UPPER SPATHIAN TO BITHYNIAN (LOWER TO MIDDLE TRIASSIC) BRACHIOPODS FROM NORTH DOBROGEA (ROMANIA)

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Abstract. Brachiopods obtained from several Triassic localities in North Dobrogea, in Romania, are described. Upper Spathian and Aegean Hallstatt-type red limestones have been sampled in the Deşli Caira section, proposed as the GSSP for the base of the Anisian. The Bithynian brachiopods mostly originate from the Tubiphytes-microbial buildup in the Mahmudia quarry, and also from the Hallstatt-type limestones of Agighiol and Orta Bair. Their age estimates are supported by ammonoids collected from the same beds.

The upper Spathian and Aegean assemblages of Deşli Caira consist of four rhynchonellids, with one genus and two species newly described, Ortarhynchia petersi gen. n. sp. n. and Austriellula iordanae sp. n. The Bithynian assemblages comprise the most diverse fauna, with 15 species, four species of which are newly described, Ortarhynchia petersi gen. n. sp. n., Piarorhynchella kittli sp. n., Ptychomentzelia dobrogeana sp. n. and P. simionescui sp. n. In the Tubiphytes facies of Mahmudia, the assemblage is numerically dominated by mentzeliids and dielasmatids, forming 84.8 % of the whole assemblage. Spiriferinids and rhynchonellids form the minor component. Instead, rhynchonellids prevail in the Hallstatt facies at Agighiol and Orta Bair.

The assemblages described here are hardly comparable with those of the western Tethys. The Bithynian assemblage is very different from its equivalent described from the substage stratotype in Turkey. In North Dobrogea, the carbonate substrate and clear and agitated water supported an assemblage with high diversity. In contrast, in Bithynia, the brachiopod community dwelled on a softer and muddier substrate, with higher density and lower diversity. The locality of Aghdarband (Iran) also delivered Bithynian brachiopods, forming another different assemblage. The recovery and radiation of brachiopods after the P/T crisis is discussed in the framework of Palaeo-Tethyan palaeogeography, making comparisons with the South China localities.

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INTRODUCTION (E. GRĂDINARU)

Bounded on the north by the Danube Delta and rimmed on the east by the Black Sea, the North Dobrogea region is a fold-and-thrust belt, commonly named as the North Dobrogean Orogen (Sândulescu 1995; Visarion et al. 1990). It is located on the western tip of the Cimmerian Orogenic System, which continues eastwards with the Mountainous Crimea, North Caucasus and extends furthermore to the Asian Cimmerides (Şengör 1984, 1986). The North Dobrogean Orogen is tectonically bounded to the north by the Galaţi-Sfântul Gheorghe Fault and to the south by the Peceneaga-Camena Fault, which separate it from the Scythian Platform on the north and from the Moesian Platform on the south, respectively (Fig. 1). The North Dobrogean Orogen includes several tectonic units, namely the Măcin, Consul, Niculitel and Tulcea units, which are overthrust north-easterly (i.e. Sândulescu 1984; Visarion et al. 1990).

The Triassic sedimentary series that unconformably overlies a Variscan basement has the widest extension in the Tulcea Unit of the North Dobrogean Orogen, with basinal facies developed westwards in its inner part and a carbonate platform facies that extends in the mid-eastern part.
The carbonate platform was tectonically dissected by synsedimentary faulting into a complex network of pelagic swells and deep depressions. As a result, in the middle part of the Tulcea Unit, Middle and Upper Triassic deep-water sequences of reddish and greyish cherty, nodular limestones and varicoloured marly shales diachronously interfinger with thick sequences of Hallstatt-type thick-bedded limestones.

The present-day remote location of the North Dobrogean Triassic occurrences, placed outside of the Mediterranean Triassic, is currently interpreted as the result of the post-Triassic large-scale horizontal displacements of Tethyan terranes and the opening of the West Black Sea Basin (e.g. Grădinaru 1988; Okay et al. 1994; Banks & Robinson 1997).

The Triassic development of North Dobrogea is well known in the relevant literature for its Tethyan-type facies and richness in various groups of fossils (Arthaber 1906; Kittl 1908; Simionescu 1927; Tozer 1984; Grădinaru 1995, 2000). Ammonoid faunas, alongside brachiopods, bivalves and gastropods, have been described in classic monographs by Kittl (1908) and Simionescu (1910a-b, 1911, 1913a, 1925), with Agighiol (former Hagighiolo) as the reference locality. More recent studies on the cephalopods, brachiopods, gastropods, bivalves, conodonts, ostracods and foraminifers have been done by Mirăuţă & Gheorghian (1975), Mirăuţă & Iordan (1982), Mirăuţă et al. (1984, 1993), Crasquin-Soleau & Grădinaru (1996), Grădinaru & Sobolev (2006), Grădinaru et al. (2006, 2007), Orchard et al. (2007), Sebe et al. (2013), Forel and Grădinaru (2018), and Nützel et al. (2018). The potential for delivering vertebrate fossils (ichthyosaurs and coelacanths) is revealed by Simionescu (1913b) and Cavin & Grădinaru (2014), and Martin and Grădinaru (work in progress).

Lastly, it is worth mentioning that the first-ranked GSSP candidate for the base of the Anisian is represented by the Deşli Caira section, which is located in the Triassic classic area of Agighiol, in the Tulcea Unit (Grădinaru 2000; Grădinaru et al. 2006, 2007; Orchard et al. 2007; Ogg et al. 2016).

With special reference to the Triassic brachiopods from North Dobrogea, data have been published by Peters (1867), Kittl (1908), Simionescu (1910a-b, 1911, 1913), Mirăuţă et al. (1984) and Iordan (1993).

For the Spathian to the Bithynian stratigraphic interval, on which the present paper is focused, brachiopods of this age have been mentioned only by Kittl (1908), Simionescu (1910a-b, 1911, 1913), Mirăuţă et al. (1984) and Iordan (1993).
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Kittl (1908) cited *Spirigera marmorea* var. *auriculata* Bittner from Deşli Caira (Taşli, in Kittl), while, from Mandra, located westward of Agighiol, the same author cited *Rhynchonella* cf. *arcula* Bittner, *Rhynchonella refractifrons* cf. var. *bosniaca* Bittner, *Spirigera marmorea* var. *auriculata* Bittner, *Spirigera aff.* *S. balatonica* Bittner, and *Retzia* sp. Also from Deşli Caira, Simionescu (1910a) described and illustrated a brachiopod fauna that includes *Rhynchonella* (*Norella*) *kellneri* Bittner, *Spirigera marmorea* var. *auriculata* Bittner, *Rhynchonella* aff. *R. nux* Suess, *Rhynchonella* sp. The brachiopods reported from Deşli Caira by Kittl (1908) and Simionescu (1910a) originate from Hallstatt-type limestones that, based on the present ammonoid and conodont biostratigraphic data, are latest Spathian to Aegean in age (Grădinaru et al. 2006, 2007; Orchard et al. 2007).

Mirăuşă et al. (1984) cited from the Sarica region and illustrated *Spirigerellina* cfr. *pygmea* Dagys and *Fletcherithyris margaritovi* (Bittner), which, in view of the associated conodonts, bivalves and the ammonite *Tirolites* cf. *spinosus* Mojsisovics, are dated as early Spathian.

Iordan (1993) illustrated a few brachiopods from the lower Spathian. Also, she quoted several species from the Anisian (Pelsonian and Illyrian) from different localities in the central and eastern part of the Tulcea Unit, but their ages are not properly constrained biostratigraphically. The taxonomic assignments have to be revised for most of the material.

Unfortunately, the repository of the materials cited by Kittl (1908), Mirăuşă et al. (1984) and Iordan (1993) has not been identified yet. Only a few specimens illustrated by Simionescu (1910a) are preserved in the Museum of Palaeontological Collections in the University “Alexandru Ioan Cuza” of Iaşi (fide Turculeţ & Brânzilă 2012, p. 90).

