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Sporadic Pliocene and Pleistocene brachiopods in Naturalis Biodiversity Center (Leiden, the Netherlands): Records from the Mediterranean, and the North Sea Basin

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Abstract – The Cenozoic Mollusc Collection of the Naturalis Biodiversity Center (NBC) contains several Pliocene and some Pleistocene brachiopods from the Mediterranean (5 Italian localities), and from the North Sea Basin (2 English localities, 1 French locality, 4 Dutch localities). The studied samples altogether yielded more than 1000, mostly fragmentary specimens (8 genera, 8 species). The Italian Pliocene (and Pleistocene) assemblage is dominated by large terebratulids (*Terebratula ampulla*), while rhynchonellids (*Aphelesia bipartita*) and cancellothyridids (*Terebratulina retusa*) are rare. The Coralline Crag samples of England are characterized by large terebratulids (*Pliothyrina sowerbyana*) and lingulids (*Glottidia dumortieri*), the zeilleriid *Macandrevia cranium* is rare. The only French locality yielded few brachiopods, with relatively higher diversity (*P. sowerbyana* is more common, the others are rare: *G. dumortieri*, *M. cranium*, *Argyrotheca* cf. *plicata*). The Dutch Pliocene samples are dominated by mostly fragmentary lingulids (*G. dumortieri*), while the others are much less common (*Notosaria nysti*, *P. sowerbyana*, *T. retusa*, *M. cranium*). This is the first photo documentation of *N. nysti*. With 64 figures.

Key words – Brachiopoda, Mediterranean, Naturalis Biodiversity Center, North Sea, Pleistocene, Pliocene

INTRODUCTION

The studied brachiopods were found as part of the Cenozoic Mollusc Collection of the Naturalis Biodiversity Center in Leiden (the Netherlands) (see details in Dulai 2013). As the result of a Synthesys visit in Naturalis (NL-TAF-3270), some papers have already been published on the basis of unpublished brachiopod materials separated from the Cenozoic Mollusc Collection. A small fauna from the Upper Miocene layers of Tetti Borelli (Piemonte, North Italy) yielded 6 species (Dulai 2010). (On the basis of the NBC collection labels, the Tetti Borelli fauna was erroneously indicated as Messinian in age. However, according to Janssen (2012) the pteropod fauna of this locality refers to the Tortonian). Description of a new Central Paratethyan *Argyrotheca* spe-

cies was partly also based on material from NBC (Dulai & Stachacz 2011). Geochemical analysis of Miocene and Pliocene phosphatic shelled brachiopods (lingulids, discinids) yielded important results on palaeoenvironments and ancient connections among different seas (Kocsis *et al.* 2012). Sporadic Miocene brachiopods from different palaeogeographic realms (Mediterranean, North Sea, and Atlantic Ocean, respectively) were presented by Dulai (2013) (12 species from 16 localities). Central Paratethyan Middle Miocene (Badenian) brachiopods are also represented in the NBC collection (Dulai 2015). A voluminous paper on Maltese Oligocene and Miocene brachiopods is partly based on materials stored in Naturalis (Dulai *et al.* in prep.). Some other papers are also in preparation ("Redonian" brachiopods from France, Miocene and Pliocene brachiopods from Belgium, Neogene Discinidae brachiopods from the North Sea Basin). The present part of this series deals with some sporadic Pliocene brachiopod materials from the Mediterranean and the North Sea Basin. Samples of a Mediterranean locality contain few Pleistocene specimens, which were also included in this study.

There were four marine provinces in Europe during the Miocene: the Atlantic Ocean, the North Sea, the Paratethys and the Mediterranean. For the Late Miocene and the Pliocene marine conditions ceased in the Central Paratethys. Last widespread normal marine assemblages, including brachiopods were identified from the Middle Miocene Badenian (Langhian-Early Serravallian) (see references in Bitner 1990; Bitner & Dulai 2004; Dulai 2015). The subsequent Sarmatian (= Late Serravallian) was characterized mainly by brackish environments, without stenohaline organisms (e.g. without brachiopods). However, some authors supposed partly normal marine conditions in the Sarmatian, too (e.g. Piller & Harzhauser 2005). Recently, few brachiopods were reported from the Sarmatian of Sandberg, Vienna Basin (Bitner *et al.* 2014), however, redeposition from the Badenian cannot be excluded unambiguously. For the Late Miocene and Pliocene Lake Pannon occupied the Carpathian Basin with lacustrine environments. However, the other marine realms continued from Miocene to Pliocene, and brachiopods were recorded from all three areas in the literature. The studied sporadic samples of the Naturalis Biodiversity Center yielded Pliocene brachiopods from the Mediterranean and the North Sea Basin.

PLIOCENE BRACHIOPODS IN EUROPE – PREVIOUS RESEARCH

Mediterranean – Pliocene brachiopods of the Mediterranean were published mainly from Spain and Italy. After some historical records, Pajaud (1976) mentioned *Terebratula terebratula*, and described *Phapsirhynchia sancta-*

paulensis as new genus and species from the Lower Pliocene glauconitic and biodetritic facies of Alicante region. Pajaud (1977) described eight species from the Lower Pliocene organodetritic facies of Águilas. Martinell (1982) recorded borings produced by Pliocene brachiopods in Catalonia. Encinas & Martinell (1992) found five species in the Pliocene of Empordà Basin (Catalonia). Calzada (1997) mentioned *Megerlia eusticta* from Almeria. Bitner & Martinell (2001) described four species from the Lower Pliocene sandy deposits of Estepona. (It is worth mentioning that a new private collection from Estepona yielded 12–13 species; Dulai & Mulder in prep.). Garcia Ramos (2004) mentioned 11 brachiopod species from Águilas and later five species from the Lower Pliocene of SE-Spain (Garcia Ramos 2005). The above author (Garcia Ramos 2006) summarized the European Tertiary terebratulids, including some Pliocene forms, too. Toscano-Grande *et al.* (2010) described three species from the Guadalquivir Basin, and summarized 11 species from the Pliocene of Spain.

Davidson (1870) and Sacco (1902) described the Tertiary brachiopods of Italy including some Pliocene species, too. Foresti (1893) documented 10 species in the Pliocene sediments of Bologna. Gaetani & Saccà (1984) discussed bathyal brachiopods from the Pliocene and Pleistocene of Sicily and Calabria. Gaetani & Saccà (1985a) described 12 species from nine Late Pliocene localities of Messina and Calabria. Gaetani & Saccà (1985b) revised the genus *Aphelesia*. Saccà (1986) mentioned *Megerlia echinata* from Sicily and Calabria. Gaetani (1986) discussed Pliocene and Pleistocene palaeocommunities from Sicily and Calabria, and distinguished three main facies groups from the Pliocene. Benigni & Robba (1990) discussed a micromorphic brachiopod-pectinid assemblage from the Late Zanclean sands (with four brachiopod species). Taddei Ruggiero (1994, 1996) mentioned brachiopods from the Salento Neogene and the Gravina calcarenite. Borghi (2001) described 10 species from Emilia. Lee *et al.* (2001) revised the type species *T. terebratula* and confirmed the presence of *T. ampulla* in the Pliocene of Emilia and Toscana. Bertolaso *et al.* (2009) described 11 Pliocene species from Emilia.

