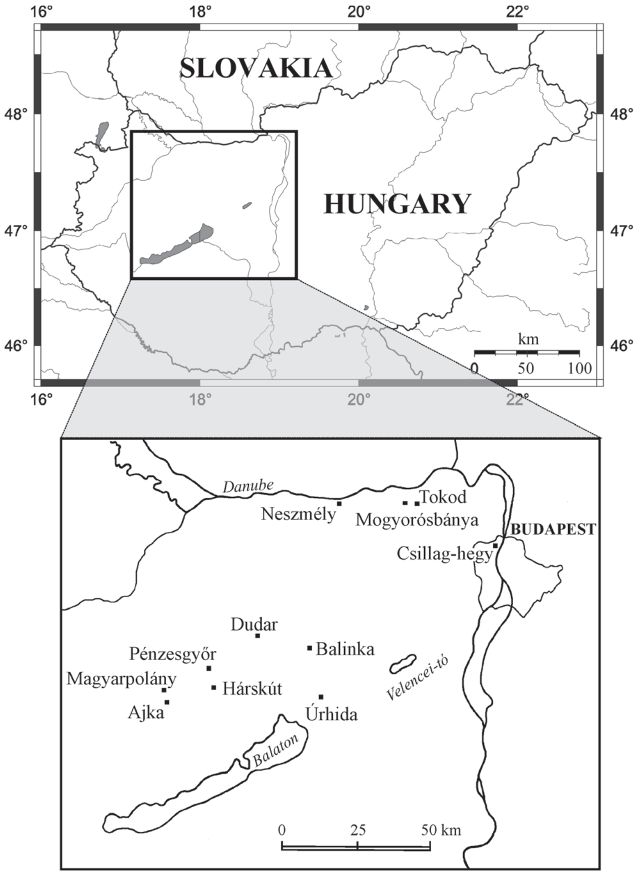

Fig. 1. Sketch map, showing the location of the studied outcrops and boreholes.

The investigated brachiopod material, consisting of 262 specimens (166 articulated specimens and 96 separate valves), comes from 7 outcrops, namely Ajka (one sample), Pénzesgyőr, Ree-hegy (12 samples), Úrhida (one sample), Tokod (4 samples), Neszmély (one sample), Budapest, Csillag-hegy (3 samples), and Budapest, Buda Hills (without exact locality, one sample), and from 7 boreholes, namely Magyarpolány-40 (one sample), Hárskút, Hkt/c (one sample), Dudar-218 (5 samples), Balinka-224 (one sample), Balinka-239 (one sample), Úrhida-1 (two samples) and Mogyorósbánya-87 (2 samples) (Figs. 1, 2) in the Szőc Limestone, Padrag Marl, Szépvölgy Limestone and Buda Marl Formations. Most of the studied specimens are articulated (63.6 %), nevertheless some specimens are damaged and a few are eroded.

The material under study is housed in the collections of the Department of Geology and Paleontology of the Hungarian Natural History Museum, Budapest under the inventory numbers 2006.16.1–2006.48.1, with the exception of *Novocrania bayaniana* (collection of the Hungarian Geological Institute, E.5174).

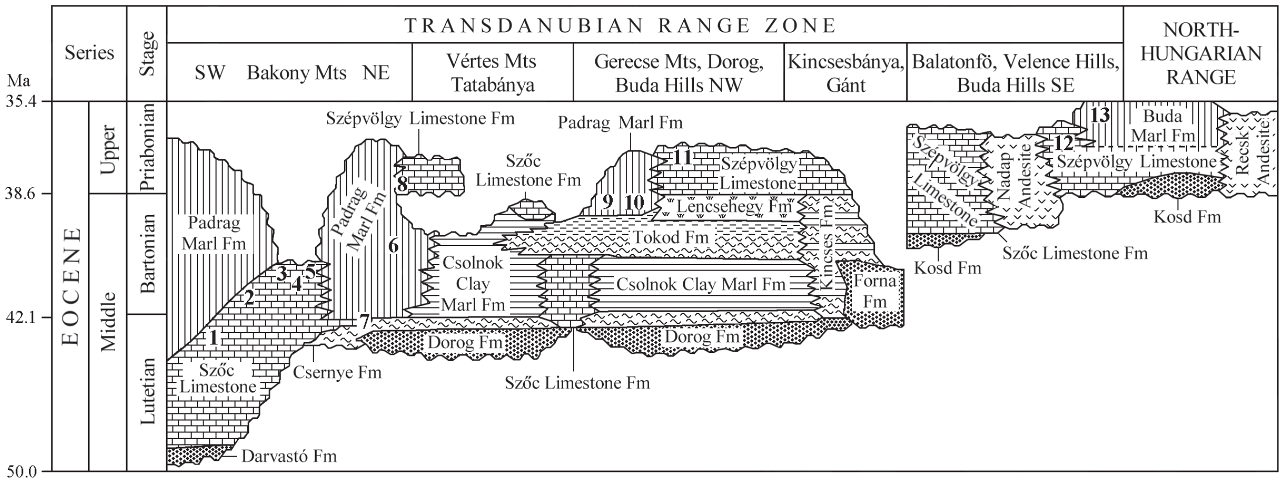

Fig. 2. Lithostratigraphic units of the Hungarian Middle and Upper Eocene (modified after Császár 1997). The numbers indicate the following localities and boreholes: 1 — Magyarpolány-40; 2 — Ajka; 3 — Pénzesgyőr, Ree-hegy; 4 — Hárskút, Hkt/c; 5 — Dudar-218; 6 — Balinka-224 and -239; 7 — Úrhida-1; 8 — Úrhida; 9 — Mogyorósbánya-87; 10 — Tokod; 11 — Neszmély; 12 — Budapest, Csillag-hegy; 13 — Buda Hills, Buda Marl.

Systematic part

Phylum: **Brachiopoda** Duméril, 1806
Subphylum: **Craniiformea** Popov, Bassett, Holmer & Laurie, 1993
Class: **Craniata** Williams, Carlson, Brunton, Holmer & Popov, 1996
Order: **Craniida** Waagen, 1885
Superfamily: **Cranioidea** Menke, 1828
Family: **Craniidae** Menke, 1828
Genus: *Novocrania* Lee & Brunton, 2001

Type species: *Patella anomala* Müller, 1776.

Novocrania bayaniana (Davidson, 1870)
Fig. 3.1–2

1870 *Crania Bayaniana* Davidson, p. 464, pl. 21, fig. 20, 20a
1901 *Crania Bayaniana* Davidson — Oppenheim, p. 260
1908 *Crania bayaniana* Davidson — Fabiani, p. 60
1913 *Crania bayaniana* Davidson — Fabiani, p. 11, pl. 4, fig. 19
1992 *Crania bayaniana* Davidson — Altichieri, p. 214, pl. 2, figs. 9, 10

Material: One dorsal valve from Budapest, Buda Hills (E.5174).

Dimensions: Length 6.0 mm, width 6.2 mm.

Remarks: The investigated material, although poorly preserved and very limited, is consistent with the specimens from the Upper Eocene of Italy, described as *Crania bayaniana* (see Davidson 1870; Fabiani 1913; Altichieri 1992). The valve is weakly convex with a posterior margin straight and beak situated posterocentrally. The shell surface is eroded but concentric growth lines and fine pustules are visible on the better preserved parts. The marginal rim is very broad, tuberculate. The posterior adductor muscle scars are large, rounded and widely separated. The anterior adductor scars are small, transversally oval and joined medially.

N. bayaniana can be distinguished from other Eocene craniid species by its very wide marginal rim. From the Middle Eocene *Crania fabianii* Dainelli *in* Fabiani 1913, of NE Italy, *N. bayaniana* differs also in being much smaller and in its shell surface which in *C. fabianii* lacks any pustules (Fabiani 1913; Dainelli 1915).

The investigated specimen is easily distinguishable from another Italian Late Eocene species, *Venetocrania euganea* Bitner & Dieni, 2005. The latter species has a rough, irregular shell surface and a different muscle scar pattern with very large posterior adductor muscle scars and anterior adductor muscle scars in the form of narrow, high ridges (Bitner & Dieni 2005).

This is the first record of *N. bayaniana* from Hungary.

Occurrence: This species was previously noted from the Upper Eocene of Italy (Davidson 1870; Altichieri 1992).

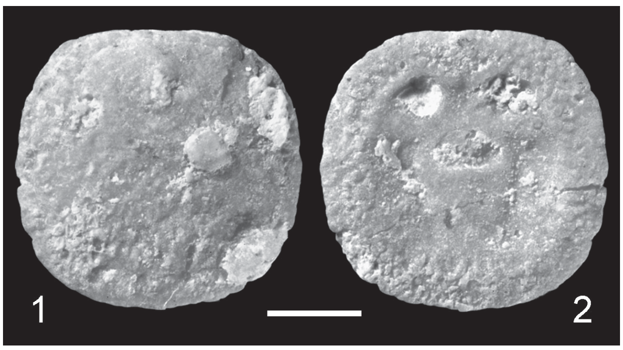

Fig. 3. 1–2 — *Novocrania bayaniana* (Davidson, 1870), dorsal valve, E.5174, Upper Eocene, Budapest, Buda Hills; 1 — outer view, 2 — inner view. Scale bar: 2 mm.