**Stratigraphy (E. Grădinaru)**

The late Spathian to Bithynian brachiopods studied in the present paper originate from the successions exposed in the hill of Deşli Caira (upper Spathian to Aegean) and in the regions of the Agighiol (Bithynian), Orta Bair (Bithynian), and Mahmudia (Bithynian) localities. The materials were collected by the first author (EG) over several decades.

**Deşli Caira** (Fig. 2A). The front of the quarry (45°04'24.71" N, 28°48'04.92" E) exposes a total of 5 m of mixed reddish to light grey coloured limestones that grade upwards into brick-red coloured limestones at the top of the quarry face. Subordinate “Posidonia”-bearing, pale coquinaoid limestones are interbedded with the Hallstatt-type limestones. The Olenekian-Anisian Boundary (OAB) is located...
just above the top of the quarry (Fig. 2B). Above the OAB, the basal part of the lower Anisian is made up almost exclusively of thick-bedded, brick-red coloured Hallstatt-type limestones, with only rare intercalations of “Posidonia” bearing reddish coquinoioid limestones. The Hallstatt-type limestones are extensively bioturbated at some levels, with mottled aspects, and, in a few layers, they show condensed sedimentation features; small open-space features are present in the upper part of the section. The sequence yielded abundant ammonoids and fewer nautiloids of late Spathian to Aegean age. Other macrofaunas are poorly represented, with rare occurrences of small-sized brachiopods, gastropods and crinoids, and thin shelled bivalves at a few levels.

From the upper Spathian part, layers 810, 811, 816, and loose blocks from 816 to 821 (Fig. 2C) delivered three species (19 specimens): *Norella kellneri* Bittner, 1892, *Austriellula iordanae* sp. n., and *Ortarhynchia petersi* gen. n. sp. n.

From the Aegean part, layers 822A, 828 and 830 (Fig. 2C) contain three species (11 specimens): *Austriellula iordanae* sp. n., *Ortarhynchia petersi* gen. n. sp. n. and *Costirhynchopsis* sp. A.

The high-resolution ammonoid biostratigraphy in the Deşli Caira section, which was achieved in the last decade due to bed-by-bed investigation...
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Grădinaru, work in progress), accurately demonstrates that the Spathian/Aegean boundary is placed a little higher in the section than had been previously estimated by Grădinaru et al. (2007). It is now placed between the levels 821 and 822A. The topmost part of the level 821 (821A) yields the uppermost Spathian ammonoid assemblage, including *Procarnites kokeni* (Arthaber, 1908), *Eogymnites arthaberi* (Diener, 1915), *Proptychitoides* sp., *Albanites* sp., and others, whilst the level 822A yields a lowermost Aegean ammonoid assemblage, including *Aegeiceras ugra* (Diener, 1895), *Paracrochordiceras* sp., *Japonites* sp., *Stenopanoceras* sp., *Lenotropites* sp., and others. *Aegeiceras ugra* extends till layer 830.

**Agighiol** (Fig. 3A). Westward and near the Agighiol village, the Bithynian brachiopods come from thick-bedded, variously coloured, cream to cream-pinkish and grey limestones exposed in deep ravines north of the hill Dealul Pietros. They were collected in three separate outcrops, B1 (45°01’53.24” N, 28°51’47.57” E), B2 (45°01’51.82” N, 28°51’47.71” E), and B3 (45°01’53.20” N, 28°51’43.95” E), presently included in the Agighiol Natural Protection area. From Agighiol (18 specimens) originate *Norella kellneri* Bittner, 1892 and *Ortarhynchia petri* gen. n. sp. n.

The Bithynian age of the brachiopods is properly documented by a rich assemblage of ammonoids, with species of *Acrochordiceras*, *Platycoceras*, *Intornites*, *Nevadisculites*, *Phyllocladiscites*, *Ussurites*, *Gymnites* and other genera.

**Orta Bair** (Fig. 3B). At the hill of Orta Bair (45°01’40.76” N, 28°48’31.84” E), located 4 km west of the Agighiol village, the Bithynian brachiopods come from medium- to thick-bedded Hallstatt-type reddish limestones that are exposed on the western side of the hill. Three species are present. *Norella kellneri* Bittner, 1892, *Austriellula iordanae* sp. n. and *Ortarhynchia petri* gen. n. sp. n.,
Grădinaru E. & Gaetani M.

The studied brachiopods originate from a single layer at the top of Hallstatt-type limestones at this locality (14 specimens). The associated ammonoid fauna includes species of Acrochordiceras, Hollandites, Robinsonites, Pseudodanubites, Ussurites, Gymnites and other Bithynian genera.

Mahmudia (Fig. 4). The studied brachiopods come from middle Anisian carbonate rocks that are exposed in a 1.5 km-long limestone quarry located in the Caeracul Mare hill area (45°03'12.41" N, 29°03'34.52" E), south of the village of Mahmudia. The Caerace Formation, which includes middle Anisian carbonate rocks, is divided into two distinct lithostratigraphic subunits, the Stromatactis-Limestone Member and the Tubiphytes-Limestone Member. From the Stromatactis-Limestone Member only a single valve of Ko-om voricus sp. was collected. The microfacies and depositional environment have been described in detail by Popa et al. (2014). The brachiopods were collected almost exclusively from the Tubiphytes-Limestone Member, at two stratigraphic levels, layers 106 and 114. The second level is by far the richest, the studied brachiopods being extracted from only 1.5 cubic meters of rock (Fig. 5). The stratigraphic section of the Tubiphytes-boundstones, about 250 m thick, which contained brachiopods is exposed in a vertical wall in the northeastern part of the Mahmudia quarry. As shown by Popa et al. (2014), the Tubiphytes-boundstones are a massive carbonate buildup, lacking any visible bedding and showing a mixture of different carbonate facies, with frequent, microbially-mediated cement crusts (Fig. 6). These are very fossiliferous in various groups of macroinvertebrates, including ammonoids, nautiloids, gastropods, brachiopods, bivalves, sponges and crinoids, the gastropods and the bivalves being described by Nützel et al (2018) and Friesenbichler et al. (submitted). A very rich ostracod assemblage has been reported by Forel & Grădinaru (2018). When broken, the rock releases a pungent smell of rotten eggs. The high mass mortality ensured a high organic matter content to the carbonate sediment, and thus the reachness in nutrients of the Tubiphytes facies. The Bithynian Tubiphytes-microbial facies from North Dobrogea may be viewed as a chemosynthetically-driven oasis for various groups of organisms (Grădinaru 2017). The breakdown of organic matter by specific chemosynthetic microbial consortia enabled the richness of nutrients for the superabundant biota in the Tubiphytes-microbial facies of North Dobrogea (Forel & Grădinaru 2018; Nützel et al. 2018; Friesenbichler et al. submitted).

The Middle Anisian Tubiphytes-microbial reef was firstly documented in North Dobrogea by Popa et al. (2014), and this is the only known reef of this kind in the western part of the Cimmeride Orogenic System. It is evidence, with other examples worldwide (e.g. Stanley 1988; Senowbari-Daryan et al. 1993; Flügel 2002; Payne et al. 2006), of the recovery of carbonate production after the major biotic crisis at the Permian-Triassic boundary.

The early middle Anisian age (referred as the Bithynian substage in the standardized Geologic Time Scale 2016 published under the auspices...

The ammonoid assemblage is similar to those of the lower middle Anisian (Bithynian) of the North-Western Caucasus (Shevyrev 1995) and the lower part of the Hyatti Zone in the middle Anisian of Western Nevada (Silberling & Nichols 1982; Bucher 1992; Monnet & Bucher 2006).


**Methods.** The brachiopods have been mechanically cleaned and prepared. The internal structures were studied by serial sections, taking photographs and making peels at each step of grinding.

**Repository of the material.** The material is housed in the Museum of the Laboratory of Palaeontology in the University of Bucharest, with Catalogue numbers LPB IIIb 800 to LPB IIIb 880. The numbers refer to the catalogue for Brachiopoda from Romania.
**SYSTEMATIC PALAEOONTOLOGY**  
(M. GAETANI)

The brachiopod fauna under study consists of 16 species. Nine of them are represented by a single or very few specimens, and not fit for full description and therefore left in open nomenclature. However, it was decided to illustrate all of the material collected in order to give a comprehensive view of the new fauna. The classifications of Mancenido & Owen (2001), Savage et al. in Williams et al. (2002), Carter in Williams et al. (2006), and Jin et al. in Williams et al. (2006) are followed in the systematic description.