From other parts of the Mediterranean Pliocene brachiopods are not so well-known. Dermitzakis (1969) mentioned seven species from different Pliocene localities of Crete. Six species were recorded from Upper Pliocene sandy and calcareous deposits of the Rhodes Island by Koskeridou (2007). From the southern, African part of the Mediterranean Dautzenberg (1909) described a new rhynchonellid species from the Pliocene of Algeria. Seven Pliocene species were described from Algeria and Morocco by Bitner & Moissette (2003), while the high frequency of predatory drill holes in Pliocene brachiopod shells was recorded by Baumiller *et al.* (2006).

North Sea Basin – Charlesworth (1837) described a "gigantic" species of *Terebratula* from the Coralline Crag of England (*T. maxima*). Davidson (1852, 1874a) described the Tertiary brachiopod fauna of Great Britain, including some Pliocene forms, too. The brachiopods of the Pliocene Coralline Crag in England were studied in detail by Wood (1872). Buckman (1908) discussed the nomenclatural problems of large terebratulids from the Coralline Crag. Bell (1921) described a new species, *Terebratula harmeri*, which later was also accepted by Muir-Wood (1938) who separated two species (*T. maxima*, *T. orfordensis*) from the Coralline Crag, and three species (*T. harmeri*, *T. perforata*, *T. variabilis*) from the Red Crag of the British Pliocene. Cooper (1983) erected a new genus (*Apletosia*) for the Pliocene species *maxima*. Harper (2005) studied the predation damages on Coralline Crag *Apletosia maxima*. *Apletosia* was synonymized with *Pliothyrina* in the revised new Treatise (Lee & Smirnova 2006).

Nyst (1843) described two important and wide-spread species, *Lingula dumortieri* and *Terebratula sowerbyana* from the Pliocene of Belgium. Davidson (1874b) and Vincent (1893) described the Tertiary brachiopods of Belgium, including some Pliocene forms, too. Dautzenberg & Dolfuss (1896) studied large Pliocene terebratulids around Anvers. van Roy (1980) described a new genus, *Pliothyrina* for large terebratulids of the Neogene of Belgium. Lacourt (1983) mentioned 30 different species names for large terebratulids of the Netherlands, including some new species. Wesselingh (2003) mentioned *Terebratula grandis* (actually, *Pliothyrina sowerbyana*) from Westerschelde. Raad (2004a, b, 2008) discussed *Pliothyrina* from the Netherlands. van Nieulande (2009) described in more details the "strand fossils" of the Netherlands and mentioned the difference between *Pliothyrina sowerbyana* and *Terebratula* sp. Voskuil (2004) discussed in detail not only the large terebratulids, but all brachiopods known from the strand fossils of the Netherlands, and he revised correctly Lacourt's (1983) unestablished work. Wesselingh *et al.* (2013) described a lingulid (*Glottidia*)-dominated assemblage from the Late Pliocene of the eastern Netherlands. Moerdijk (2016) discussed the nomenclatural problems of Miocene and Pliocene *Pliothyrina* assemblages of the North Sea Basin.

MATERIAL

All studied specimens were found in the Cenozoic Mollusc Collection of NBC. Locality data are mainly according to the NBC labels of specimens and personal information by Ronald Pouwer (NBC collection manager). The studied specimens are under the inventory numbers prefixed by RGM (Rijksmuseum van

Geologie en Mineralogie). Only some important references are given on the general aspects and previous brachiopod records of the localities.

Mediterranean

Italy

(Fig. 1)

Asti, Valle Andona (Piemonte region, Asti province), 200 m N of the village, right side of the road. Pliocene, Piacenzian (= "Astian"), collected by H. J. W. G. Schalke and M. van den Bosch, 1969. The type locality of the regional stage "Astian" is in the Valle Andona, about 6 km west of Asti (calcareous sands, shell conglomerates, oyster beds, soft marls; Berggren & van Couvering 1974).

Terebratula ampulla (Brocchi, 1814), 3 pedicle valves, RGM.115498; 1 complete specimen (Figs 19–21), RGM.1309882; 1 pedicle valve (Fig. 26), RGM.1309883

Lugagnano (Emilia-Romagna region, Piacenza province), Monte Giogo outcrop. Pliocene, Piacenzian, collected by H. J. W. G. Schalke and M. van den Bosch, May-August 1969 (NBC internal Report 21, 1970). Geology and palaeontology of Monte Giogo and its surroundings, including Castell'Arquato and Stirone River was discussed by Monegatti *et al.* (2001).

Terebratula ampulla (Brocchi, 1814), 3 fragmentary pedicle valves, RGM.1309884

Lugagnano, unspecified locality, probably Pliocene.

Terebratula ampulla (Brocchi, 1814), 1 pedicle valve (Figs 24–25), RGM.1309885

San Nicomede (Emilia-Romagna region, Parma province), Streambed Torrente Stirone, Pleistocene, Gelasian, grey sandy clay, collected by A. W. Janssen, 21 June 1988. According to Janssen (2012) the pteropod assemblage of the same samples refer to Pleistocene (Gelasian) age (Pteropod Zone 24). Some brachiopods were mentioned from this locality by Borghi (2001).

About 4.7–8.2 m below the base of sandstone level:

Terebratula ampulla (Brocchi, 1814), 1 brachial valve, RGM.1309891; 1 brachial valve (Figs 33–34), RGM.1309892

About 8.2–8.6 m below the base of sandstone level:

Terebratula ampulla (Brocchi, 1814), 6 pedicle valves, RGM.1309886; 4 brachial valves, RGM.1309887; 1 brachial valve (Figs 27–29), RGM.1309888; 1 pedicle valve (Figs 30–31), RGM.1309889; 1 brachial valve (Fig. 32), RGM.1309890

Ceriale (Liguria region, Savona province), outcrop in streambed of Rio Torsero. Pliocene, Piacenzian, grey clays, collected by A. W. Janssen, July 1988. Pteropods of this locality indicate Pteropod Zone 22 (Janssen 2012). The very

diverse mollusc fauna was described by Andri *et al.* (2005), while some brachiopods were mentioned by Sacco (1902).

Aphelesia bipartita (Brocchi, 1814), 1 complete specimen, 1 brachial valve, RGM.1309893; 1 complete specimen (Figs 10–12), RGM.1309894; 1 pedicle valve (Fig. 13), RGM.1309895

Terebratula ampulla (Brocchi, 1814), 2 complete specimens, 9 pedicle valves, 2 fragments, RGM.1309896; 1 complete specimen (Figs 22–23), RGM.1309897; 8 brachial valves, RGM.1309898; 1 brachial valve, RGM.1309899

Fig. 1. Location of the studied Italian Pliocene (and Pleistocene) localities

Apricena (Puglia region, Foggia province), Pirro limestone quarry, Pliocene. Neogene stratigraphy and sedimentology of the Gargano Promontory was given by Casolari *et al.* (2000) and shallow-water deposits (Gravina Calcarenites) were mentioned from the Middle-Late Pliocene. Pavia *et al.* (2010) studied the tectono-sedimentary evolution of western Gargano and mentioned some brachiopods, too.