Subphylum: **Rhynchonelliformea** Williams, Carlson, Brunton, Holmer & Popov, 1996
Class: **Rhynchonellata** Williams, Carlson, Brunton, Holmer & Popov, 1996
Order: **Terebratulida** Waagen, 1883
Superfamily: **Cancellothyridoidea** Thomson, 1926
Family: **Cancellothyrididae** Thomson, 1926
Subfamily: **Cancellothyridinae** Thomson, 1926
Genus: *Terebratulina* d'Orbigny, 1847

Type species: *Anomia retusa* Linnaeus, 1758.

Terebratulina tenuistriata (Leymerie, 1846)
Fig. 4.1–8

2000 *Terebratulina tenuistriata* (Leymerie) — Bitner, p. 118–120, figs. 2, 3, 4A–F, 5A–G (*cum syn.*)

Material: 39 complete specimens, five ventral valves and five dorsal valves from Ajka; 30 complete specimens, 6 ventral valves and 2 dorsal valves from Pénzesgyőr, Ree-hegy; fragment of ventral valve from the borehole Hárskút; 68 complete specimens and one dorsal valve from the borehole Dudar-218; one complete specimen from the borehole Balinka-224; 6 complete specimens and one broken dorsal valve from the borehole Úrhida-1; three complete specimens from Úrhida; one complete specimen from the borehole Mogyorósbánya-87; three juvenile complete specimens from Budapest, Csillag-hegy, Ibolya street. Many specimens are eroded, in some cases damaged and/or crushed. There are also many fragments.

Dimensions (in mm):

Specimen No.	Length	Width	Thickness
2006.16.1	7.0	6.5	2.7
2006.17.1	2.4	1.7	0.7
2006.18.1	4.1	3.5	1.4
2006.19.1	4.4	3.5	1.6
2006.20.1	6.3	5.5	2.0
2006.21.1	5.6	4.4	2.0
2007.21.1	10.5	6.1	–

Remarks: The presence of this species in the Eocene of Hungary was already reported by Meznerics (1943) who described it under the name *Terebratulina striatula* Sowerby, 1829. However, the specific name *striatula* is not

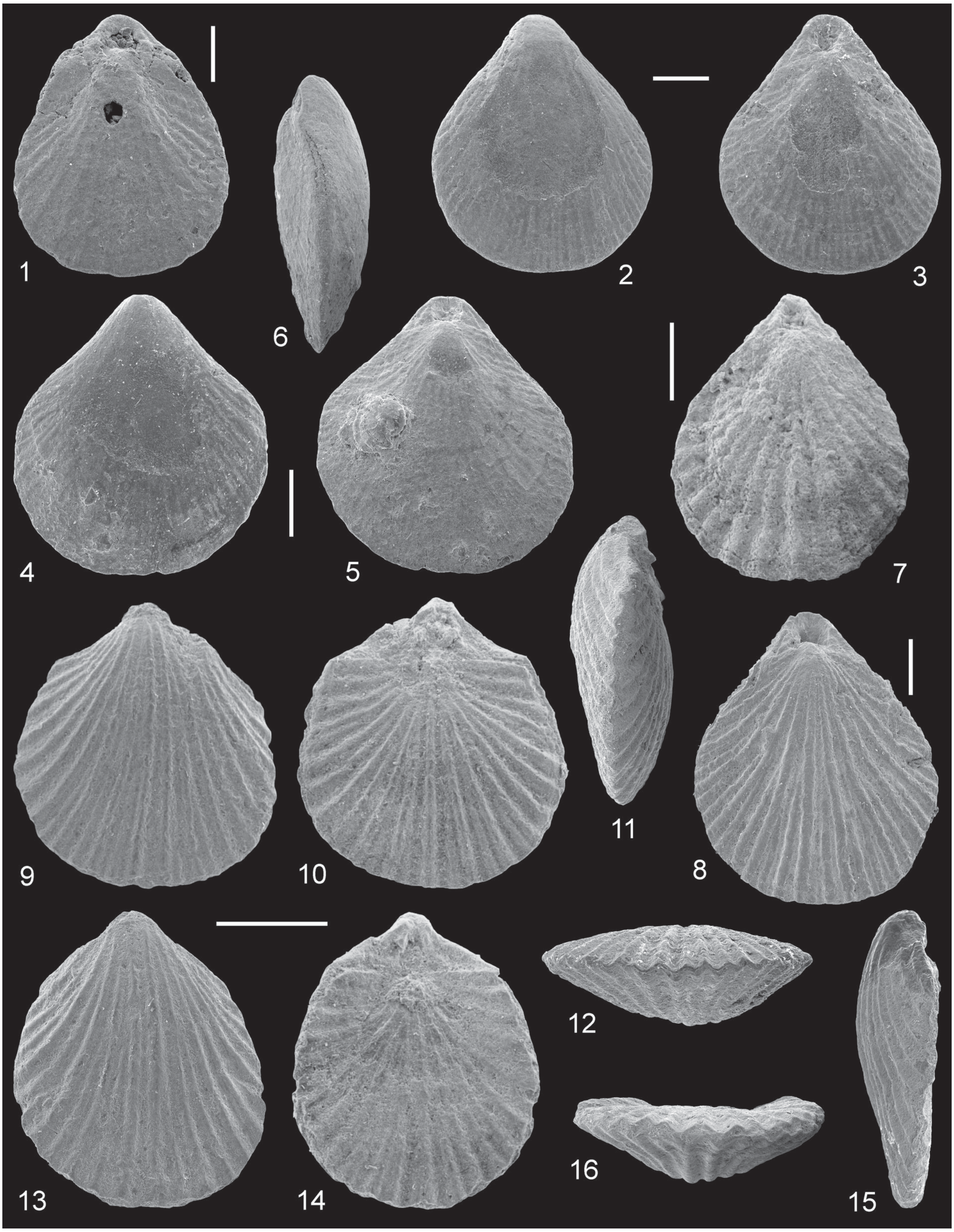

Fig. 4. 1–8 — *Terebratulina tenuistriata* (Leymerie, 1846). 1 — Dorsal view of complete specimen, 2006.17.1, Pénzesgyőr, Ree-hegy 65/91, Middle Eocene; 2–3 — Complete specimen, 2006.19.1, Pénzesgyőr, Ree-hegy 65/79, Middle Eocene, 2 — ventral view, 3 — dorsal view; 4–6 — Complete specimen, 2006.18.1, Pénzesgyőr, Ree-hegy 65/78, Middle Eocene, 4 — ventral view, 5 — dorsal view, 6 — lateral view; 7 — Dorsal view of complete specimen, 2006.33.1, Úrhida, Upper Eocene; 8 — Dorsal view of complete specimen, 2006.21.1, Ajka, Middle Eocene. **9–16** — *Orthothyris pectinoides* (von Koenen, 1894), Neszmély, Upper Eocene. 9–12 — Complete specimen, 2006.23.1, 9 — ventral view, 10 — dorsal view, 11 — lateral view, 12 — anterior view; 13–16 — Complete specimen, 2006.24.1, 13 — ventral view, 14 — dorsal view, 15 — lateral view, 16 — anterior view. Scale bars: 1 — 0.5 mm, 2–16 — 1 mm.

valid for the specimens from the Eocene, the name *tenuistriata* having priority (Bitner 2000; see also Owen 1988).

Terebratulina tenuistriata is one of the commonest species in the studied material (more than 100 specimens). The investigated specimens are consistent with those hitherto described (Leymerie 1846; Doncieux 1905, 1926; Elliott 1938; Bitner 2000), however they do not reach their size. The maximum observed length in the studied material is 10.5 mm. This species shows great variability in outline, from nearly circular, subpentagonal to elongate oval, a feature also observed in other populations of this species (Doncieux 1905, 1926; Bitner 2000). Both valves bear numerous, fine, smooth costae which are less numerous and clearly granular in young individuals.

Occurrence: *Terebratulina tenuistriata* is a very common and widely distributed species in the Eocene of Europe, being known from Great Britain (Elliott 1938), through Belgium (Davidson 1874; Vincent 1893), France (Leymerie 1846; Doncieux 1905, 1926), Spain (Bitner 2000), Italy (Davidson 1870), to Poland (Barczyk 1973; Popiel-Barczyk & Barczyk 1987) and Bulgaria (Gochev 1933). From Hungary it was noted by Meznerics (1943) from the localities of Bajót, Budapest-Zugliget, Szentgál.

Family: **Chlidonophoridae** Muir-Wood, 1959
Subfamily: **Orthothyridinae** Muir-Wood, 1965
Genus: *Orthothyris* Cooper, 1955

Type species: *Orthothyris radiata* Cooper, 1955.