**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  
**Genus** Norella Bittner, 1890  
Type species: *Norella refractifrons* Bittner, 1890, p.315.

**Norella kellneri** Bittner, 1892  
Fig. 7A, Pl. 1, figs A-D

1910a *Rhynchonella* (Norella) *Kellneri* Bittner – Simionescu: p. 19, fig. 25, pl. 1, fig.18.

**Material**: Twelve specimens from the Bithynian of Agighiol, of which 10 are complete specimens: 3 figured specimens (LPB IIIb 800-802, Agighiol B2), 1 sectioned specimen (LPB IIIb 803, Agighiol B3), 1 complete specimen and 7 fragmentary specimens (LPB IIIb 804, Agighiol B2). Two complete specimens from the Bithynian of Orta Bair (LPB IIIb 805). One juvenile from the Aegen of Deşli Caira, layer 822A (LPB IIIb 806). Nine tiny complete specimens from the uppermost Spathian of Deşli Caira: layer 821, 1 figured specimen (LPB IIIb 807), layer 821, 2 additional specimens (LPB IIIb 808), layer 816, 6 specimens (LPB IIIb 809).

**Description**  
**External characters.** Small norellid, subpentagonal in outline, equi-biconvex, gently sulciplicate. A faint incision is present in the posterior dorsal valve in the juvenile specimens. Beak recurved, deltoidal plates not observed. Shell smooth.

**Internal characters** (Fig. 7A). Thick-shelled norellid, in which some details are obscured by crystallization. Ventral valve with rudimentary dental plates, supporting stout teeth, deeply inserted into the sockets, forming a robust articulation. Muscle fields well incised in transverse section. Median septum absent in the dorsal valve, with short and feeble hinge plates. Deep sockets with lateral accessory ridges. Hamiform crura.

**Dimensions** (in mm)

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**Remarks.** *Norella kellneri* Bittner, 1892 is much smaller than all the other *Norella* species so far described. It differs from *N. refractifrons*, type.

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**PLATE 1**

*Norella kellneri* Bittner, 1892  
Fig. A1-5 - specimen LPB IIIb 800. Dorsal, ventral, lateral, frontal, and posterior views, respectively. Agighiol B2, Bithynian.  
Fig. B1-5 - specimen LPB IIIb 801. Dorsal, ventral, lateral, frontal, and posterior views, respectively. Agighiol B2, Bithynian.  
Fig. C1-5 - specimen LPB IIIb 802. Dorsal, ventral, lateral, frontal, and posterior views, respectively. Agighiol B2, Bithynian.  
Fig. D1-5 - specimen LPB IIIb 807. Dorsal, ventral, lateral, frontal, and posterior views, respectively. Deşli Caira layer 821, Spathian.  

*Austriellula iordanae* sp. n.  
Fig. E1-5 - specimen LPB IIIb 810 holotype. Dorsal, ventral, lateral, frontal, and posterior views, respectively. Orta Bair, Bithynian.  
Fig. F1-5 - specimen LPB IIIb 812. Dorsal, ventral, lateral, frontal, and posterior views, respectively. Orta Bair, Bithynian.  
Fig. G1-5 - specimen LPB IIIb 815. Dorsal, ventral, lateral, frontal, and posterior views, respectively. Deşli Caira, layer 821, Spathian.  

Scale bar 1 cm.
Triassic brachiopods from North Dobrogea (Romania)
species of the genus, in the more elongate and inflated shape, especially in the ventral valve, and has no faint plicae in the sinus. The species was firstly described from the Dinarids, without well-defined stratigraphic position. In North Dobrogea it was already described from Deşli Caira by Simionescu (1910a).

**Occurrence.** Deşli Caira, upper Spathian, layer 816 and loose blocks from layers 816 to 821; Deşli Caira, Aegean, layer 822A; Agighiol B2-B3 and Orta Bair, Bithynian.

**Genus Austriellula Strand, 1928**
Type species: *Rhynchonella dilatata* Suess, 1855; Dagys, 1974, p. 89, pl. 29, figs 8-9, text-fig. 57.

**Austriellula iordanae** sp. n.

**Derivation of name:** Dedicated to Magdalena Iordan, who studied and illustrated the Triassic brachiopod fauna of Romania.

**Type specimens:** Holotype LPB IIIb 810, four paratypes (LPB IIIb 811), all from the Bithynian of Orta Bair.

**Material:** Other specimens: upper Spathian, Deşli Caira, la-
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yer 810, 3 specimens (LPB IIIb 816), layer 811, 2 specimens (LPB IIIb 817), layer 821, 1 figured specimen (LPB IIIb 815), 1 additional specimen (LPB IIIb 818); Aegean, Deşli Caira, layer 828, 1 figured specimen (LPB IIIb 812), 1 sectioned specimen (LPB IIIb 813), and 5 additional specimens (LPB IIIb 814).

Diagnosis: Small sized shell, uniplicate, smooth. Thick shed, with dental plates fused inside the callus. Laminal crura.

Description

External characters. Very small sized shell, subrounded in outline, with maximum thickness in the posterior part. Feebly uniplicate. Ventral valve forming ¾ of the total thickness. Dorsal valve almost flat and with a feeble depression in the posterior part of the valve in some specimens. Shell smooth, but with growth lines evident in some specimens.

Internal characters (Fig. 7B). Thick-shelled ventral valve, with deep muscle impression. Dental plates fused inside the callus; therefore, the teeth appear as directly supported by the shell wall and obliquely inserted in the sockets. Strong cardinal process, oblique hinge plates, with elevated inner socket ridge and a short median septum, poorly visible inside the callosity of the shell. Laminal crura.

Dimensions (in mm)

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Remarks. If the assignment to Austriellula is correct, this species is the oldest representative so far known for the genus. With Austriellula it shares the general shape, the thick internal callosity and the deep muscle impression. The very small size could be linked to the “Lilliput effect,” which was typical of brachiopods during their recovery and radiation after the P/T mass extinction. Gaetani (2016) described Austriellula kavakensis (Arthaber, 1914) from the Bithynian of Gebze (Turkey). It is proportionally wider and less thick. Internally it has rudimentary dental plates. The genus is most widespread in the Upper Triassic, particularly in the Hallstatt facies (Siblik 1982), as it occurs in North Dobrogea.

Occurrence. Deşli Caira section, upper Spathian, layers 810, 811, and loose blocks from layers 816-821; Aegean, layer 828. Orta Bair, Bithynian.

Subfamily Paranorellininae Xu, 1990

Ortarhynchia gen. n.

Derivation of name: From the hill of Orta Bair in North Dobrogea.


Content: At present only the type species Ortarhynchia petersi gen. n. sp. n. is known. Upper Spathian and Anisian.

Ortarhynchia petersi gen. n. sp. n.

Fig. 8, Pl. 2, figs A-E

Derivation of name: In honour of Carl Ferdinand Peters, founder of the geological knowledge of North Dobrogea.

Type specimens: Holotype LPB IIIb 819, two figured paratypes (LPB IIIb 820 and 821); four other paratypes (LPB IIIb 825), all from Orta Bair, Bithynian.

Material: Other specimens: Bithynian, Agighiol B3, 1 specimen (LPB IIIb 830), Orta Bair, 1 sectioned specimen (LPB IIIb 823); Aegean, Deşli Caira, layer 822A, 7 specimens (LPB IIIb 829). Upper Spathian, Deşli Caira, layer 810, 1 specimen (LPB IIIb 822), layer 811, 1 specimen (LPB IIIb 826), layer 821, 1 sectioned specimen (LPB IIIb 824), 1 specimen (LPB IIIb 827), 1 specimen (LPB IIIb 828).