Terebratula ampulla (Brocchi, 1814), 2 fragmentary pedicle valves and 1 brachial valve, RGM.1309900

Terebratulina retusa (Linnaeus, 1758), 1 complete specimen, RGM.1309901

North Sea Basin

England

(Fig. 2)

Gedgrave (Suffolk), Butley River cliff outcrop, 52.084167 N; 1.497500 E. Pliocene, Zanclean, Coralline Crag Formation, collected by A. W. Janssen, 14 September 1987. Lithostratigraphy of the Coralline Crag was given by Balson *et al.* (1993) on the basis of seven boreholes between Gedgrave and Aldeburgh. Brachiopods of the Coralline Crag were discussed by classical papers as Wood (1872) and Davidson (1874a).

0.55–0.85 m below top of Pliocene deposits:

Glottidia cf. *dumortieri* (Nyst, 1843), 80 fragments, RGM.793905; fragmentary valve (Figs 8–9), RGM.793904; fragmentary valve (Figs 5–6), RGM.1309902

Pliothyrina sowerbyana (Nyst, 1843), 8 pedicle and 9 brachial valves, RGM.793906; 1 complete specimen (Figs 38–40) and 1 pedicle valve, RGM.793903

Macandrevia cranium (Müller, 1776), 1 pedicle valve, RGM.1309903; 1 complete specimen (Figs 56–57), RGM.1309904; 1 pedicle valve (Fig. 59), RGM.1309905

0.85–1.00 m below top of Pliocene deposits:

Glottidia? sp., 24 fragments, RGM.793911

Pliothyrina sowerbyana (Nyst, 1843), 1 pedicle valve (Figs 43–45), RGM.793907; 1 complete specimen (Figs 35–37), RGM.793908; 4 pedicle and 13 brachial valves, RGM.793909

Pliothyrina sp., 8 fragments, RGM.793910

1.00–1.25 m below top of Pliocene deposits:

Glottidia cf. *dumortieri* (Nyst, 1843), 39 fragments, RGM.793912

Pliothyrina sowerbyana (Nyst, 1843), 5 brachial valves, 7 pedicle valves, RGM.793913

Pliothyrina sp., 14 indeterminable fragments, RGM.793914

Macandrevia cranium (Müller, 1776), 1 pedicle valve (Fig. 60), RGM.1309917; 1 brachial valve, RGM.1309918

1.25–1.45 m below top of Pliocene deposits:

Glottidia cf. *dumortieri* (Nyst, 1843), 15 fragments, RGM.793917

Pliothyrina sowerbyana (Nyst, 1843), 4 pedicle valves, 5 brachial valves, RGM.793915

Pliothyrina sp., 33 fragments, RGM.793916

1.50–1.70 m below top of Pliocene deposits:

Glottidia cf. *dumortieri* (Nyst, 1843), 4 fragments, RGM.793920
Pliothyrina sowerbyana (Nyst, 1843), 2 pedicle and 3 brachial valves, RGM.793918
Pliothyrina sp., 21 fragments, RGM.793919

Fig. 2. Location of the studied British Pliocene localities

1.70–1.90 m below top of Pliocene deposits:

Glottidia cf. *dumortieri* (Nyst, 1843), 19 fragments, RGM.793925

Pliothyrina sowerbyana (Nyst, 1843), 22 pedicle valves, RGM.793922; 14 brachial valves, RGM.793923; 1 brachial valve (Figs 41–42), RGM.793921

Pliothyrina sp., 100 fragments, RGM.793924

Macandrevia cranium (Müller, 1776), 1 complete specimen (Fig. 55), RGM.1309906

Brightwell (Suffolk), Brightwell Hill, abandoned sandpit, 52.039167 N, 1.280000 E. Pliocene, Piacenzian, Red Crag Formation ("Newbournian Red Crag"), collected by A. W. Janssen, 1 April 1970. Stratigraphy and palaeoenvironments of the Red Crag was discussed in detail by Zalasiewicz *et al.* (1988).

Pliothyrina sowerbyana (Nyst, 1843), 1 brachial valve, RGM.793926

France
(Fig. 3)

Cricqueville-en-Bessin (Basse-Normandy, Calvados), temporary excavation in meadow, Pliocene, yellowish sands with shells, collected by A. W. Janssen, September 1988. The fossiliferous locality of Cricqueville-en-Bessin was studied in detail by Pareyn *et al.* (1983).

Glottidia cf. *dumortieri* (Nyst, 1843), 1 fragment (Fig. 7), RGM.1309907; 1 fragment, RGM.1309908

Pliothyrina sowerbyana (Nyst, 1843), 1 brachial valve (Fig. 46), RGM.1309909; 4 brachial valves, RGM.1309910; 5 pedicle valves, RGM.1309911; 1 pedicle valve, RGM.1309912; 1 complete juvenile specimen, RGM.1309913

Macandrevia cranium (Müller, 1776), 1 pedicle valve (Fig. 58), RGM.1309914; 1 pedicle valve, RGM.1309915

Argyrotheca cf. *plicata* (de Morgan, 1915), 1 pedicle valve (Figs 61–64)

Terebratulida indet., 4 fragments, RGM.1309916

The Netherlands
(Fig. 4)

Goes (Zeeland), unspecified borehole (Pouwer, pers. comm.).

68 m below surface, Pliocene:

Terebratulida indet sp. (not *Terebratella* cf. *spitzbergensis* as indicated on the label), 4 indeterminable fragments, RGM.29657

Terebratulida indet sp. (not *Terebratulina caputserpentis* as indicated on the label), 1 indeterminable fragment, RGM.29672

Pliothyrina? indet. sp. (not *Argiope* cf. *cistellula* as indicated on the label), 1 fragment, RGM.29679

74 m below surface, Pliocene:

Pliothyrina cf. *sowerbyana* (Nyst, 1843) (not *Terebratula maxima* as indicated on the label), 3 large fragments, RGM.29658

Pliothyrina sowerbyana (Nyst, 1843), 2 pedicle valves and 1 brachial valve (Figs 47–48), RGM.14604

87 m below surface, Pliocene:

Pliothyrina cf. *sowerbyana* (Nyst, 1843) (not *Terebratula maxima* as indicated on the label), 3 fragmentary specimens, RGM.29678

101 m below surface, Early Pliocene or Miocene:

Terebratulida indet. sp. (not *Terebratula grandis* as indicated on the label), 4 indeterminable fragments, RGM.29671

Fig. 3. Location of the studied French Pliocene locality

Kreekrak (Zeeland), Kreekraksluizen, borehole 49D.12–15, 51.40995 N, 4.21999 E. Pliocene, Zanclean, Breda Formation (Kattendijk Sands equivalent), Petaloconchus Bed, collected and donated by Rijkswaterstaat. Deltadienst, 1968

47–50 m below surface:

Notosaria nysti (Davidson, 1874) 1 complete specimen (Figs 14–15), RGM.1309924; 1 brachial valve (Figs 16–17), RGM.1309925; 1 brachial valve (Fig. 18), RGM.1309926

Terebratulina retusa (Linnaeus, 1758), 1 fragmentary brachial valve, RGM.1309919

Macandrevia cranium (Müller, 1776), 1–1 fragmentary brachial and pedicle valve, RGM.1309920

50–51m below surface:

Glottidia? sp., 7 fragments, RGM.1309921

Fig. 4. Location of the studied Dutch Pliocene localities

Notosaria nysti (Davidson, 1874), 6 fragments, RGM.1309922
Terebratulina retusa (Linnaeus, 1758), 1 specimen with separated brachial and pedicle valve (Figs 49–54), RGM.1309923

Delden (Gelderland), borehole Twickel, Hellecaterveld at Twickelervaart (B28G0201) (old number 28G.3–1), 52.289793 N, 6.700508 E, Early Pliocene, Breda Formation, Delden and Zenderen Member, collected by M. van den Bosch, 21 June 1974. Borehole 28G.3–1 was described in detail and section of the borehole was illustrated by VAN DEN BOSCH *et al.* (1975, Fig. 13). The stratigraphic position of the Delden Member was discussed by BOSCH & WESSELINGH (2006).