Orthothyris pectinoides (von Koenen, 1894)
Fig. 4.9–16

1894 *Terebratulina pectinoides* v. Koenen, p. 1354–1355, pl. 99, figs. 8–9
1975 *Terebratulina pectinoides* von Koenen — Zelinskaya, p. 116–118, pl. 13, figs. 5–19
2005 *Orthothyris pectinoides* (von Koenen) — Bitner & Dieni, p. 108–109, figs. 5, 6B–N

Material: Five complete specimens from the borehole Dudar-218; three complete specimens (one crushed) from Neszmély.

Dimensions (in mm):

Specimen No.	Length	Width	Thickness
2006.22.1	2.75	2.25	?0.9
2006.23.1	2.6	2.4	0.8
2006.24.1	2.6	2.1	0.8
2006.25.1	2.0	1.6	0.7
2006.26.1	1.6	1.4	0.6
2006.27.1	2.1	1.6	0.7

Description: The shell is small, subcircular to elongate oval in outline, with wide, nearly straight hinge line. The shell is biconvex to concave-convex in profile. The anterior commissure is rectimarginate to broadly, incipiently sulcate. The surface is ornamented by coarse costae and costellae arising by bifurcations that vary in number from 16 to 26. The interarea is well developed with strong beak ridges. The pedicle opening is small, triangular, of hypothyrid type. The deltidial plates form elevated, narrow ridges. The internal structures were not studied because of the paucity of the material.

Remarks: The investigated specimens agree very well with those hitherto described (von Koenen 1894; Zelinskaya 1975; Bitner & Dieni 2005). They differ, however, from the Italian specimens which are smaller and have fewer ribs (Bitner & Dieni 2005).

This species, originally described by von Koenen (1894), was assigned by him to the genus *Terebratulina*. It differs, however, strongly from any *Terebratulina* species in having differentiated interarea with distinct beak ridges, wide, straight hinge line and triangular, hypothyrid foramen bordered by deltidial plates in the form of elevated ridges. Based on external and internal similarities to the Late Cretaceous genus *Orthothyris* (Cooper 1955, 1973), it was transferred by Bitner & Dieni (2005) into that genus. The species *O. pectinoides* is very similar to the Late Cretaceous type species *O. radiata* Cooper, 1955, however, it differs in being smaller and having bifurcating ribs that are single in *O. radiata*.

The specimens from the Eocene of Tonga described by Cooper (1971) in open nomenclature as terebratulinid gen. and sp. indet. are very similar in outline, ornamentation, beak character and convexity to *O. pectinoides*. Cooper (1971) also indicated the similarities of his material to *Orthothyris*.

Occurrence: This is the first record of this species from Hungary. It was already noted from the Eocene of Germany (von Koenen 1894), Ukraine (Zelinskaya 1975) and Italy (Bitner & Dieni 2005).

Superfamily: **Megathyridoidea** Dall, 1870
Family: **Megathyrididae** Dall, 1870
Genus: *Megathiris* d'Orbigny, 1847

Type species: *Anomia detruncata* Gmelin, 1791.

Megathiris detruncata (Gmelin, 1791)
Fig. 5.1–4

1990 *Megathiris detruncata* (Gmelin) — Bitner, p. 135–138, text-figs. 3–4, pl. 3, figs. 1–8; pl. 6, figs. 1–7 (*cum syn.*)
1990 *Megathiris detruncata* (Gmelin) — Popiel-Barczyk & Barczyk, p. 175–178, text-figs. 10–11, pl. 6, figs. 6–11; pl. 7, figs. 1–13
2003 *Megathiris detruncata* (Gmelin) — Bitner & Moissette, p. 473–474, fig. 6G–H
2003 *Megathiris detruncata* (Gmelin) — Logan, p. 239–240
2004 *Megathiris detruncata* (Gmelin) — Bitner & Dulai, p. 74, 76, pl. 3, figs. 11–15

Material: Two complete, poorly preserved specimens from Budapest, Csillag-hegy (Ibolya street).

Dimensions (in mm):

Specimen No.	Length	Width	Thickness
2006.28.1	2.5	3.3	1.6
2006.29.1	2.5	3.1	1.6

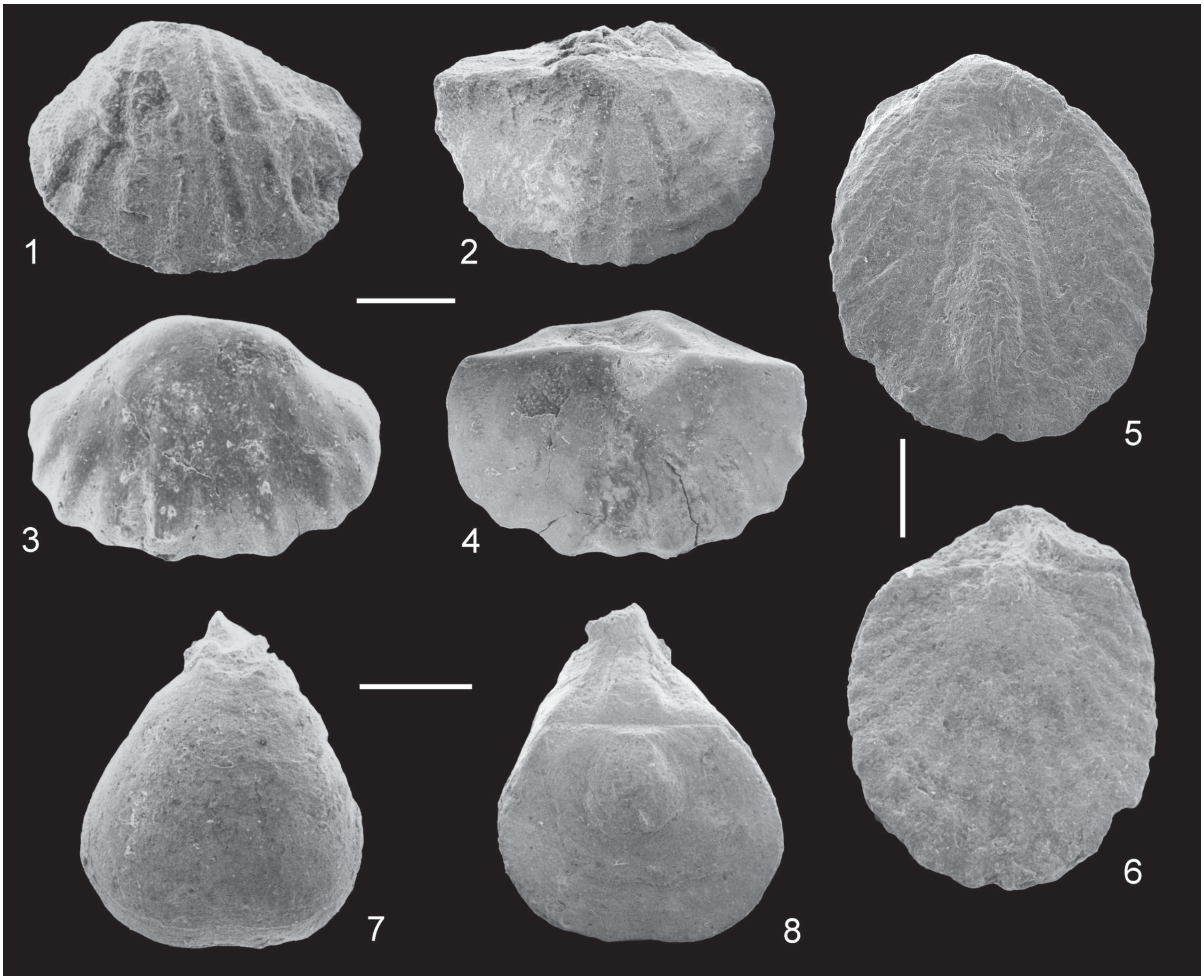

Fig. 5. 1–4 — *Megathiris detruncata* (Gmelin, 1791), Budapest, Csillag-hegy (Ibolya street), Upper Eocene. 1–2 — ventral and dorsal views of complete specimen, 2006.28.1; 3–4 — ventral and dorsal views of complete specimen, 2006.29.1. **5–6** — *Argyrotheca michelottina* (Davidson, 1870), ventral and dorsal views of complete specimen, 2006.30.1, Magyarpolány-40, 72.3–72.5, Middle Eocene. **7–8** — *Lacazella mediterranea* (Risso, 1826), Budapest, Csillag-hegy (Ibolya street), Upper Eocene, complete specimen 2006.34.1; 7 — ventral view, 8 — dorsal view. Scale bars: 1 mm.

Remarks: This species was previously reported from the Eocene strata of Hungary by Meznerics (1943). The investigated material is very poorly preserved and limited in number (only two specimens), however, it is identified as *Megathiris detruncata* by its characteristic transverse outline, long, straight hinge line and ornamentation of single, rounded ribs. The specimens under study represent young individuals as indicated by their small size.