Description

External characters. Very small to small sized shell, subpentagonal to trigonal in outline, rectimarginate, smooth. The ventral valve has a small
sub-erect umbo, with a small foramen, hardly visible because of sediment infilling (Pl. 2, fig. E). Maximum thickness at mid-length.

Internal characters (Fig. 8). Very thick shell. In the ventral valve, dental plates merged to lateral wall. Stout and short teeth, with small denticula. Deeply incised muscle field. Well developed cardinal process in the dorsal valve, high inner socket ridges. A potential septalium is embedded in the callosity of the thickened shell, from which the crural basis emerges forward. No septum. Short crura.

**Dimensions** (in mm)

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**Remarks.** The size of the shell is double in the Bithynian specimens vs the upper Spathian and Aegean specimens. The increase in size should be linked to the end of the “Lilliput effect”. No similar brachiopod seems to have been described in the Oleknian and Anisian.

**Occurrence.** Deşli Caira, upper Spathian, layers 810, 811 and 821; Aegean, layer 822A; Agighiol B3 and Orta Bair, Bithynian.

Subfamily Holcorhynchellinae Dagys, 1974

**Genus Piarorhynchella Dagys, 1974**

Type species: *Piarorhynchella mangystalakensis* Dagys, 1974, p. 110, pl. 32, figs 8-10, text-fig. 75.

**Piarorhynchella kittli** sp. n.

Fig. 9, Pl. 3, figs A-E

**Derivation of name:** In honour of Ernst Kittl, who first extensively described the Triassic of North Dobrogea.

**Type specimens:** Holotype LPB IIIb 869; eight paratypes (LPB IIIb 831-835, LPB IIIb 870), all from Mahmudia, Bithynian.

**Material:** Other specimens: Bithynian, Mahmudia, 4 isolated valves (LPB IIIb 836).

**Description**

**External characters.** Small sized uniplicate rhynchonellid, wider than longer, strong sub-erect beak; maximum thickness at ¾ of the length, fold and sulcus starting at middle length. The dorsal valve has a significant depression in the early stage of ontogeny, then it is uniplicate with the fold showing a triangular contour. Fold slightly recumbent at the front. The ventral valve shows a low bulge posteriorly, passing forward to a deep sulcus, with a triangular shape.
Shell smooth in the posterior part, then with rounded costae in the half-anterior part, 2/3 in the middle, 3/2 on the flanks. In some specimens, especially juvenile, the surface is almost smooth, with indentation present only along the frontal commissure. Peculiar is the tendency to have an asymmetrical development or to duplicate the median costae.

*Internal characters* (Fig. 9). Heavy recrystallization prevents accurate descriptions. Dental plates, septalium, and median short septum are recognized.

### Dimensions (in mm)

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Triassic brachiopods from North Dobrogea (Romania)

Remarks. The North Dobrogea specimens have some characters of Piarorhynchella and others approach those of Holcorhynchella. If compared with other species of Piarorhynchella, P. kittli sp. n. has the general shape, wider than longer, and the costae. From P. mangyshlakensis Dagys, 1974 it differs in the dimensions, the presence of a depressed area in the posterior part of the dorsal valve, and the irregularity of the median costae. The species from the Spathian of Mangyshlak is probably still under the “Lilliput “effect (Zakharov & Popov 2014). From the genus Holcorhynchella and its numerous species from Dalmatia, P. kittli sp. n. differs in the wider contour, higher number of costae and the wider, deep sulcus.

Occurrence. The Mahmudia quarry, Tubiphytes-boundstone, layer 114, Bithynian.

Costirhynchopsis sp. B
Pl. 3, figs G1-3

Material. One incomplete specimen (LPB IIIb 838).

Description. Small biconvex shell, with sub-pentagonal outline, uniplicate. Fold and sulcus developed from mid-length. Fully costate, with sharp angular costae, starting from the umbonal region. The specimen has 3/4 costae on sulcus and fold, and 5/4 on each flank.

Remarks. The attribution to Costirhynchopsis is tentative. Some characters approach C. mentzeli (Buch, 1843).

Occurrence. The Mahmudia quarry, Tubiphytes-boundstone, layer 114, Bithynian.

Costirhynchopsis sp. C
Pl. 3, figs H1-5

Material: One complete specimen (LPB IIIb 873), one incomplete specimen (LPB IIIb 879).

Description. Small biconvex uniplicate shell, with sub-rounded outline. Sub-erect beak. Sulcus gently depressed from the middle of the length. Low depression in the posterior part of the dorsal valve, then gently elevated fold. Maximum thickness at the middle of the length. Fully costate, with thin angular costae on thewhole surface; 6/7 in the median region, and 5/4 on each flank.

Remarks. The costal pattern recalls C. orientalis (Peters, 1867) from the Norian of the island of Popina in North Dobrogea. However, the outline of the shell in that species is wider, forming an apron.
Dimensions (in mm): length 10.50, width >10.90, thickness 7.90.

Occurrence. The Mahmudia quarry, Tubiphytes-boundstone, layer 114, Bithynian.

Order Spiriferinida Ivanova, 1972
Suborder Spiriferinidina Ivanova, 1972
Superfamily Pennospiriferinoidea Dagys, 1972
Family Punctospirellidae Dagys, 1974
Genus Punctospirella Dagys, 1974
Type species: Terebratula fragilis Schlotheim, 1814; Dagys, 1974, p. 136, pl. 39, figs 2-3, text-fig. 91.

Punctospirella sp. ind.
Pl. 4, figs A1-2

Material: One specimen (LPB IIIb 839) represented by a dorsal valve and part of the ventral valve.

Description. Small uniplicate spiriferinid, wider up to double of the length, with obtuse cardinal extremities. Apsacline interarea.

Smooth fold and sulcus, 4 rounded and stout costae on each flank, extended over all of the surface.

The partial abrasion of the interarea allows observation of the dental plates well separated with a median septum as deep as half of the plates (Pl.4, fig. A2).

Dimensions (in mm): length 11.30; width 18.5; thickness 10.20.

Remarks. The external shape perfectly matches the holotype of Nudispiriferina minima Yang & Xu, 1966. However, the well separated and extended dental plates approach much more to the species of the genus Punctospirella.

Occurrence. The Mahmudia quarry, Tubiphytes-boundstone, layer 114, Bithynian.

Genus Dinarispira Dagys, 1974
Type species: Spiriferina pia var. dinarica Bittner, 1890; Dagys, 1974, p. 131, pl. 37, fig. 8, text-fig. 88.

? Dinarispira sp. ind.
Pl. 4, figs B-C

Material: Four incomplete ventral valves (LPB IIIb 840-841, LPB IIIb 847 and 877).

Description. Medium sized spiriferinid, as long as wide, gently curved, with three costae in the sulcus and 6-7 on the flanks. Apsacilne interarea.

Dimensions (in mm): length > 17, width 19.5.

Remarks. These specimens are tentatively referred to the genus Dinarispira, for the median septum is partly visible on the surface of the shell. Instead, the dental plates seem to be absent.

Occurrence. The Mahmudia quarry, Tubiphytes-boundstone, layer 114, Bithynian.

Superfamily Mentzelioidea Dagys, 1974
(nom. transl. Sun & Ye, 1982)

Family Mentzeliidae Dagys, 1974
(nom. transl. Sun & Ye, 1982)
Genus Koeveskallina Dagys, 1965
Type species: Koeveskallina koeveskalyensis (Stur, 1865); Dagys, 1965, p. 172; Dagys, 1974, p. 140, pl. 40, figs 3-4, text-fig. 94.

Koeveskallina sp. A
Fig. 10, Pl. 4, figs D-E

Material: Five ventral valves (LPB IIIb 842-844 and 871) and 3 dorsal valves (LPB IIIb 845).