Delden Member:

3.0–3.5 m: *Glottidia* cf. *dumortieri* (Nyst, 1843), > 30 fragments, RGM.793801
3.5–4.0 m: *Glottidia* cf. *dumortieri* (Nyst, 1843), > 30 fragments, RGM.793802
4.0–4.5 m: *Glottidia* cf. *dumortieri* (Nyst, 1843), > 30 fragments, RGM.793803
5.0–5.5 m: *Glottidia* cf. *dumortieri* (Nyst, 1843), > 30 fragments, RGM.793804
5.5–6.0 m: *Glottidia* cf. *dumortieri* (Nyst, 1843), > 30 fragments, RGM.793805
6.0–6.5 m: *Glottidia* cf. *dumortieri* (Nyst, 1843), > 30 fragments, RGM.793806
6.5–7.0 m: *Glottidia* cf. *dumortieri* (Nyst, 1843), > 30 fragments, RGM.793807
7.0–7.5 m: *Glottidia*? sp., 22 fragments, RGM.793808

Zenderen Member:

7.5–8.0 m: *Glottidia*? sp., > 30 fragments, RGM.793809
8.0–8.5 m: *Glottidia*? sp., 5 fragments, RGM.793810
8.5–9.0 m: *Glottidia*? sp., 5 fragments, RGM.793811
9.0–9.5 m: *Glottidia*? sp., > 30 fragments, RGM.793812
9.5–10.0 m: *Glottidia*? sp., 12 fragments, RGM.793813
10.0–10.5 m: *Glottidia*? sp., 6 fragments, RGM.793814
10.5–11.0 m: *Glottidia*? sp., 7 fragments, RGM.793815
12.0–12.5 m: *Glottidia* cf. *dumortieri* (Nyst, 1843), > 30 fragments, RGM.793816

Neede (Gelderland), borehole Gelselaarsbrug (B34B0175) (old name Neede II, 34B.3–1), 52.164278 N, 6.549397 E, Early Pliocene, Breda Formation, Delden and Zenderen Members, collected by M. van den Bosch, 30 October 1970. Borehole 34B.3–1 was described in detail and the section of the borehole was illustrated by VAN DEN BOSCH *et al.* (1975, Fig. 12); *Lingula* specimens and *Lingula* fragments were mentioned along the section.

Delden Member:

32.5–33.5 m: *Glottidia*? sp., 6 fragments, RGM.793769
33.5–34.5 m: *Glottidia*? sp., 8 fragments, RGM.793770
34.5–35.5 m: *Glottidia*? sp., > 10 fragments, RGM.793771
35.5–36.5 m: *Glottidia*? sp., 1 fragment, RGM.793772

36.5–37.5 m: *Glottidia*? sp., 4 fragments, RGM.793773
37.5–38.5 m: *Glottidia*? sp., > 10 fragments, RGM.793774
38.5–39.5 m: *Glottidia*? sp., > 10 fragments, RGM.793775
39.5–40.5 m: *Glottidia*? sp., > 10 fragments, RGM.793776
40.5–41.5 m: *Glottidia*? sp., > 10 fragments, RGM.793777
41.5–42.5 m: *Glottidia*? sp., > 10 fragments, RGM.793778
42.5–43.5 m: *Glottidia*? sp., > 10 fragments, RGM.793779
43.5–45.5 m: *Glottidia*? sp., > 10 fragments, RGM.793780
45.5–46.5 m: *Glottidia*? sp., > 10 fragments, RGM.793781
46.5–47.5 m: *Glottidia*? sp., > 10 fragments, RGM.793782
47.5–48.5 m: *Glottidia*? sp., 3 fragments, RGM.793783
48.5–49.5 m: *Glottidia*? sp., 2 fragments, RGM.793784

Zenderen Member:

49.5–50.5 m: *Glottidia*? sp., 2 fragments, RGM.793785
50.5–51.5 m: *Glottidia*? sp., 1 fragment, RGM.793786
51.5–52.5 m: *Glottidia*? sp., 1 fragment, RGM.793787
52.5–53.5 m: *Glottidia*? sp., 3 fragments, RGM.793788
53.5–54.5 m: *Glottidia*? sp., 1 fragment, RGM.793789
54.5–55.5 m: *Glottidia*? sp., 4 fragments, RGM.793790
55.5–56.5 m: *Glottidia*? sp., 3 fragments, RGM.793791
56.5–58.0 m: *Glottidia*? sp., 2 fragments, RGM.793792
58.0–59.0 m: *Glottidia*? sp., 2 fragments, RGM.793793
59.0–60.0 m: *Glottidia*? sp., 2 fragments, RGM.793794
60.0–61.5 m: *Glottidia*? sp., 3 fragments, RGM.793795
61.5–62.5 m: *Glottidia*? sp., 6 fragments, RGM.793796
62.5–63.5 m: *Glottidia*? sp., 2 fragments, RGM.793797
64.5–66.5 m: *Glottidia*? sp., 1 fragment, RGM.793798
66.5–67.5 m: *Glottidia*? sp., 1 fragment, RGM.793799
67.5–68.5 m: *Glottidia*? sp., 1 fragment, RGM.793800

SYSTEMATIC PALAEONTOLOGY

Phylum Brachiopoda Duméril, 1806
Subphylum Linguliformea Williams, Carlson, Brunton, Holmer et Popov, 1996
Class Lingulata Gorjansky et Popov, 1985
Order Lingulida Waagen, 1885
Superfamily Linguloidea Menke, 1828
Family Lingulidae Menke, 1828

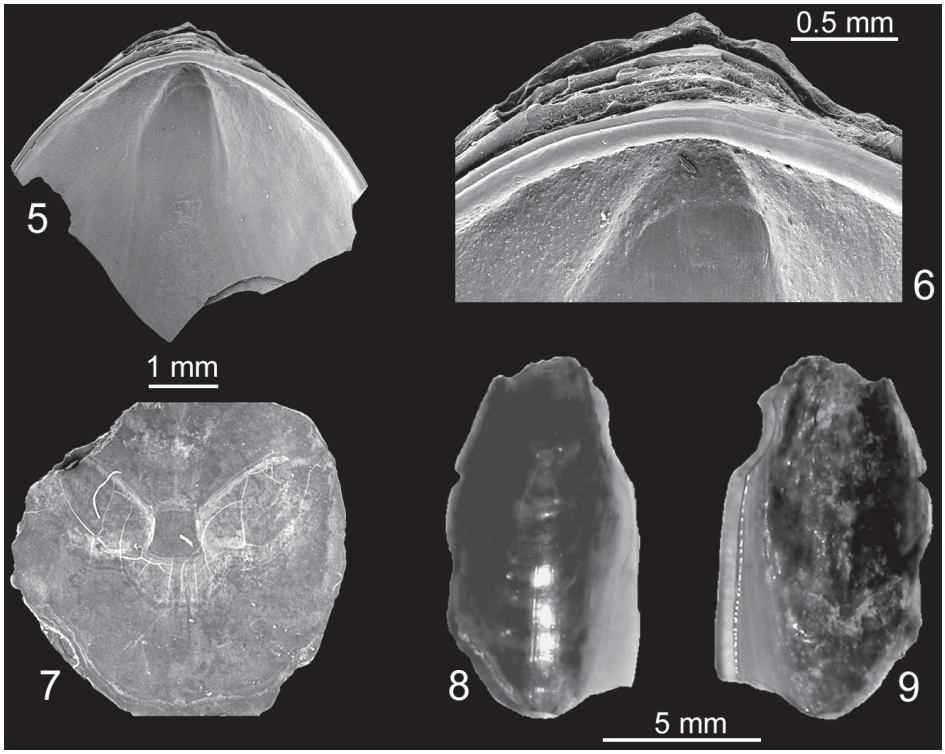
Genus *Glottidia* Dall, 1870
Type species – *Lingula albida* Hinds, 1844