Occurrence: The stratigraphical range of *M. detruncata* is from the Eocene to Recent. Meznerics (1943) recorded this species from the Upper Eocene *Nummulites* limestone of Bakonybél. In the Eocene it was also found in Italy (Davidson 1870; Sacco 1902; Fabiani 1908, 1913). It is one of the commonest species in the Middle Miocene of the Central Paratethys (Dreger 1889; Barczyk & Popiel-Barczyk 1977; Bitner 1990; Popiel-Barczyk & Barczyk 1990; Bitner & Dulai 2004). Today it is common in the Mediterranean and eastern North Atlantic (Brunton & Curry 1979; Logan 1979, 1983, 1988, 1993, 2003; Logan et al. 2004; Álvarez & Emig 2005), as well the Caribbean Sea (Cooper 1977).

Genus: *Argyrotheca* Dall, 1900

Type species: *Terebratula cuneata* Risso, 1826.

Argyrotheca michelottina (Davidson, 1870)
Fig. 5.5–6

2000 *Argyrotheca vidali* (Mallada) — Bitner, p. 122, 124, figs. 4G–N, 5H–P, 6 (*cum syn.*)

Material: One crushed complete specimen from the borehole Magyarpolány-40; one complete specimen and one ventral valve from Ajka.

Dimensions (in mm):

Specimen No.	Length	Width	Thickness
2006.30.1	3.8	2.9	–
2006.31.1	3.9	3.3	1.2
2006.32.1	4.3	3.5	–

Remarks: The specimens described by Davidson (1870) as *Terebratulina michelottina* display externally all the features of the genus *Argyrotheca* and not those of *Terebratulina*. As a result Bitner (2000) transferred this species into the genus *Argyrotheca* and synonymized it with *A. vidali*. As the specific name *michelottina* has never been associated with the genus name *Argyrotheca*, and in turn *A. vidali* was a well-known species in the Eocene deposits of Spain (Abrard 1926; Calzada & Urquiola 1994), the rules of priority were not applied in this case. However, the reversal of precedence according to Art. 23.9.1 of the ICZN (1999) can be applied only under very particular conditions which have not been fulfilled in the case of *A. vidali*, thus the specific name *michelottina* has priority over the name *vidali*.

A. michelottina is very rare in the investigated material, however, it is an easily distinguishable species of *Argyrotheca* due to its characteristic oval elongate shape and ornamentation of wide, rounded ribs. It is consistent with the Spanish material (Calzada & Urquiola 1994; Bitner 2000). This is the first occurrence of this species in the Paleogene deposits of Hungary.

Occurrence: Eocene of Italy (Davidson 1870; Fabiani 1908, 1913; Dainelli 1915) and Spain (Calzada & Urquiola 1994; Bitner 2000).

Argyrotheca tokodensis sp. nov.
Figs. 6, 7.1–12, 8.1–8

Holotype: 2006.37.1 (Fig. 7.6–9).
Type horizon: Middle Eocene, Bartonian.
Type locality: Tokod, north Hungary.
Etymology: From Tokod, referring to the type locality.

Diagnosis: *Argyrotheca* of small size, subsquare in outline with straight hinge line usually equal to the maximum width, ornamented by 12–16 single, delicate, rounded ribs; dorsal valve medium septum very high, triangular in profile with numerous serrations.

Material: One complete specimen from the borehole Balinka-239; one dorsal valve from the borehole Mogyorósbánya-87; 52 complete specimens, 21 ventral valves and 51 dorsal valves from Tokod. Some specimens are strongly crushed, many are broken; there are also many fragments.

Dimensions (in mm): (see also Fig. 6)

Specimen No.	Length	Width	Thickness
2006.35.1 (paratype)	1.6	1.8	0.7
2006.36.1 (paratype)	3.3	4.0	–
2006.37.1 (holotype)	3.5	3.5	1.9
2006.38.1 (paratype)	2.2	2.2	1.0?
2006.39.1 (paratype)	2.3	2.5	1.0
2006.40.1 (paratype)	2.6	2.8	1.0?
2007.41.1	3.4	3.3	1.8

Description: The shell is small (maximum length 3.5 mm), ventribiconvex, coarsely endopunctate, variable in outline, from subsquare to transversely oval, usually wider than long. The hinge line is long and straight, usually equal to the maximum width. The shell surface is ornamented by 12–16 single, delicate, rounded ribs. In some specimens the ribs are so weak that they are almost imperceptible. The growth lines are numerous but indistinct in many specimens. In juvenile individuals the shape is subtriangular with hinge line shorter than the maximum width and the surface is nearly smooth (Fig. 7.1). The anterior commissure is rectimarginate. The ventral beak is high, suberect with a large interarea with distinct growth lines but without radial ornamentation. The large pedicle opening is of hypothyrid type, restricted by two narrow deltidial plates. Ventral valve interior with short but wide teeth lying parallel to hinge line. The pedicle collar is wide,

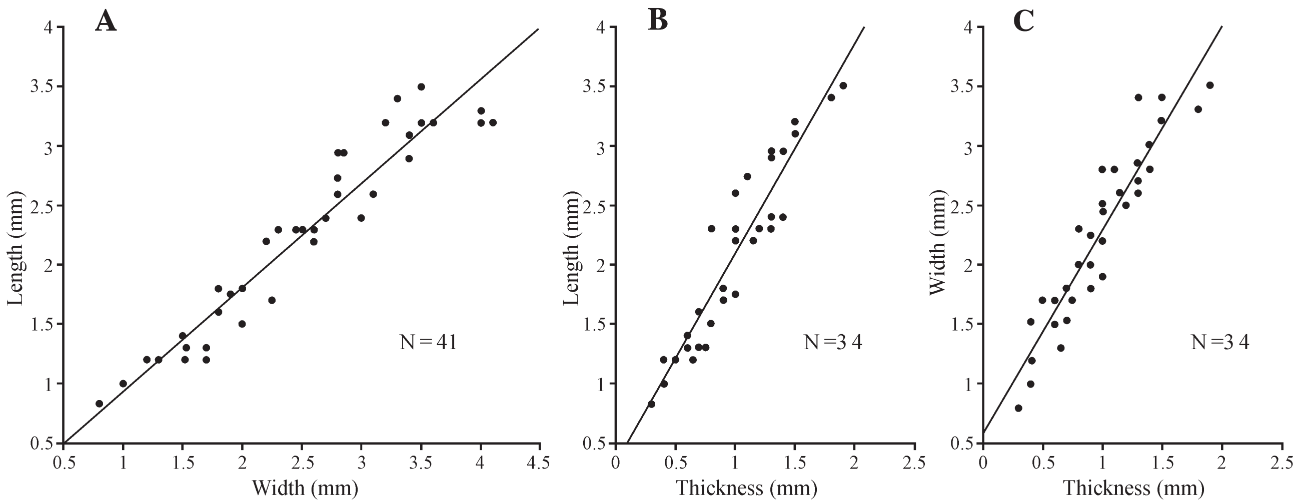

Fig. 6. Intraspecific variability of *Argyrotheca tokodensis* sp. nov. Scatter diagrams plotting length/width (**A**), length/thickness (**B**) and width/thickness (**C**). N = number of specimens.