PLATE 5

Ptychomentzelia dobrogeana sp. n.
Fig A1-5 - specimen LPB IIIb 849 paratype. Ventral, dorsal, lateral, frontal, and posterior views, respectively.
Fig B1-5 - specimen LPB IIIb 848, paratype. Ventral, dorsal, lateral, frontal, and posterior views, respectively.
Fig C1-5 - specimen LPB IIIb 872, holotype. Ventral, dorsal, lateral, frontal, and posterior views, respectively.
Fig D1-5 - specimen LPB IIIb 870, paratype. Ventral, dorsal, lateral, frontal, and posterior views, respectively.
Fig E - specimen LPB IIIb 851 paratype. Ventral view.
Fig F - specimen LPB IIIb 852, paratype. Ventral view.
Fig G1-2 - specimen LPB IIIb 853 paratype. Ventral and dorsal views, respectively.
The Mahmudia quarry, Bithynian.

Ptychomentzelia simionescui sp. n.
Fig H1- 5 - specimen LPB IIIb 851, holotype. Ventral, dorsal, lateral, frontal, and posterior views, respectively.
The Mahmudia quarry, Bithynian.

Scale bar 1 cm.
**Grădinaru E. & Gaetani M.**

**Ptychomentzelia dobrogeana** sp. n.

*Fig. 11, Pl. 5, figs A-G*

**Derivation of name:** From the Dobrogea region.

**Type specimens:** Holotype LPB IIIb 872, 6 figured paratypes (LPB IIIb 848-853), 1 sectioned paratype (LPB IIIb 854), all from Mahmudia, Bithynian.

**Material:** Other specimens: LPB IIIb 855 and 876, 21 nearly complete specimens and 34 isolated valves, 28 ventral and 6 dorsal.

**Description**

**External characters:** Medium to large sized mentzeliid, usually wider than long. Feebly unipli cate. The ventral valve shows a feeble narrow sulcus in the anterior half, with rounded flanks. The dorsal valve has a very feeble fold.

Ornament consists of very feeble costae, often poorly visible on the internal mould, present in the anterior part, 2-3 on the fold and sulcus, and 4-5 on the flanks.

**Internal characters** (Fig. 11). Ventral valve with simple median septum that extends for 1/3 of the total length. Divergent dental plates, originating by the fusion of adminicula and dental flanges. Teeth small, deeply inserted in the sockets. Dorsal valve with high cardinal process, very short median septum, thinning out in a myophragm anteriorly. Horizontal hinge plates, with high inner socket ridges. Laminar diverging crural bases. Spiralium not preserved.

---

**Ptychomentzelia dobrogeana** sp. n.

*Fig. 11, Pl. 5, figs A-G*

**Derivation of name:** From the Dobrogea region.

**Type specimens:** Holotype LPB IIIb 872, 6 figured paratypes (LPB IIIb 848-853), 1 sectioned paratype (LPB IIIb 854), all from Mahmudia, Bithynian.

**Material:** Other specimens: LPB IIIb 855 and 876, 21 nearly complete specimens and 34 isolated valves, 28 ventral and 6 dorsal.

**Description**

**External characters:** Medium to large sized mentzeliid, usually wider than long. Feebly unipli cate. The ventral valve shows a feeble narrow sulcus in the anterior half, with rounded flanks. The dorsal valve has a very feeble fold.

Ornament consists of very feeble costae, often poorly visible on the internal mould, present in the anterior part, 2-3 on the fold and sulcus, and 4-5 on the flanks.

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Dimensions (in mm)

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Discussion. The general shape is similar to Ptychomentzelia propontica (Toula, 1896). However, the sulcus is narrow and not so triangularly shaped and open as in *P. propontica*. The short septum supporting a septalium does not occur in *P. propontica*.


*Ptychomentzelia simionescui* sp. n.

Fig. 12, Pl. 5, figs H1-5

Derivation of name: In honor of Ion Simionescu, who significantly contributed to the study of the Triassic deposits of North Dobrogea.

Type specimens: Holotype LPB IIIb 856, 2 paratypes sectioned (LPB IIIb 857, partially complete, and LPB IIIb 858, ventral valve).

Material: Other specimens: 6 ventral valves and 1 dorsal valve (LPB IIIb 859).

Discussion. The general shape is similar to *Ptychomentzelia ptychitiphila* (Bittner, 1890), from which it differs in the flat and less developed sulcus and fold, and the higher number of costae on the flanks. *P. simionescui* sp. n. differs from *P. dobrogeana* sp. n. in size and in having a sulcus and fold that are smooth, without costae.

Triassic brachiopods from North Dobrogea (Romania)

Order Terebratulida Waagen, 1883
Suborder Terebratulidina Waagen, 1883
Superfamily Dielasmatoidea Schuchert, 1913
Family Dielasmatidae Schuchert, 1913
Subfamily Dielasmatinae Schuchert, 1913
Genus Adygella Dagys, 1959
Type species: Adygella cubanica Dagys, 1959: 25; Dagys, 1974, 172, pl. 46, fig.1, text-figs 117-118.

Adygella sp. ind.
Fig. 13. Pl. 6, figs A1-5

Material: One complete specimen (LPB IIIb 859) and a fragment of a ventral valve (LPB IIIb 860, sectioned).

Description
External characters. Sub-pentagonal elongate contour, with maximum thickness in the posterior part of the shell. Umbo recurved, but partly broken. Gently uniplicate. Shell smooth with faint growth lines. Muscle field in the ventral valve with rounded diductors and adductor scars elongate till the middle length of the valve.

Internal characters (Fig. 13). No pedicle collar. Extremely thin convergent dental plates. Teeth small, supported by the shell wall.

Dimensions (in mm): length 20.00, width 18.10, thickness 10.10.

Discussion. The general shape of this species recalls the genus Coenothyris Douville, 1879, but the presence of the dental plates suggests the attribution to the genus Adygella Dagys, 1959.

Occurrence. The Mahmudia quarry, Tubiphytes-boundstone, layer 114, Bithynian.

Sulcatinella aff. S. incrassata (Bittner, 1890)
Figs 14, 15, Pl. 6, figs C-F

Material: One of the two most abundant species in the assemblage under study. Twenty-five bivalved specimens and 18 incomplete. Four figured specimens (LPB IIIb 862-865), 1 sectioned specimen (LPB IIIb 866), 20 measured specimens (LPB IIIb 867), 3 measured specimens (LPB IIIb 874).

Description
External characters. Small sized, sulciplicate dielasmatid, pentagonal in outline, slightly wider than long. Ventral valve inflated and convex, at least double the thickness of the dorsal valve. Greatest width and thickness attained around the mid-length. Dorsal valve with large and stout beak, straight and pointed in some specimens, curved in others. Straight beak ridges. Foramen partially occluded, especially in the thicker specimens. In the dorsal valve, the sulcus is starting near the dorsal umbo, forming an acute apron at the front, with rounded shoulders. Shell smooth.

Internal characters (Fig. 14). Ventral valve with short dental plates, near to the flanks, leaving a broad delthyrial cavity. Septalium deep, hinge plate in low position. Inner socket ridges prominent. Teeth inserted obliquely, sided by small denticle. The median septum reaches half of entire length.

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Genus Sulcatinella Dagys, 1974
Type species: Sulcatinella sulcata Dagys, 1974, p. 178, pl. 46, fig.5, text-figs 122-123.

Discussion. The species of Sulcatinella under
exam differs from the type-species of the genus, *S. sulcata* Dagys, 1974, for the less deep sulcus, starting near the dorsal umbo, and for the rounder shoulders of the sulcus itself. Some specimens are thicker, with recurved beak even if they are still small. Others specimens are longer with erect beak and are less thick. *Sulcatinella incrassata* (Bittner, 1890) is proportionally longer and thicker, with more rounded contour (Bittner, 1890, pl. 41, figs. 23-26) whilst the specimens described by Palfy (2003) are more pentagonal in outline. Therefore, the Mahmudia specimens are considered as only *affinis* to the *incrassata* species.

**Occurrence.** The Mahmudia quarry, *Tubiphytes*-boundstone, layer 114, Bithynian.

**Material:** One complete specimen (LPB IIIb 861) and one fragmentary specimen (LPB IIIb 875).

**Description.** Olive shaped dielasmatid of middle size. The ventral valve is thicker than the dorsal, maximum width and thickness at mid-length. A gently elevated fold divides anteriorly into two plicae, forming a sulciplicate anterior commissure. The ventral valve has a sulcus starting from the umbo, in which anteriorly a faint plica emerges. Shell smooth.