Glottidia cf. *dumortieri* (Nyst, 1843)
(Figs 5–9)

1843 *Lingula Dumortieri* – Nyst, pp. 337–338, Pl. 34, Figs 4a-c.
1872 *Lingula Dumortieri* Nyst – Wood, pp. 172–173, Pl. 11, Figs 1a-c.
1874b *Lingula Dumortieri* Nyst – Davidson, p. 153, Pl. 7, Figs 1–3.
1881 *Lingula Dumortieri* Nyst – Nyst, p. 252, Pl. 28, Figs 4a-c.
1893 *Lingula Dumortieri* Nyst – Vincent, pp. 41–42.
1964 *Glottidia dumortieri* (Nyst) – Chuang, pp. 155–157, Text-Fig. 1.
2004 *Glottidia dumortieri* (Nyst) – Voskuil, p. 47, Text-Fig. 1.
2013 *Glottidia dumortieri* (Nyst) – Dulai, pp. 25–26, Figs 6–14.

Material – Gedgrave (159 fragmentary specimens); Delden (Delden Member: > 210 fragmentary specimens; Zenderen Member: > 30 fragmentary specimens).

Remarks – Although their fossilization potential is rather low (Emig 1990), remains of lingulid brachiopods are common in the Miocene and Pliocene de-



Figs 5–9. *Glottidia* cf. *dumortieri* (Nyst, 1843). – **5–6.** Gedgrave, 0.55–0.85 m, England, RGM.1309902. – **5.** Internal view of dorsal valve. – **6.** Detail of Fig. 5. – **7.** Internal view of fragmentary valve, Cricqueville-en-Bessin, France, RGM.1309907. – **8–9.** Gedgrave, 0.55–0.85 m, England, RGM.793904. – **8.** External view. – **9.** Internal view

posits of the North Sea Basin. In several cases these are the dominant fossils, as all or most of the calcium carbonate shells dissolved from the sediments. Species *dumortieri* was described from the Pliocene of Belgium by Nyst (1843) as *Lingula*. This generic assumption was accepted until the mid-1960s, when Chuang (1964) recognised that this species should be assigned to the genus *Glottidia*. This classification was confirmed recently by Dulai (2013) on the basis of Miocene samples from the Netherlands (Beugen). *Lingula* sp. was mentioned several times even recently from the North Sea Basin, but up to now, the only confirmed lingulid brachiopod is *Glottidia*. *Lingula* is known from the Miocene of the Central Paratethys (Emig & Bitner 2005), the Atlantic Ocean in France (Emig *et al*. 2007) and from the Mediterranean (Dreger 1911).

The studied samples contain rather fragmentary lingulids, but some of the specimens can be identified clearly as *G. dumortieri*. Lingulids are especially frequent in the two boreholes (Delden and Neede), which yielded samples from the Delden and Zenderen Members of the Breda Formation. The identifiable lingulid specimens are from the Delden Member of Twickel borehole at Delden (Gelderland), while the older Zenderen Member yielded very fragmentary lingulids which were not identifiable at species level. In the case of Gelselaarsbrug borehole at Neede (Gelderland) both members of the Breda Formation contain only very fragmentary lingulids. All of the Coralline Crag samples from Gedgrave contain more or less fragmentary lingulid specimens. Species *dumortieri* was mentioned from the Coralline Crag as early as Wood (1872) and he realised that it is not rare at Sutton, but all specimens are mutilated.

Glottidia? sp.

Material – Gedgrave (24 fragments); Cricqueville-en-Bessin (2 fragments); Kreekrak (7 fragments); Delden (Delden Member: 22 fragments, Zenderen Member: > 95 fragments); Neede (Delden Member: > 124 fragments; Zenderen Member: 35 fragments).

Remarks – Several samples from the Pliocene of England, France and the Netherlands yielded indeterminable Lingulidae fragments. The small size of the fragments makes it impossible to decide whether they belong to *Lingula* or *Glottidia*. Until now, only *Glottidia* has surely been confirmed from the Neogene of the North Sea Basin (e.g. Chuang 1964; Dulai 2013), therefore, *Glottidia* is used for these fragments with question mark.

Subphylum Rhynchonelliformea Williams, Carlson, Brunton, Holmer et Popov, 1996
Class Rhynchonellata Williams, Carlson, Brunton, Holmer et Popov, 1996
Order Rhynchonellida Kuhn, 1949

Superfamily Pugnacoidea Rzhonsnitskaia, 1956
Family Basiliolidae Cooper, 1959
Subfamily Aphelesiinae Cooper, 1959
Genus *Aphelesia* Cooper, 1959
Type species – *Anomia bipartita* Brocchi, 1814

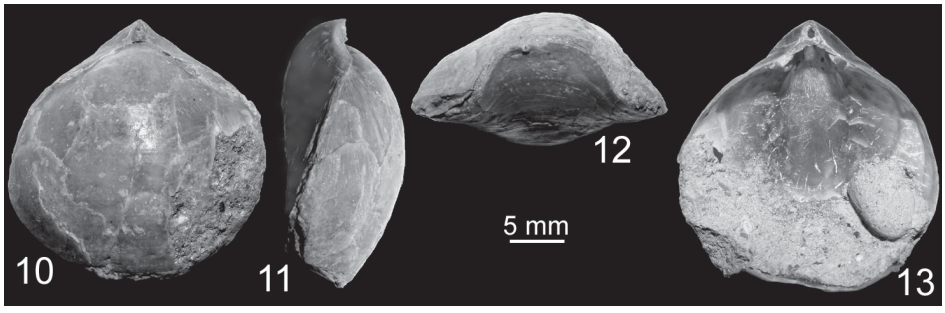
Aphelesia bipartita (Brocchi, 1814)
(Figs 10–13)

1944 *Hemithiris bipartita* (Brocchi) – Meznerics, p. 22, Pl. 5, Figs 12, 16.
1944 *Hemithiris acuta* n. sp. – Meznerics, pp. 22–23, Pl. 3, Figs 7–10.
1985a *Aphelesia bipartita* (Brocchi) – Gaetani & Saccà, p. 5, Text-Fig. 2, Pl. 7, Figs 1–4 (cum. syn.).
1985b *Aphelesia bipartita* (Brocchi) – Gaetani & Saccà, pp. 363–365, Text-Figs 2–3, Pl. 17, Figs 1–3, Pl. 19, Figs 1–3.
2001 *Aphelesia bipartita* (Brocchi) – Borghi, pp. 49–50, Pl. 2, Figs 1–5.
2001 *Aphelesia bipartita* (Brocchi) – Bitner & Martinell, pp. 179–181, Figs 3A-H.
2003 *Aphelesia bipartita* (Brocchi) – Bitner & Moissette, p. 466, Figs 2A-M.
2005 *Aphelesia bipartita* (Brocchi) – García Ramos, pp. 28–29, Pl. 1, Figs 9, 11, Pl. 2, Figs 5, 7.