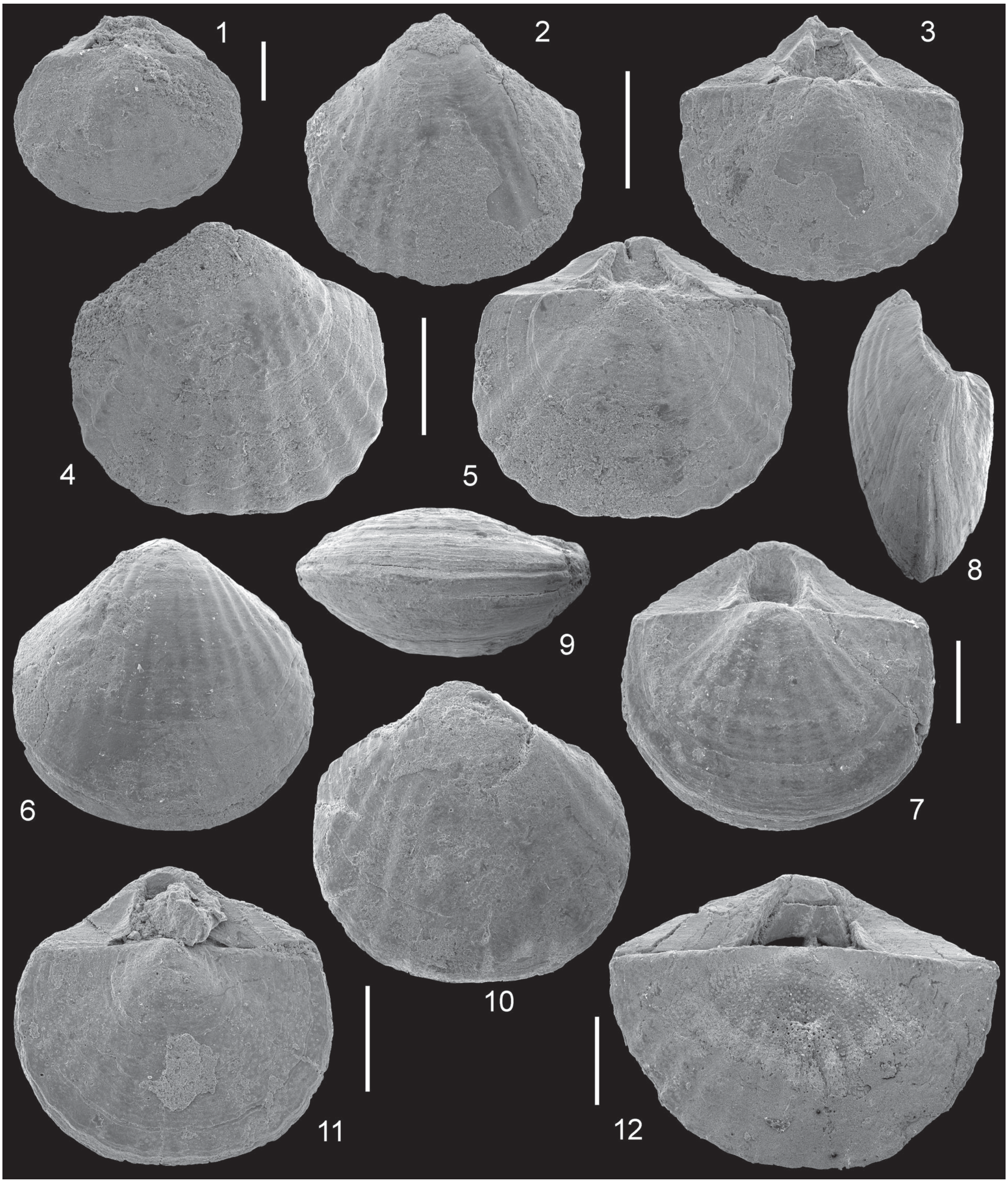

Fig. 7. 1–12 — *Argyrotheca tokodensis* sp. nov., Tokod, Middle Eocene. 1 — Dorsal view of immature complete specimen, 2006.35.1, paratype; 2–3 — Complete specimen, 2006.38.1, paratype, 2 — ventral view, 3 — dorsal view; 4–5 — Complete specimen, 2006.39.1, paratype, 4 — ventral view, 5 — dorsal view; 6–9 — Complete specimen, 2006.37.1, holotype, 6 — ventral view, 7 — dorsal view, 8 — lateral view, 9 — anterior view; 10–11 — Complete specimen, 2006.40.1, paratype, 10 — ventral view, 11 — dorsal view; 12 — Dorsal view of complete specimen, 2006.36.1, paratype. Scale bars: 1 — 0.5 mm, 2–12 — 1 mm.

supported by a median septum. Anteriorly to the septum there are two or three shallow, ovoid depressions to accommodate a dorsal septum. Dorsal valve interior with high, relatively narrow inner socket ridges and small but distinct cardinal process (Fig. 8.3–5,8). The hinge plates, ventrally concave, are attached laterally to the inner socket ridges and converge medially to define a shallow hollow in front of cardinal process. The median septum is

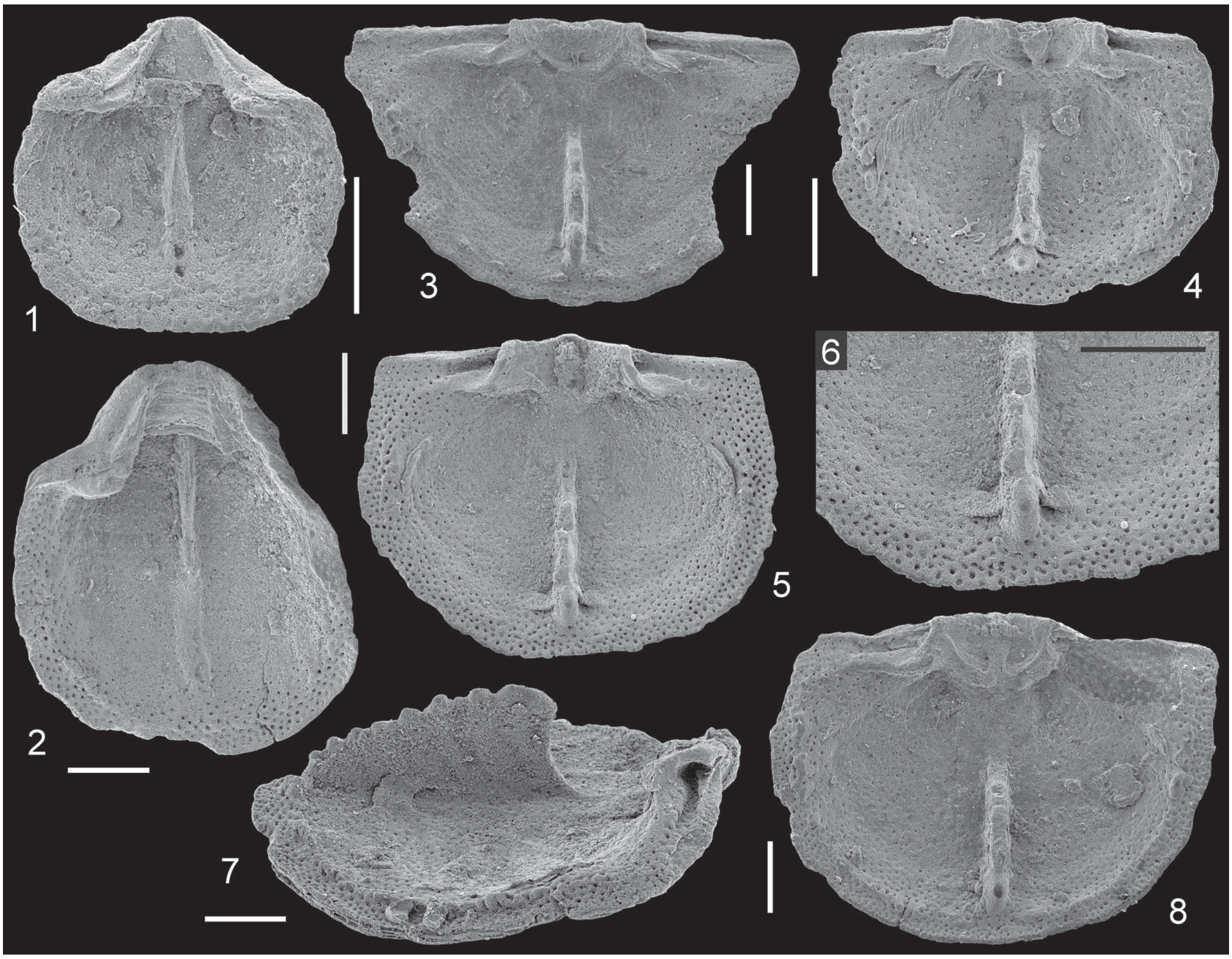

Fig. 8. **1–8** — *Argyrotheca tokodensis* sp. nov., Tokod, Middle Eocene, paratypes. 1–2 — Inner views of ventral valves, 1-2006.42.1, 2-2006.43.1; 3–4 — Inner views of dorsal valves, 3 — 2006.44.1, 4 — 2006.45.1; 5–6 — Dorsal valve, 2006.46.1, 5 — inner view, 6 — enlargement of anterior part of 5 to show attachment of the loop to septum; 7 — Lateral view of dorsal valve interior to show high septum with numerous serrations, 2006.47.1; 8 — Inner view of dorsal valve, 2006.48.1. Scale bars: 0.5 mm.

high and triangular in profile, beginning at about one-third of the dorsal valve length and sloping towards the anterior margin with numerous serrations (Fig. 8.7). The loop is preserved only anteriorly where it is attached to the septum.

Remarks: *Argyrotheca tokodensis* sp. nov. is the commonest species in the studied material. It is easily distinguishable from *A. michelottina* by its subsquare outline and finely ribbed ornamentation.

Numerous species of *Argyrotheca* have been described from Paleogene deposits of Europe. Nevertheless, in many cases it is difficult to estimate the validity of those species because of insufficient description, often not presenting internal structures, and poor illustrations. In extreme cases new species were identified on the basis of a single valve (e.g. Cossmann 1902).