**Dimensions** (in mm): length 18.40, width 15.60, thickness 8.10.

**Discussion.** The specimen is tentatively referred to the genus *Rhaetina* Waagen, 1882, with which it shares the double fold in the ventral valve. However, *Rhaetina* has a non-depressed posterior part of the dorsal valve and lacks the small plica near the front of the dorsal valve.

This pattern is similar to the species of *Sichuanothyris* Shen, He & Zhu, 1992 of the Changhsingian of southern China. *Sulcatinella* Dagys, 1974

**Order RHYNCHONELLIDAE** Kuhn, 1949
**Family Norellidae** Ager, 1959
Subfamily Norellinae Ager, 1959
* Norella kellneri (Bittner, 1892) 24
* Austriellula iordane sp. n. 19
Subfamily Paranorellinae Xu, 1990
* Otarhythchia petersi gen. sp. n. 21
Subfamily Holcorhychnellinae Dagys, 1974
* Piarorhynchella kitti sp. n. 13
**Family Cyclothyracidae** Makridin, 1956
* Costirhynchopsis sp. A 1
* Costirhynchopsis sp. B 1
* Costirhynchopsis sp. C 2
**Order SPIRIFERINIDAE** Ivanova, 1972
**Family Punctospirellidae** Dagys, 1974
* Punctospirella sp. ind. 1
* ?Dinarispira sp. ind. 4
**Family Mentzeliidae** Dagys, 1974
* Koeveskalina sp. A 8
* Koeveskalina sp. B 2
* Ptychometzella dobrogeana sp. n. 63
* Ptychometzella simionescui sp. n. 10
**Order TEREBRATULIDAE** Waagen, 1883
**Family Dielasmatidae** Schuchert, 1913
* Adygella sp. ind. 2
* Sulcatinella aff. incrassata (Bittner, 1890) 43
**Family Angustothyrididae** Dagys, 1972
* Rhaetina sp. ind. 2

Tab. 1 - List of late Spathian, Aegean and Bithynian brachiopods from North Dobrogea (Romania) described in the present paper, and number of specimens.
and *Caucasothyris* Dagys, 1974 also do not have the median plica in the sulcus in the dorsal valve.

**Occurrence.** The Mahmudia quarry, *Tubiphytes*-boundstone, layer 114, Bithynian.

**The North Dobrogea Brachiopod Fauna (M. Gaetani)**

The upper Spathian to Bithynian new brachiopod fauna of North Dobrogea is rather diversified, with three species in the upper Spathian (to which should be added one by Simionescu (1910a) and four by Iordan (1993), three in the Aegean and 15 species in the Bithynian (Tabs 1 and 2). The number of available specimens is, however, too low. Only seven species may be conveniently described, the others are represented by one or a few specimens in the collection.

They originate from two distinct environments, the pelagic limestone in the Hallstatt facies, and the *Tubiphytes* facies.

The pelagic limestones of the Hallstatt facies were sampled along the section of Deșli Caira, candidate as GSSP for the base of Anisian, and in the localities of Agighiol and Orta Bair, where the brachiopod assemblage is preserved in a fine reddish wackestone. Commonly, the brachiopods are

<table>
<thead>
<tr>
<th>Brachiopod species</th>
<th>Sarica Veche</th>
<th>Desli Caira</th>
<th>Mandra</th>
<th>Orta Bair</th>
<th>Agighiol</th>
<th>Mahmudia</th>
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<tbody>
<tr>
<td>Gradinaru &amp; Gaetani, this paper</td>
<td></td>
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<tr>
<td>Norella kelneri (Bittner)</td>
<td>Sp2-Ae</td>
<td>Bi</td>
<td>Bi</td>
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<tr>
<td>Austriellula iordananae sp. n.</td>
<td>Sp2-Ae</td>
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<tr>
<td>Otrarhynchia petersi gen. n. sp. n.</td>
<td>Sp2-Ae</td>
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<td>Piarorhynchella kitti sp. n.</td>
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<tr>
<td>Costirhynchopsis sp. A</td>
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<td>Costirhynchopsis sp. B</td>
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<td>Costirhynchopsis sp. C</td>
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<tr>
<td>Punctospirella sp. ind.</td>
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<tr>
<td>? Dinarispira sp. ind.</td>
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<tr>
<td>Koeveskallina sp. A</td>
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<td>Bi</td>
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<tr>
<td>Koeveskallina sp. B</td>
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<tr>
<td>Ptychometzelia dobrogeana sp. n.</td>
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<tr>
<td>Ptychometzelia simionescui sp. n.</td>
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<td>Adygella sp. ind.</td>
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<tr>
<td>Sulcatinella aff incrassata (Bittner)</td>
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<tr>
<td>Rhexina sp. ind.</td>
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</table>

Tab. 2 - Synopsis of Spathian, Aegean and Bithynian brachiopods from North Dobrogea, described in the present paper and mentioned in literature, showing their stratigraphic levels and localities of occurrence. Abbreviations: Sp1 – lower Spathian; Sp2 – upper Spathian; Ae – Aegean; Bi – Bithynian.
too rare and of small-size in the Hallstatt-type limestone of North Dobrogea (65 specimens), and they are represented only by species of Rhynchonellida, almost exclusively belonging to Norellidae, 98, 5% (Fig. 17). These species cross the Spathian /Anisian boundary, doubling their size in the Bithynian. The “Lilliput” effect in the Lower Triassic brachiopod fauna is already known (Chen et al. 2005; Zakharov & Popov 2014). A rather deep, quiet-water bottom may be suggested. It could be that the Rhynchonellida dominance is related to a nutrient poor environment in deep-water settings.

Simionescu (1910a), Miriță et al. (1984) and Iordan (1993) reported also species of Athyridida and Terebratulida. Unfortunately, the Iordan material is apparently lost, whereas of the material of Simionescu, only a few specimens of Norella kelhneri and Triadispira? marmorea auriculata Bittner are preserved in the Museum of Paleontological Collections in the University of Iași. The Tubiphytes-boundstone was sampled in the Mahmudia quarry (Popa et al. 2014). The main constituent of the boundstone are ramose individuals of the problematic organism Tubiphytes, a common fossil of the Anisian reef assemblages. Also important are local concentrations of ostracods, foraminifera, bivalves, brachiopods and crinoids, all embedded in large amounts of isopachous, fibrous, cm-thick cements (Popa et al. 2014). The Mahmudia brachiopod assemblage consists of about 151 specimens (plus about 30 fragmentary specimens not identified), extracted from a hard bioclastic whitish limestone. Apparently, this fauna is made of epifaunal suspension feeders, mostly pedicle-attached species. The assemblage is dominated by two species: Psychomantzia dobrogeana sp. n. and Sulcadinella aff. S. incrassata (Bittner, 1890), forming about the 70% of the assemblage. Mentzeliids, with Psychomantzia and Koerskallina species representing 55,0 % of the assemblage (Fig. 17), are medium sized, while all the other species are small sized. Almost all are smooth or feebly costate forms. Only one specimen of Punctaspirella sp. ind. has stronger costae. The two species of Rhynchonellida (Costirhynchopsis spp. B, C), representing only 2,0 % of the assemblage, have thin and sharp costae. Although smooth forms suggest deep or cool water, Vöros (2005) showed that in the Jurassic of Bakony, in Hungary, for which the palolatitude was around 15-30° N, 94% of the brachiopod specimens are smooth forms, and argued this is not however indicative for a deep environment.

The same situation occurs in North Dobrogea, where the brachiopods are associated to and dwelling on the Tubiphytes crusts. These microproblematica are thought to be light dependent organisms. The paleolatitude of North Dobrogea was around 30-35° N (pers. com. G. Muttoni 2017, on data by Gallet and Krystyn, in Grădinaru et al. 2007) during the Anisian. Vöros (2010) also noted that scaling ornamentation increases in size and importance during the Triassic, suggesting a relationship with the predation pressure. Was the Bithynian a time of low predation pressure?