Material – Ceriale (2 complete specimens, 1 pedicle and 1 brachial valve).

Remarks – The few studied specimens from Ceriale are easily recognizable as *A. bipartita*. This species was described in detail by Cooper (1959), Gaetani & Saccà (1985a, b), Bitner & Martinell (2001) and Bitner & Moissette (2003). It is a very significant component of the *Terebratula-Aphelesia* Bed in Malta (Pedley 1976; Dulai *et al*. in prep.).

Aphelesia is the most common rhynchonellid brachiopod in the European Neogene. It is especially widespread and most diverse in the Mediterranean where three species were recognised in Italy (*A. bipartita*, *A. margineplicata*, *A. pseudobipartita*; Gaetani & Saccà 1985b). Some papers mentioned *A. plicatodentata*



Figs 10–13. *Aphelesia bipartita* (Brocchi, 1814). – **10–12.** Complete specimen from Ceriale, Italy, RGM.1309894. – **10.** Dorsal view. – **11.** Lateral view. – **12.** Anterior view. – **13.** Internal view of pedicle valve, Ceriale, Italy, RGM.1309895

from the Mediterranean Neogene (e. g. Calzada 1978; García Ramos 2004), but it is a junior synonym of *A. margineplicata* (see Gaetani & Saccà 1985b). Pajaud (1976) described a new genus and new species from the Pliocene of Spain (*Phapsirhynchia sanctapaulensis*). However, later *Phapsirhynchia* was synonymized with *Aphelesia* (Llompart & Calzada 1982; Gaetani & Saccá 1985b). García Ramos (2005) went even further and synonymized *A. sanctapaulensis* with *A. bipartita*. An additional new form in the Mediterranean is under description from Malta (Dulai *et al.* in prep.). *A. bipartita* was also recognised in the Miocene of the Central Paratethys (Meznerics 1944; Bitner & Dulai 2004). *A. acuta* described by Meznerics (1944) from the Middle Miocene (Karpatian) of Hungary is most probably a junior synonym of *A. bipartita*. A separated species (*A. winebergeri*) was recently erected from the Upper Burdigalian of the Upper Marine Molasse of Southern Germany by Bitner & Schneider (2009).

Superfamily Hemithiridoidea Rzhonsnitskaia, 1956
Family Notosariidae Manceñido et Owen, 2001
Genus *Notosaria* Cooper, 1959
Type species – *Terebratula nigricans* Sowerby, 1846

Notosaria nysti Davidson, 1874
(Figs 14–18)

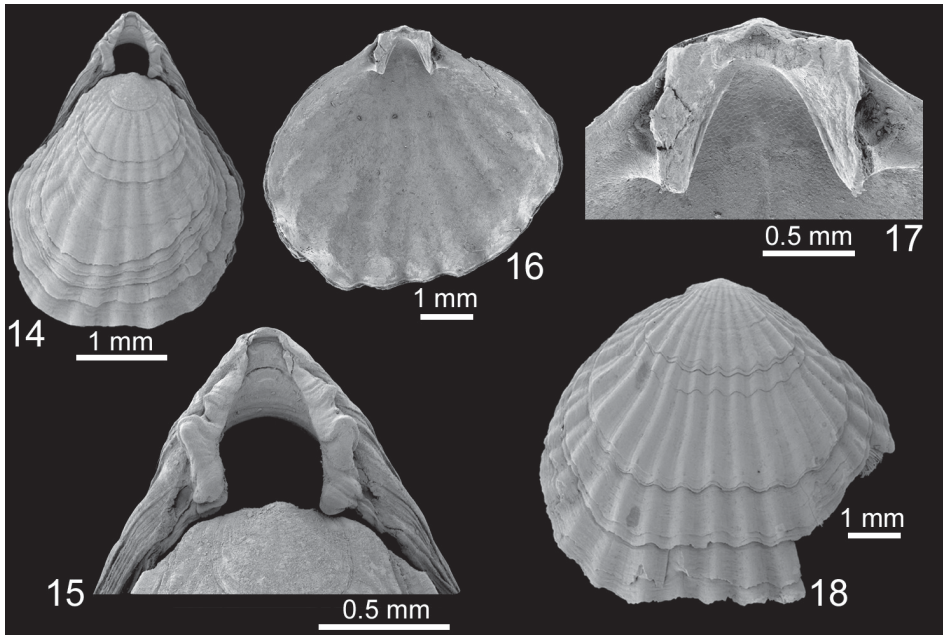
1874b *Rhynchonella Nysti* n. sp. – Davidson, p. 157, Pl. 7, Fig. 17.
1881 *Rhynchonella Nysti* Davidson – Nyst, p. 250, Pl. 28, Figs 2a-c.
1927 *Tegulorhynchia nysti* (Davidson) – Thomson, p. 153.
1959 *Notosaria nysti* (Davidson) – Cooper, p. 49.
1979 *Notosaria nysti* (Davidson) – Lee & Wilson, p. 439.
1987 *Tegulorhynchia nysti* (Davidson) – Ottema & in't Hout, p. 76, Fig. 4.

Material – Kreekrak (1 complete specimen, 3 brachial valves; 6 fragments).

Remarks – N. nysti was originally described by Davidson (1874b) from the "Scaldisien" (= Pliocene, Late Zanclean to Piacenzian; Laga & Louwye 2006) of Antwerp, Belgium. Unfortunately, Davidson (1874b) had very limited material and illustrated only the ventral valve, but mentioned its close similarity to *Rh. nigricans*. Chapman & Crespin (1923) erected a new genus *Tegulorhynchia* for ribbed rhynchonellids of the southern hemisphere, and some years later Thomson (1927) attributed species *nysti* to *Tegulorhynchia*. Cooper (1959) described a new genus, *Notosaria* with type species *Terebratula nigricans*, and distinguished his new genus from *Tegulorhynchia* on the basis of ornamentation, beak characters and cardinalia. Cooper also studied a pedicle and a brachial valve of *Rh. nysti* confirming Davidson's (1874b) original observation and included this species also to his new genus, *Notosaria*. Later Lee & Wilson (1979)

accepted and followed this opinion. The new, revised Treatise also mentioned *Notosaria* from Europe (Middle Miocene of Poland and Pliocene of Belgium) (Manceñido *et al.* 2002) and erected the new family Notosariidae. The only Miocene record of *Notosaria* from Europe is an eroded and very uncertain pedicle valve from Poland (Popiel-Barczyk & Barczyk 1990).

This species has not been illustrated since Davidson's (1874b) original description (his figures were re-published by Nyst 1881), although it is not rare in some Neogene assemblages. Ottema & in't Hout (1987) probably also redrew Davidson's (1874b) pedicle valve illustrations, which is rather strange, as this species is common in the studied Kallo assemblage. Vincent (1893) mentioned species *nysti* from Belgium, while Dolfuss & Dautzenberg (1901) and de Morgan (1915) reported it from the Miocene of France (Savigné, Saint-Saturnin, Saint-Emy) without illustrations. In the studied material this species occurs in the Kreekraksluizen sample only with some valves, but it is common in some Pliocene ("Redonian") samples of France (e.g. St. Clément-de-la Place) or in the Pliocene of Belgium (e.g. Kallo). The detailed description of both of these faunas is in progress and emended diagnosis of *N. nysti* will be given there.