In outline the studied specimens are similar to *A. batalleri* Abrard, 1926 from the Eocene of north-eastern Spain (Abrard 1926; Calzada & Urquiola 1994) but they differ in being smaller and having much more delicate ornamentation. In outline and ornamentation the specimens from Hungary are similar to those from the Paris Basin described by Morgan (1883) as *Cistella douvillei*. The French forms, however, have more numerous ribs (15–20), and their internal structures are unknown. The specimens from Tokod resemble in shell outline and ornamentation the Upper Paleocene species *Argyrotheca sabaratensis* Pajaud, 1970 (in Pajaud & Tambareau 1970) but the latter species is smaller than *A. tokodensis* and its interior details are unknown. In ornamentation *A. tokodensis* displays similarities to *A. megapora* Zelinskaya, 1975, differing somewhat in outline, beak character and in having a higher brachial septum. The investigated specimens of *A. tokodensis* also resemble in shell outline the Upper Eocene species *A. piperipyxis* Elliott, 1954 (Elliott 1954; Popiel-Barczyk & Barczyk 1987). They differ, however, from the latter species in their larger size, more numerous ribs and hinge line usually equal to the maximum width.

The high, serrated median septum of *A. tokodensis* is very similar to that observed in Recent *A. cordata* (Risso, 1826) from the Mediterranean (see Logan 1979: pl. 5, fig. 8; Álvarez & Emig 2005: fig. 47D) but the new species lacks the prominent row of submarginal ridges nodded at their extremities in the interior of the dorsal valve of the Mediterranean species.

Occurrence: In the Eocene deposits of Balinka-239 and Mogyorósbánya-87 boreholes and Tokod, north-western Hungary.

Order: **Thecideida** Elliott, 1958
Superfamily: **Thecideoidea** Gray, 1840
Family: **Thecideidae** Gray, 1840
Subfamily: **Lacazellinae** Backhaus, 1959
Genus: *Lacazella* Munier-Chalmas, 1881

Type species: *Thecidea mediterranea* Risso, 1826.

Lacazella mediterranea (Risso, 1826)
Fig. 5.7–8

1826 *Thecidea mediterranea* Risso, p. 394, pl. 12, fig. 183
1861 *Thecidium mediterraneum* (Risso) — Lacaze-Duthiers, p. 259, pls. 1–5
1870 *Thecidium Mediterraneum* (Risso) — Davidson, p. 407, pl. 21, fig. 17a,b
1881 *Lacazella mediterranea* (Risso) — Munier-Chalmas, p. 279
1901 *Thecidium mediterraneum* Risso — Oppenheim, p. 259–260
1908 *Thecidium mediterraneum* Risso — Fabiani, p. 61
1913 *Thecidea (Lacazella) mediterranea* Risso — Fabiani, p. 39–40, pl. 4, fig. 18a
1970 *Lacazella mediterranea* (Risso) — Pajaud, p. 128, text-figs. 50, 52, pl. 1, fig. 4; pl. 5, fig. 4; pl. 7, fig. 3; pl. 10, figs. 1–6; pl. 11, fig. 3; pl. 12, fig. 2; pl. 16
1972 *Lacazella mediterranea* (Risso) — Pajaud & Plaziat, p. 455, text-fig. 7, pl. 2, fig. 4
1979 *Lacazella mediterranea* (Risso) — Logan, p. 73–75, text-fig. 22, pl. 10, figs. 1–8
1987 *Lacazella mediterranea* (Risso) — Popiel-Barczyk & Barczyk, p. 101, pl. 3, figs. 3–11
2005 *Lacazella mediterranea* (Risso) — Bitner & Dieni, p. 109–110, fig. 4I–K

Material: One complete specimen from Budapest, Csillag-hegy (Ibolya street).

Dimensions: Length 3.0 mm, width 2.6 mm, thickness 1.7 mm (2006.34.1).

Remarks: The very limited material (only one specimen) prevents any study of internal structures, nevertheless based on external features such as outline, profile, beak area, and shell surface, the investigated specimen corresponds very well to *Lacazella mediterranea* (see Pajaud 1970; Logan 1979). *Thecidellina*, although similar externally to *Lacazella*, differs from the latter genus by bearing no trace of a pseudodeltidium on ventral interarea. The ventral interarea in the studied specimen is triangular, flat with visible pseudodeltidium. The shell is very small (length 3.0 mm), triangular in outline, slightly biconvex with ventral valve much more convex, the dorsal one is nearly flat. The shell surface is smooth, rare growth lines are indistinct. This is the first occurrence of this species in the Paleogene deposits of Hungary.

Occurrence: *Lacazella mediterranea* has a very long stratigraphical range from the Upper Paleocene (Pajaud & Plaziat 1972) to Recent. In the Eocene deposits it has been recorded from Italy (Davidson 1870; Sacco 1902; Fabiani 1908, 1913; Pajaud 1970; Bitner & Dieni 2005), Germany (von Koenen 1894; Oppenheim 1901) and Poland (Popiel-Barczyk & Barczyk 1987). Today this species lives in the Mediterranean being restricted to its south-western part (Logan 1979; Logan et al. 2004; Álvarez & Emig 2005).

Discussion

The investigated Eocene brachiopods from north-western Hungary contain seven micromorphic species. Two of them, namely *Terebratulina tenuistriata* (Leymierie) and *Megathiris detruncata* (Gmelin), were previously recorded from the Eocene beds of Hungary (Meznerics 1943). The species *Novocrania bayaniana* (Davidson), *Orthothyris pectinoides* (von Koenen), *Argyrotheca michelottina* (Davidson) and *Lacazella mediterranea* (Risso) are reported for the first time from Hungary, and the species *Argyrotheca tokodensis* has been described as a new taxon. The latter species and *T. tenuistriata* are most common and they constitute 91.5 % of all the material. The other species occur in a small number of one to eight specimens. The investigated brachiopods were collected in 7 outcrops and in cores from 7 boreholes. The species composition in particular localities differs considerably. Being the most common, *A. tokodensis* sp. nov. occurs in abundance only in one locality, Tokod; but single specimens were also found in two boreholes, Balinka-239 and Mogyorósbánya-87. All the specimens of *A. tokodensis* are from the shallow bathyal Padrag Marl Formation. The second most common species, *T. tenuistriata* is much more widespread; it is reported from 4 outcrops and from 5 boreholes. Most of these specimens are from the shallow water Szőc Limestone and Szépvölgy Limestone Formations but there are few specimens also from the Padrag Marl Formation. Very often only one species is found in a particular locality. The locality of Csillag-hegy (Budapest) shows the greatest diversity with three species, *T. tenuistriata*, *M. detruncata* and *L. mediterranea* present. In the investigated material brachiopods from the locality of Ajka are represented by two species, *T. tenuistriata* and *A. michelottina*. From the same locality, Meznerics (1943) reported three additional species, *Magellania hilarionis*, and two species created by herself, *M. hantkeni* and *M. gibbosa*. It is difficult to estimate the validity of these last two species because the internal structures were not examined and the material is lost, being not available for study.

The type of sediment (mostly marls and marly intercalations in limestones) in which the investigated brachiopods occur may indicate conditions similar to those of the white chalk assemblage where micromorphic brachiopods, capable of using very small, hard objects, dominate the soft bottom benthos (Surlyk 1972). Ecologically, the species described here belong to three categories among those distinguished by Surlyk (1972). *Terebratulina tenuistriata* is a representative of the group of medium-sized species attached directly to the fine sediment by a root-like, divided long pedicle (Curry 1981). The bathymetric range of extant *Terebratulina* species is very wide, however, they are most common at the depth of 100 and 500 m (Curry 1982). The second group constitutes minute forms attached by a pedicle to small hard objects. Both *Argyrotheca* species, *M. detruncata* and *O. pectinoides* belong to this group. All Recent megathyrids live attached by a very short pedicle to firm substrates. The extant representatives of *M. detruncata* are reported from depth of 16 to 896 m (Logan 1979, 1988; Logan et al. 2004; Álvarez & Emig 2005). Recent *Argyrotheca* species also have a relatively wide depth range, being known from few meters to more than 600 m (Logan 1979, 1983, 1988; Logan et al. 2004; Álvarez & Emig 2005). The functional pedicle opening of *O. pectinoides* indicates that this fossil species also belongs to the pedunculate taxa. The third group contains species cementing to the substrate by a ventral valve and is represented in the studied material by two species, *Novocrania bayaniana* and *Lacazella mediterranea*. The Recent *Novocrania anomala* (Müller) from the Mediterranean and eastern North Atlantic is usually found in shallow-water cryptic habitats, characterized by low light and low hydrodynamic conditions (Logan 1979; Logan & Long 2001; Álvarez & Emig 2005). Today the representatives of *L. mediterranea* live in the Mediterranean at the depth of 31–110 m (Logan 1979; Álvarez & Emig 2005), being regarded as a neoendemic species (Logan et al. 2004).