The Tubiphytes facies has a highly abundant benthic macrofauna (gastropods, bivalves, brachiopods), as well as ostracods that should have lived in a high nutrient environment. The more diversified brachiopod fauna and the abundance of spiriferinids could suggest the presence of a more efficient filtering device as was hypothesized for the spiriferid/athyrids vs productids in the Pennsylvanian shallowing cycles (Pérez-Huerta & Sheldon 2006). Could it be the same for spiriferinids vs rhynchonellids in the Bithynian of North Dobrogea?

The recovery of Rhynchonellata brachiopods along the northern shores of the Palaeo-Tethys

The aftermath of the P/T crisis has been discussed by many authors during the last tens of years (e.g. Erwin et al. 2002; Chen et al. 2005; Zakharov & Popov 2014; Chen et al. 2015; Ke et al. 2016). It is now widely accepted that after a short time of survival of Permian taxa during the early Griesbachian, the early recovery started in the late Griesbachian, followed by a long interval of recovery and dispersal between the Dienerian and Olenekian, to eventually reach the final radiation during the Anisian (Chen et al. 2005; Bottjer et al. 2008; Chen & Benton 2012).

In the Lower Triassic, Rhynchonellida were the best represented, mostly by the superfamly Norellidae. According to Chen et al. (2005), Rhynchonellida formed 46,8% of the total taxa, Terebratulida 25%, Athyridida 18,7%, and Spiriferinida 9,5%.

The additional data published in the following years did not significantly change this general picture (Zakharov & Popov 2014; Chen et al. 2015). The distribution of biotic provinces was analysed.
Triassic brachiopods from North Dobrogea (Romania) by Ke et al. (2016).

The main radiation occurred in the Anisian. According to Hallam & Wignall (1997) and Sepkoski (2002), about 50 genera of Rhynchonelliformean brachiopods occur during the Anisian. However, this datum includes the whole Anisian. In fact, the true blossoming occurred in the Pelsonian, at least in the western Palaeo-Tethys (Gaetani, pers. data). The Bithynian taxa were not yet so abundant.

The subsequent geological evolution and collision/orogenies along the northern shores of the Palaeo-Tethys, mostly affected the Lower and Middle Triassic records in Central Asia and caused the present occurrence in two separate areas: the China blocks at the east (Cathaysian Province) and the belt from Kazakhstan to the Alps at the west (Western Tethyan Province). Together they may be grouped in the Tethyan Realm (Ke et al. 2016). However, it should be noted that the analyses and percentages on which these two areas are defined are based on lists of taxa, without having a taxonomic evaluation of the validity of all of these taxa. Nor was the number of specimens represented by each species calculated.

In the Bithynian of North Dobrogea, Terebratulida are represented by only three species, being 31.1 % of the assemblage (Fig. 17). However, one of them, Sulcatinella aff. S. incrassata, is the most abundant, being 28.4 %. Terebratulida seems to be less represented in comparisons to the Spiriferidina or Rhynchonellicida, which form together more than half of the population, 68.9 % (Fig. 17).

**Cathaysian Province.** The recovery of Rhynchonelliformean brachiopods after the P/T crisis is up to now better documented on the eastern arms of the Palaeo-Tethys (Komatsu 2004; Chen et al. 2005; Chen et al. 2010a,b; Ke et al. 2016).

Along the shores of the South China block, assemblages with a fully Mesozoic aspect are developing from the late Griesbachian (Chen et al. 2015). They are rare during the earliest Triassic, represented mainly by lingulids. In the Spathian (Olenekian)
six species of Rhynchoneliformean brachiopods are known. In the Olenekian of South China, Rhynchonellida formed 33%, Spiriferinida 45%, and Athyridida 22% (Chen et al. 2015). Instead, brachiopod assemblages became definitely richer in the Aegean (25 species) and Bithynian (26 species) substages of the Anisian (Chen et al. 2010a,b; Ke et al. 2016). Athyridida, Rhynchonellida, Spiriferinida, and Terebratulida are present, and all are characterized by relatively small size, a biconvex shell, weak ornamentation and pediculate shells (Ke et al. 2016). In the Pelsonian, a slightly lower number of species has been reported.

As regards the diversity, in the Aegean, Rhynchonellida formed 20%, Spiriferinida 44%, Athyridida 16%, and Terebratulida 20% (Chen et al. 2015). In the Bithynian, Rhynchonelliformea are represented by 26 species, most of them already present in the Aegean. Only four new entries are reported, while three are missing in the Bithynian. The percentage does not change significantly, with Rhynchonellida at 27%, Spiriferinida at 46%, Athyridida at 15%, and Terebratulida at 12%. In the Bithynian, Spiriferinida and Rhynchonellida prevail, at least with regard to number of species. To be noted is the importance of the mentzeliiids also in China (He et al. 2015).

**Western Tethyan Province.** The Induan stage of the Lower Triassic has no suitable facies for preservation of Rhynchonelliformean brachiopods. Only some lingulids are known (Posenato et al. 2014). In the Olenekian, particularly in the Spathian, data are more consistent: Mangyshlak in Kazakhstan, and North Dobrogea (present study). Of interest are the findings in the Dolnapa area (Mangyshlak hillocks, Kazakhstan). Dagys (1974) reported four species from the Olenekian: Piarorhynchella mangyshlakensis Dagys, Costispiriferina mansfeldi Girty, Spirigerellina pygmaea Dagys, and Flettericythyris margaritovi Bittner (now Bittnericythys in Popov...)
Triassic brachiopods from North Dobrogea (Romania)

& Zakharov 2017). In addition to the species quoted by Dagys (1974), Zakharov & Popov (2014) mention the occurrence of *Hustedtiella planicosta* Dagys, *Spirigerellina* sp., *Antegeilleria* sp., *Pronaadryrella* (? sp.), and new species of *Prelissorhynchia* (?), *Lissorhynchia*, and *Thyatriaria*. Several species are represented by small sized specimens, considered under the “Lilli-put effect”. It should be noted that the Mangyshlak Gulf was partially closed during the Olenekian, and the ammonoid fauna is largely endemic (Balini et al. 2000) (Fig. 16). Some of these species are also present in Primorye in eastern Russia (Zakharov & Popov 2014; Popov & Zakharov 2017; Popov, pers. comm. 2017). The marine succession in Mangyshlak ends with the Olenekian and the overlying Anisian is in elastic facies (Gaetani et al. 1998; Balini et al. 2000; Zakharov & Popov 2014). In Mangyshlak, Rhynchoellida form 27.2%, Spiriferinida 9%, Athyridida 27.2%, and Terebratulida 36.3%.

Kittl (1908), Mirăuţă et al. (1984) and Iordan (1993) quoted four species in the Spathian from different localities of North Dobrogea, *Spirigerellina pygmaea* Dagys, *Fletcherithyris* (now *Bittnerithyris*) *margaritovii* (Bittner), and *Hustedtiella cf. planicosta* Dagys. The identification of *Crurithyris extima* Grant is doubtful because it is a Permian species. These specimens originate from the “platy limestone formation” cropping out east of Sarica, in the northeast area of the Niculiţel Unit, in reddish partly dolomitized limestones associated with dark greyish limestones that are underlain by basalts (Mirăuţă et al. 1984). In our collection, three additional species are found: *Norella kellneri* Bittner, *Austriellula iordanae* sp. n. and *Ortarbunchia petersi* gen. n.sp. n., all coming from the Hallstatt-type limestones cropping out at Deşli Caira, Agighiol and Orta Bair, all located in the Tulea Unit. Including Iordan’s (1993) identifications, in North Dobrogea, Rhynchoellida form 42.8%, Athyridida 28.5%, and Terebratulida 28.5%.

In Bulgaria, Ganev (1961) reported the presence of *Terebratula* (now *Bittnerithyris*) *margaritovii* Bittner in the Olenekian of the Stara Planina. No Rhynchoelliforme brachiopods are known from the Alps, Dinarids and Transdanubian Range.