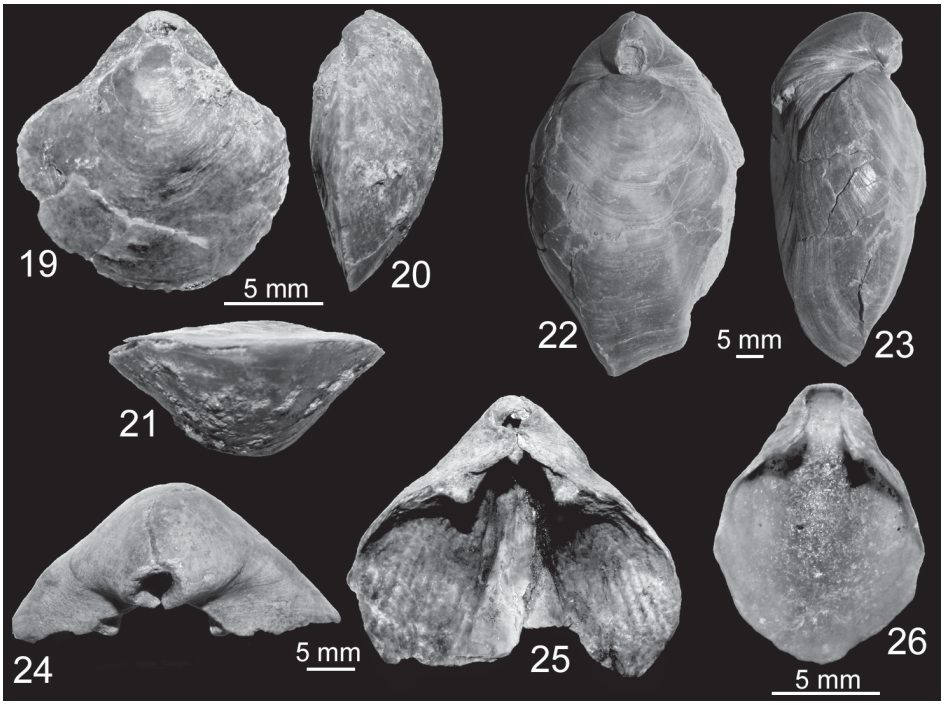


Figs 14–18. *Notosaria nysti* Davidson, 1874, Kreekrak (47–50 m), the Netherlands. – **14.** Complete juvenile specimen, RGM.1309924, dorsal view. – **15.** Detail of Fig. 14, showing the beak region of the specimen. – **16.** Brachial valve, RGM.1309925, internal view. – **17.** Detail of Fig 16. – **18.** Brachial valve, RGM.1309926, external view

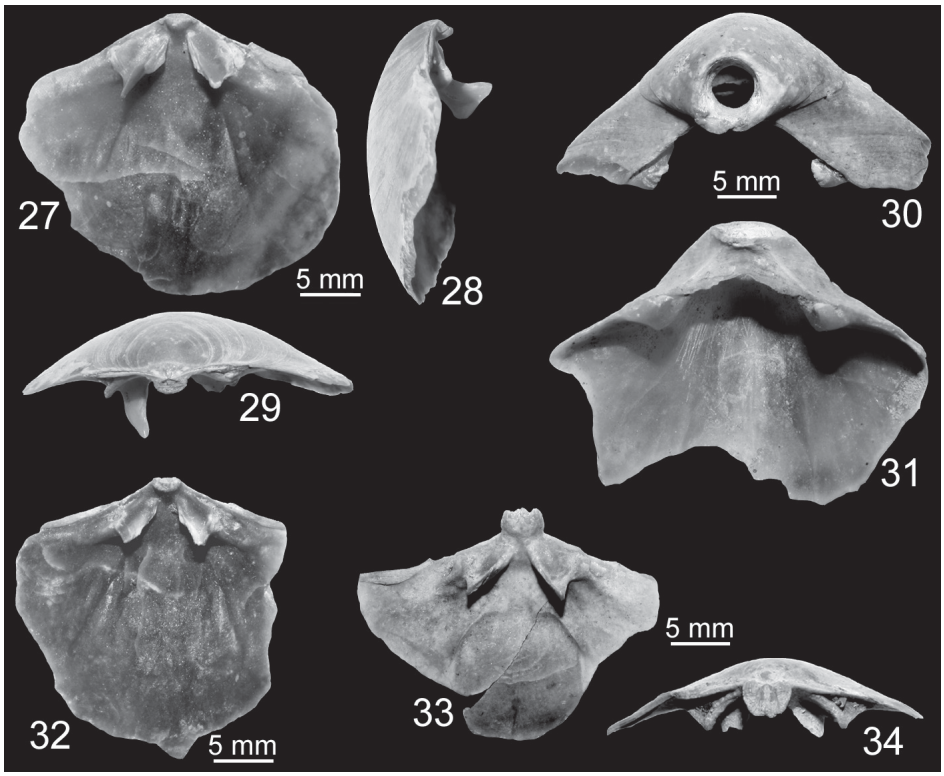
Order Terebratulida Waagen, 1883
Suborder Terebratulidina Waagen, 1883
Superfamily Terebratuloidea Gray, 1840
Family Terebratulidae Gray, 1840
Subfamily Terebratulinae Gray, 1840
Genus *Terebratula* Müller, 1776
Type species – *Anomia terebratula* Linnaeus, 1758

Terebratula ampulla (Brocchi, 1814)
(Figs 19–26, 27–34)

1983 *Terebratula ampulla* (Brocchi) – Cooper, Pl. 4, Figs 8–16.
2001 *Terebratula ampulla* (Brocchi) – Borghi, pp. 51–52, Pl. 3, Figs 2, 3, 4, 6, 7, Pl. 4, Fig. 1.
2004 *Terebratula ampulla* (Brocchi) – García Ramos, pp. 21–23, Pl. 5, Figs 3, 7, 8, 9, 10, Pl. 6, Fig. 3, Pl. 7, Figs 3, 4, 5, 6, 7, 9.
2008 *Terebratula ampulla* (Brocchi) – Taddei Ruggiero *et al*., p. 211, Figs 1H-M.



Figs 19–26. *Terebratula ampulla* (Brocchi, 1814). – **19–21.** Complete specimen, Valle Andona, Italy, RGM.1309882. – **19.** Dorsal view. – **20.** Lateral view. – **21.** Anterior view. – **22–23.** Complete specimen, Ceriale, Italy, RGM.1309897. – **22.** Dorsal view. – **23.** Lateral view. – **24–25.** Fragmentary pedicle valve, Lugagnano, Italy, RGM.1309885. – **24.** Posterior view. – **25.** Internal view. – **26.** Internal view of pedicle valve, Valle Andona, Italy, RGM.1309883



Figs 27–34. *Terebratula ampulla* (Brocchi, 1814). – **27–29.** Brachial valve, San Nicomede, Italy, RGM.1309888. – **27.** Internal view. – **28.** Lateral view. – **29.** Posterior view. – **30–31.** Fragmentary pedicle valve, San Nicomede, Italy, RGM.1309889. – **30.** Posterior view. – **31.** Internal view. – **32.** Internal view of fragmentary brachial valve, showing the elongated muscle scars, San Nicomede, Italy, RGM.1309890. – **33–34.** Fragmentary brachial valve, San Nicomede, Italy, RGM.1309892. – **33.** Internal view. – **34.** Posterior view

Material – Valle Andona (1 complete specimen, 4 pedicle valves); Lugagnano (4 pedicle valves); San Nicomede (7 pedicle and 8 brachial valves); Ceriale (3 complete specimens, 9 pedicle and 9 brachial valves); Apricena (2 pedicle valves and 1 brachial valve).