Although the taxonomic composition of particular Eocene brachiopod assemblages in Europe can differ strongly, a great similarity of the fauna is observed and most species have a very wide geographical distribution, being known throughout the whole of Europe. *T. tenuistriata* is the most widely spread species, being reported from Great Britain to Bulgaria (see above). Also *N. bayaniana*, *O. pectinoides*, *M. detruncata*, *A. michelottina* and *L. mediterranea* have a very wide distribution, from Spain and Italy to Poland, Hungary and Ukraine. The high sea level in the Eocene, provoked by the sea floor spreading in the Early Eocene (Briggs 1995), had biogeographical consequences and provided good conditions for faunal migrations. Especially similarities of the investigated brachiopods to the Italian fauna can be easily explained by a direct connection of the Hungarian Paleogene Basin with the North Italian basins (Báldi 1984). The similarity to the Eocene brachiopod fauna of the Western Pacific (Cooper 1971) might result from the fact that the Eocene sea of Europe constituted part of the Tethys Ocean and had direct connection to this area. In the Late Eocene, due to the collision of India with Asia, the Tethys Ocean was closed and at the Eocene/Oligocene boundary two new marine basins arose, the Mediterranean Sea and the intercontinental Paratethys Sea in the North (Rögl 1998; Schulz et al. 2005), completely changing the paleobiogeography of the area.

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References

Abrard R. 1926: Note on some brachiopods from the Lutetian of Catalonia. *Ciencia* 1, 4, 270–271 (in Spanish).

Altichieri L. 1992: Updating of the brachiopod fauna from the Veneto region. *Mem. Sci. Geol.* 44, 211–227 (in Italian).

Álvarez F. & Emig C.C. 2005: Brachiopoda. In: Álvarez F., Emig C.C., Roldán C. & Viéitez J.M. (Eds.): Lophophorata, Phoronida, Brachiopoda. *Fauna Iberica*, vol. 27. Ramos M.A. et al. (Eds.): *Museo Nacional de Ciencias Naturales*, *CSIC*, Madrid, 57–177.

Backhaus E. 1959: Monographie der cretacischen Thecideidae (Brach.). *Mitt. Geol. Staatsinst. Hamburg* 28, 5–90.

Barczyk W. 1973: Brachiopods *Terebratulina delheidi* Vincent in the Nummulite Eocene of the Tatra Mts. *Acta Geol. Pol.* 23, 491–497.

Barczyk W. & Popiel-Barczyk E. 1977: Brachiopods from the Korytnica basin (Middle Miocene; Holy Cross Mountains, Poland). *Acta Geol. Pol.* 27, 157–167.

Báldi T. 1984: The terminal Eocene and early Oligocene events in Hungary and the separation of an anoxic, cold Paratethys. *Eclogae Geol. Helv.* 77, 1–27.

Báldi T. 1986: Mid-Tertiary stratigraphy and paleogeographic evolution of Hungary. *Akadémiai Kiadó*, Budapest, 1–201.

Báldi-Beke M. 1984: The nannoplankton of the Transdanubian Paleogene formations. *Geol. Hung. Ser. Pal.* 43, 1–307.

Báldi-Beke M. & Báldi T. 1991: Palaeobathymetry and palaeogeography of the Bakony Eocene Basin in western Hungary. *Palaeogeogr. Palaeoclimatol. Palaeoecol.* 88, 25–52.

Bitner M.A. 1990: Middle Miocene (Badenian) brachiopods from the Roztocze Hills, south-eastern Poland. *Acta Geol. Pol.* 40, 129–157.

Bitner M.A. 2000: Lower Eocene (Middle Ilerdian) brachiopods from the Campo region, Central Pyrenees, north-eastern Spain. *Rev. Esp. Paleont.* 15, 117–128.

Bitner M.A. & Dieni I. 2005: Late Eocene brachiopods from the Euganean Hills (NE Italy). *Eclogae Geol. Helv.* 98, 103–111.

Bitner M.A. & Dulai A. 2004: Revision of Miocene brachiopods of the Hungarian Natural History Museum, with special regard to the Meznerics collection. *Fragm. Palaeont. Hung.* 22, 69–82.

Bitner M.A. & Moissette P. 2003: Pliocene brachiopods from north-western Africa. *Geodiversitas* 25, 463–479.

Briggs J.C. 1995: Global biogeography. Developments in pala-

eontology and stratigraphy. *Elsevier*, Amsterdam, 14, 1–452.
Brunton C.H.C. & Curry G.B. 1979: British brachiopods. *Synopses of the British Fauna* (*New Series*) 17, 1–64.
Calzada S. & Urquiola M.M. 1994: On *Argyrotheca* (Brachiopoda) species from the Upper Eocene. *Batalleria* 4, 17–25 (in Spanish).
Chemnitz J.H. 1785: Neues systematisches Conchylien-Cabinet. *Bauer & Raspe*, Nürnberg, 8, 1–372.
Cooper G.A. 1955: New Brachiopoda from Cuba. *J. Paleontology* 29, 1, 64–70.
Cooper G.A. 1971: Eocene brachiopods from Eua, Tonga. *Geol. Surv. Prof. Pap.* 640-F, F1–F9.
Cooper G.A. 1973: Fossil and Recent Cancellothyridacea (Brachiopoda). *Tohoku Univ. Sci. Rep., 2nd ser. (Geol.), Spec. Vol.* 6 (Hatai Memorial Vol.), 371–390.
Cooper G.A. 1977: Brachiopods from the Caribbean Sea and adjacent waters. *Stud. Trop. Oceanogr.* 14, 1–211.
Cossmann M. 1902: Catalogue ilustré des coquilles fossiles de l'Eocène des environs de Paris. *Ann. Soc. Roy. Mal. Belgique* 36, 9–100.
Császár G. (Ed.) 1997: Basic lithostratigraphic units of Hungary. Charts and short descriptions. *Magy. Áll. Földt. Intéz.*, Budapest, 1–114.
Curry G.B. 1981: Variable pedicle morphology in a population of the Recent brachiopod *Terebratulina septentrionalis*. *Lethaia* 14, 9–20.
Curry G.B. 1982: Ecology and population structure of the Recent brachiopod *Terebratulina* from Scotland. *Palaeontology* 25, 227–246.
Dainelli G. 1915: Friulian Eocene. Geological and palaeontological monograph. *Mem. Geografiche*, Firenze, 1–721 (in Italian).
Dall W.H. 1870: A revision of the Terebratulidae and Lingulidae. *Amer. J. Conchol.* 6, 88–168.
Dall W.H. 1900: Some names which must be discarded. *Nautilus* 14, 4, 44–45.
Davidson T. 1870: On Italian Tertiary Brachiopoda. *Geol. Mag.* 7, 359–370, 399–408, 460–466.
Davidson T. 1874: On the Tertiary Brachiopoda of Belgium. *Geol. Mag.* 1, 150–159.
Doncieux L. 1905: Catalogue descriptif des fossiles nummulitiques de l'Aude et de l'Hérault. Première partie. Montagne Noire et Minervois. *Ann. Univ. Lyon*, nouv. sér. I, 17, 1–184.
Doncieux L. 1926: Catalogue descriptif des fossiles nummulitiques de l'Aude et de l'Hérault. II (3). Corbières septentrionales. *Ann. Univ. Lyon*, nouv. sér. I, 45, 1–80.
Dreger J. 1889: Die tertiären Brachiopoden des Wiener Beckens. *Beitr. Paläontol. Oesterreich-Ungarns* 7, 179–192.
Duméril A.M.C. 1806: Zoologie analytique ou méthode naturelle de classification des animaux. *Allais*, Paris, 1–344.
Elliott G.F. 1938: A London Clay Brachiopod. *Proc. Geol. Assoc.* 49, 128–134.
Elliott G.F. 1954: New Brachiopoda from the Eocene of England, France and Africa. *Ann. Mag. Naturhist., 12th Ser.* 7, 721–728.
Elliott G.F. 1958: Classification of thecidean brachiopods. *J. Paleontology* 32, 373.
Fabiani R. 1908: Palaeontology of the Colli Berici. *Mem. Soc. Ital. Sc. (detta dei XL)*, ser. 3, 15, 44–248 (in Italian).
Fabiani R. 1913: Tertiary brachiopods from the Veneto region. *Mem. Ist. Geol. R. Univ. Padova* 2, 3–42 (in Italian).
Fodor L., Magyari Á., Kázmér M. & Fogarasi A. 1992: Gravity-flow dominated sedimentation on the Buda paleoslope (Hungary): record of Late Eocene continental escape of the Bakony unit. *Geol. Rdsch.* 81, 695–716.
Gray J.E. 1840: Synopsis of the contents of the British Museum. *42nd edit.*, London, 1–370.
Gmelin J.F. 1791: Caroli a Linné. Systema Naturae. *Tom I. Pars VI. 13 edition, Beer*, Lipsiae, 3021–3909.
Gochev P. 1933: Paläontologische und stratigraphische Untersuchungen über das Eocän von Varna. *Zeitsch. Bulgar. Geol. Gesell.* 5, 1–82 (in Bulgarian with German abstract).
International Commission on Zoological Nomenclature 1999: International Code of Zoological Nomenclature, 4th edition. *International Trust for Zoological Nomenclature*, London, 1–306.
Kázmér M., Dunkl I., Frisch W., Kuhlemann J. & Ozsvárt P. 2003: The Palaeogene forearc basin of the Eastern Alps and Western Carpathians: subduction erosion and basin evolution. *J. Geol. Soc., London* 160, 413–428.
Koenen A. von 1894: Das Norddeutsche Unter-Oligocän und seine Mollusken-Fauna. *Abh. geol. Spec.-Karte Preuss. u. Thuring. Staat.* 10, 6, 1250–1392.
Kopek G. 1980: L'Éocène de la partie nord-orientale de la Montagne du Bakony (Transdanubie, Hongrie). *Ann. Hung. Geol. Inst.* 63, 1, 1–176.
Lacaze-Duthiers H. 1861: Histoire naturelle des Brachiopodes vivants de la Méditerranée. Première monographie: Histoire de la Thécidie (*Thecideum mediterraneum*). *Ann. Soc. Nat., Zoologie* (série 4) 15, 259–330.
Lee D.E. & Brunton C.H.C. 2001: *Novocrania*, a new name for the genus *Neocrania* Lee & Brunton, 1986 (Brachiopoda, Craniida), preoccupied by *Neocrania* Davis, 1978 (Insecta, Lepidoptera). *Bull. Nat. Hist. Mus. London, Geol.* 57, 5.
Leymerie M.A. 1846: Mémoire sur le terrain à Nummulites (Epicrétacé) des Corbières et de la Montagne Noire. *Mém. Soc. Géol. France* 2, 1, 8, 337–373.
Linnaeus C. 1758: Systema Naturae. 10th edition, *Holmiae*, Stockholm, 1–824.
Logan A. 1979: The Recent Brachiopoda of the Mediterranean Sea. *Bull. Inst. Océanogr. Monaco* 72, 1–112.
Logan A. 1983: Brachiopoda collected by CANCAP I-III expeditions to the south-east North Atlantic, 1976–1978. *Zool. Med. Leiden* 57, 165–189.
Logan A. 1988: Brachiopoda collected by CANCAP IV and VI expeditions to the south-east North Atlantic, 1980–1982. *Zool. Med. Leiden* 62, 59–74.
Logan A. 1993: Recent brachiopods from the Canarian-Cape Verdean region: diversity, biogeographic affinities, bathymetric range and life habits. *Cour. Forschungsinst. Senckenberg* 159, 229–233.
Logan A. 2003: Marine fauna of the Mljet National Park (Adriatic Sea, Croatia). 3. Brachiopoda. *Nat. Croatica* 12, 4, 233–243.
Logan A. & Long S.L. 2001: Shell morphology and geographical distribution of *Neocrania* (Brachiopoda, Recent) in the eastern North Atlantic and Mediterranean Sea. In: Brunton C.H.C., Cocks L.R.M. & Long S.L. (Eds.): Brachiopods past and present. *The System. Assoc. Spec. Vol.* 63, 71–79.
Logan A., Bianchi C.N., Morri C. & Zibrowius H. 2004: The present-day Mediterranean brachiopod fauna: diversity, life habits, biogeography and paleobiogeography. In: Ros J.D., Packard T.T., Gili J.M., Pretus J.L. & Blasco D. (Eds.): Biological oceanography at the turn of the Millenium. *Sci. Mar.* 68 (Suppl. 1), 163–170.
Massalongo A. 1850: Geognostic sketch on the Prongo valley or the torrent of Illasi with an essay on the primordial flora of M. Bolca. *Antonelli*, Verona, 1–77 (in Italian).
Menke C.T. 1828: Synopsis methodica molluscorum generum omnium et specierum earum quae in Museo Menkeano adservantur, 2nd ed. *G. Uslar*, Pyrmonti, 1–91.
Meznerics I. 1943: Die Brachiopoden des ungarischen Tertiärs. *Ann. Hist.-Natur. Mus. Nat. Hung.* 36, 10–60.
Morgan J. de 1883: Note sur quelques espèces nouvelles de Mégathyridés. *Bull. Soc. Zool. France* 8, 371–396.
Muir-Wood H. 1959: Report on the Brachiopoda of the John Mur-