No brachiopod species have been so far reported from the Aegean substage, which is poorly documented in the Western Tethyan Province. Only in North Dobrogea and in Albania, the Aegean substage is documented by conodonts and ammonoids (Grădinaru et al. 2007; Germani 1997), besides the type-locality in Chios Island (Assereto 1974; Gaetani et al. 1992).

In the present study, four species are recorded in the Aegean of Deșli Caira in North Dobrogea, and are very rare, i.e. *Norella kellneri* Bittner, *Austriellula iordanae* sp. n., *Ortarbunchia petersi* gen. n.sp. n., and a single specimen of *Costirbunchopsis* sp. A.

Within the Bithynian, the scenario changes dramatically. The North Dobrogea assemblage here described is the richest, with 15 species, mainly belonging to Rhynchoellida, Spiriferinida, and Terebratulida. Amongst Spiriferinida, metzeliids with 55.0 % largely prevail (Fig. 17).

Up to now, in the western Palaeo-Tethys only three localities with brachiopods are referred to the Bithynian substage, in which the age is confirmed by ammonoids: North Dobrogea in Romania, Gebze in Turkey, and Aghdarband in Iran.

The Gebze assemblage (Gaetani 2016) has a rather high density, with two rhynchoellids, *Austriellula karakensis* (Arthaber), *Holorbunchella edhemi* (Toula), one spiriferinid, *Ptychomentzelia propontica* (Toula), and a single specimen of *Angustothyris angustaformis* (Böckh). The brachiopods are preserved in thin bedded, nodular marly limestones that alternate with marlstones, deposited under wave base in a muddier environment.

The Anisian succession of the Gebze area belongs to the Istanbul Terrane (Gaetani 2016; Lom et al. 2016). There is a current tectonic model according to which the Istanbul Terrane allegedly rifted off from the Romanian/Ukrainian conjugate margin that is arbitrarily labelled as the so-called “Odes-sa Shelf”, and was translated southward opening the West Black Sea basin during the Cretaceous (e.g. Okay et al. 1994; Okay & Tüysüz 1999; Okay & Göür 2007; Tari et al. 2015; Tüysüz 2018; Okay et al. 2018). The Bithynian (Anisian, Middle Triassic) ammonoid and brachiopod faunas of the Istanbul Terrane (Fantini Sestini 1988; Gaetani 2016) have no counterparts in the Triassic successions of the geological units underlying the so-called “Odessa Shelf”, i.e. the Scythian Platform, the North Dobrogean Orogen and the Moesian Platform. The Gebze Middle Triassic fauna, which inhabited the Istanbul Terrane located far southward of the shore of Laurasia, shows close affinities with the Middle Triassic fauna of Aghdarband in Iran (Krystyn & Tatzreiter 1991; Siblik 1991), which was located much farther eastwards on the northern shore of
the Palaeo-Tethys (Fig. 16). Therefore, from the viewpoint of Middle Triassic palaeogeography, the Istanbul Terrane cannot be conceived in any case as representing the conjugate Turkish margin of the so-called Romanian/Ukrainian “Odessa Shelf”. On the other hand, the true Odessa Shelf is underlain solely by the East European Platform, at the north, and the Scythian Platform, at the south (see fig.1 in Hippolyte et al. 2018).

The assemblage of Aghdarband (Siblík 1991) consists of Costirhynchia (now Costirhynchopsis) ruttneri Siblík, Punctospirella aff. P. fragilis (Schlotheim), Dacreithyris vulgaris Siblík, and a stratigraphically doubtful occurrence of Tetractinella trigonella (Schlotheim). The rhynchonellid Costirhynchia ruttneri is the most abundant, while the other species are represented by a single or a few specimens. Brachiopods originate from the upper part of the Nazar-Kardeh Formation, consisting of greenish-grey nodular and partly siliceous limestone beds alternating with shales and sandstones (Krystyn & Tatzreiter 1991; Zanchi et al. 2016). Apparently, the bottom conditions at Aghdarband were less turbid than in Gebze.

The Bithynian brachiopod fauna from the northern shores of the western Palaeo-Tethys (not less than 22 species) consists of Rhynchonellida (40.9%), Spiriferinida (36.3%), and Terebratulida (22.7%). No Athyridida are known.

It does not differ in number of species from the South China fauna (26 species, Chen et al. 2015). A significant difference is, however, the composition of the assemblages. In South China, Rhynchonellida forms 27%, Spiriferinida 46%, Athyridida 15 %, and Terebratulida 12 %. However, the Mentzelioidea are subordinate within the Spiriferinida, while in the western Palaeo-Tethys the Mentzelioidea are prevailing within the order. All the Rhynchonellida orders surviving the P/T crisis are represented. The faunal assemblages differ significantly at the various localities, with very few species shared by at least two localities. This fact is largely dependent on the different environmental conditions.

During the Pelsonian, brachiopods continued to radiate after the P/T crisis, especially on the western shores of the Palaeo-Tethys. The major occurrences are along the shelves of the Adria promontory (Southern Alps in Italy, Balaton area in Hungary, Dinarids, Balkans (Bittner 1890, 1903; Martelli 1906; Diener 1920; Metzeltin 1973; Pálfy 1990; Benatov 2001, amongst others), reaching a total number of about 50 species.

Contrary to the South China, where the num-
Triassic brachiopods from North Dobrogea (Romania)

The knowledge of the brachiopod fauna, from Early Triassic to the early Anisian, appears to still be largely incomplete and spotty. The reported percentages are very rough, because they do not consider the type of environment and the number of specimens within the species. The occurrences are also linked to the environmental conditions that control the existence and preservation of the fauna itself. However, notwithstanding this bias, the recovery of brachiopods, especially from the early Anisian onward, has been largely secured.

**Conclusions**

The brachiopod fauna from the late Spathian to the Bithynian of North Dobrogea casts a new light on the recovery of the brachiopods after the P/T crisis. Seven species belonging to three families are known from the Spathian. The Aegean documentation is poor, but in fact is the only one controlled by ammonoid/conodont biostratigraphy, as compared with other localities worldwide. The Bithynian fauna of North Dobrogea is instead proportionally rich, demonstrating that the brachiopod fauna was already largely diversified. It is rarely documented worldwide, because of the absence of preserved suitable environments. The paucity and the random records of brachiopods are thus more due to preservational conditions, than to a delay in the recovery of faunal diversity after the P/T crisis.

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In Homage to Maurizio Gaetani (1940-2017): Brachiopods were for Maurizio Gaetani his first love in Palaeontology. In the last three years he was very active on the Triassic brachiopods by publishing several papers (Gaetani & Mantovani 2015; Gaetani 2016; Gaetani et al. 2018). The project devoted to the study of the upper Spathian to Bithynian brachiopods from North Dobrogea started in mid January 2017 when Maurizio came to Bucharest, in spite of a harsh winter, to take the material. Maurizio worked frantically, so the first results of the taxonomic study could be presented by him at the 11th Romanian Symposium on Palaeontology, Bucharest, 27-28 September 2017 (Grădinaru & Gaetani 2017). Before his unexpected passing, Maurizio finalized the chapter on the Systematic Palaeontology and the next two chapters of the manuscript. In our last emails changed at the end of November 2017, Maurizio proposed to publish the paper in Rivista Italiana di Palaeontologia and Stratigrafia. Surely, he never believed that the present paper would be published in the Homagial Volume dedicated to his life and professional career. As a co-author of the present paper, I am very grateful to Maurizio, who in the last year of his life focused on the study of the late Spathian to Bithynian brachiopods of North Dobrogea, which otherwise would remained unstudied in my drawers. Over the years, I guided Maurizio in several field trips in North Dobrogea to show him the most important sections of the Triassic, and I remember his high devotion and also his great delight to look on other scenarios of the Triassic World. Last but not least, Maurizio enthusiastically attended the Workshop on the Lower-Middle Triassic (Olenekian-Anisian) boundary, 7-10 June 2000, Tulcea, Romania (Fig. 18), and he has been one of the most authorized advocates that supported the GSSP candidacy of the Deșli Caira section for the base of the Anisian.

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