ray Expedition. *Sc. Rep. John Murray Exped. 1933–1934* 10, 283–317.

Muir-Wood H. 1965: Mesozoic and Cenozoic Terebratulidina. In: Moore R.C. (Ed.): Treatise on invertebrate Paleontology. Part H. Brachiopoda, H762–H816.

Munier-Chalmas E.P. 1881: Note sommaire sur les genres de la famille des Thecideidae. *Bull. Soc. Géol. France* 1880 (séries 3) 8, 279–280.

Müller O.F. 1776: Zoologiae Danicae prodromus, seu animalium Daniae et Norvegiae indigenarum characters, nomina, et synonyma imprimis popularium. *Typis Hallageriis*, Havniae, 1–282.

d'Orbigny A. 1847: Considérations zoologiques et géologiques sur les brachiopodes ou palliobranches. *Ann. Soc. Nat.* (série 3) 8, 241–270.

Oppenheim P. 1901: Die Priabonaschichten und ihre Fauna im Zusammenhange mit gleichalterigen und analogen Ablagerungen. *Palaeontographica* 47, 1–348.

Owen E.F. 1988: Cenomanian brachiopods from the Lower Chalk of Britain and northern Europe. *Bull. Brit. Mus. (Nat. Hist.), Geol. Ser.* 44, 65–175.

Pajaud D. 1970: Monographie des Thécidées (Brachiopodes). *Mém. Soc. Géol. France*, n. s., 112, 1–349.

Pajaud D. & Plaziat J.-C. 1972: Brachiopodes thanétiens du synclinal sud-cantabrique au S-E de Vitoria (Pays basque espagnol). Étude systématique et interprétation paléoécologique. *Bull. Soc. Hist. Nat. Toulouse* 108, 446–473.

Pajaud D. & Tambareau Y. 1970: Brachiopodes nouveaux du "Sparnacien" des Petites Pyrénées et du Plantaurel. *Bull. Soc. Hist. Nat. Toulouse* 106, 312–327.

Popiel-Barczyk E. & Barczyk W. 1987: Eocene brachiopods from Wola Łużańska and Skalnik in the Central Carpathians. *Acta Geol. Pol.* 37, 93–104.

Popiel-Barczyk E. & Barczyk W. 1990: Middle Miocene (Badenian) brachiopods from the southern slopes of the Holy Cross Mountains, Central Poland. *Acta Geol. Pol.* 40, 159–181.

Popov L.E., Basset M.G., Holmer L.E. & Laurie J.R. 1993: Phylogenetic analysis of higher taxa of Brachiopoda. *Lethaia* 26, 1–5.

Risso A. 1826: Histoire naturelle des principales productions de l'Europe méridionale, et particulièrement de celles des environs de Nice et des Alpes Maritimes. *F.G. Levrault*, Paris, 1–439.

Rögl F. 1998: Palaeogeographic considerations for Mediterranean and Paratethys seaways (Oligocene to Miocene). *Ann. Naturhist. Mus. Wien* 99A, 279–310.

Sacco F. 1902: Brachiopods from the Tertiary terrains of Piemonte and Liguria. *Carlo Clausen*, Torino, 1–50 (in Italian).

Schulz H.-M., Bechtel A. & Sachsenhofer R.F. 2005: The birth of the Paratethys during the Early Oligocene: from Tethys to an ancient Black Sea analogue? *Global and Planet. Changes* 49, 163–176.

Sowerby J. de C. 1826–1829: The Mineral Conchology of Great Britain; or coloured figures and descriptions of those remains of testaceous animals or shells, which have been preserved at various times and depths in the earth. 6, London, 1–236.

Surlyk F. 1972: Morphological adaptations and population structures of the Danish chalk brachiopods (Maastrichtian, Upper Cretaceous). *Det Kong. Dan. Vidensk. Selsk., Biol. Skr.* 19, 1–57.

Thomson J.A. 1926: A revision of the subfamilies of the Terebratulidae (Brachiopoda). *Ann. Mag. Nat. Hist.* 9, 18, 523–530.

Vincent E. 1893: Contribution à la paléontologie des terrains tertiaires de la Belgique. Brachiopodes. *Ann. Soc. Roy. Malacol. Belgique* 28, 38–64.

Waagen W.H. 1883: Salt Range fossils, vol. I, part 4. *Productus* Limestone fossils, Brachiopoda. *Mem. Geol. Surv. India, Palaeontol. Indica* (series 13) 2, 391–546.

Waagen W.H. 1885: Salt Range fossils, vol. I, part 4. *Productus* Limestone fossils, Brachiopoda. *Mem. Geol. Surv. India, Paleontol. Indica* (series 13) 5, 729–770.

Williams A., Carlson S.J., Brunton C.H.C., Holmer L.E. & Popov L. 1996: A supra-ordinal classification of the Brachiopoda. *Phil. Trans. Roy. Soc. London*, series B 351, 1171–1193.

Zelinskaya V.A. 1975: Brachiopods from the Paleogene of Ukraine. *Naukova Dumka*, Kiev, 1–148 (in Russian).