Remarks – *Terebratula* and its type species *T. terebratula* were revised and discussed in detail by Lee *et al.* (2001). In this paper several species were synonymized with *T. terebratula*, however, the validity of *T. ampulla* as a medium-sized, strongly bisulcate species from the Pliocene was confirmed. Taddei Ruggiero *et al.* (2008) have accomplished a morphometric study on Late Cenozoic *Terebratula* from Italy, in which *T. terebratula*, *T. ampulla*, *T. scillae* and *T. sinuosa* were compared. According to their results, *T. ampulla* is distinct from *T. scillae*/*T. terebratula* in ante-

rior view, because it is much more compressed dorsoventrally. In dorsal view *T. ampulla* is readily distinguished because of its pentagonal shape (Taddei Ruggiero *et al.* 2008). *T. ampulla* is widespread in the Pliocene of the Mediterranean (e.g. Borghi 2001; García Ramos 2004; Taddei Ruggiero *et al.* 2008). Some papers (e.g. Bosselaers *et al.* 2004) mentioned this species also from the Neogene of the North Sea Basin, but until now, these records have not been confirmed.

The beak area of several San Nicomede pedicle valves is strongly eroded and the foramen is significantly widened. In the case of Ceriale samples, all complete specimens are strongly compressed, the separated pedicle valves are intact but sometimes fragmentary. The middle part of the smallest complete specimen and edge of two pedicle valves show small-sized traces of predatory organisms. A small worm tube encrustation can be seen on the internal surface of a pedicle valve.

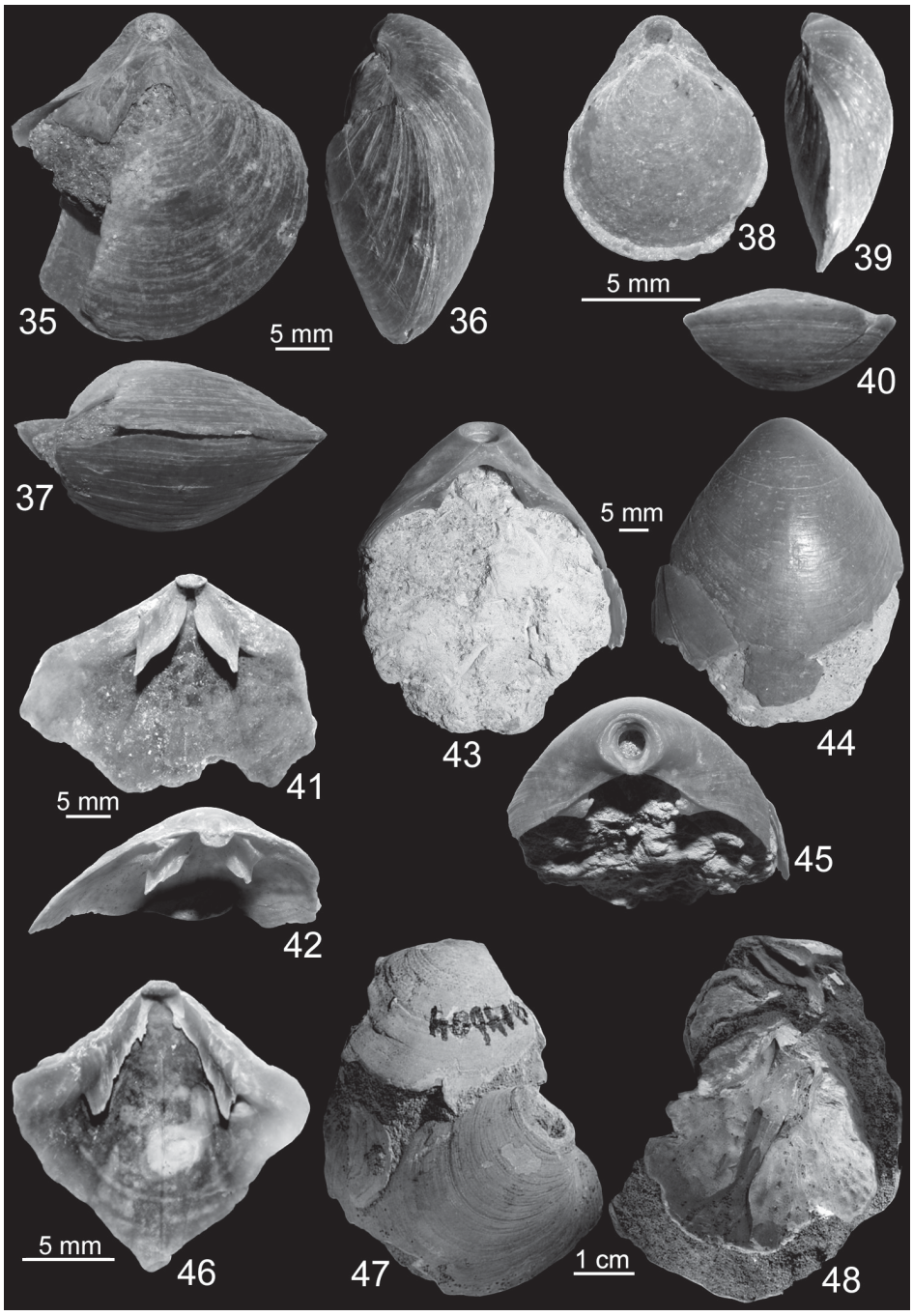
Genus *Pliothyrina* van Roy, 1980
Type species – *Terebratula sowerbyana* Nyst, 1843

Pliothyrina sowerbyana (Nyst, 1843)
(Figs 35–48)

1843 *Terebratula Sowerbyana* – Nyst, pp. 335–336, Pl. 27, Figs 3a-b.
1980 *Pliothyrina sowerbyana* (Nyst) – van Roy, pp. 3–7, Pl. 1, Figs 1–7, Pl. 2, Figs 1–7.
1983 *Pliothyrina sowerbyana* (Nyst) – Cooper, pp. 237–238, Pl. 5, Figs 1–4.
2004 *Pliothyrina sowerbyana* (Nyst) – Voskuil, pp. 50–53, Text-Figs 7A-L.

Material – Gedgrave (3 complete specimens, 50 pedicle and 50 brachial valves); Brightwell (1 brachial valve); Cricqueville-en-Bessin (1 complete specimen, 6 pedicle and 5 brachial valves); Goes (2 pedicle valves and 1 brachial valve, 6 fragments).

Remarks – Large-sized Miocene and Pliocene terebratulids have a long and complex nomenclatural history in the North Sea Basin. Several names were introduced in the literature both in the eastern (Belgium – the Netherlands) and in the western (Great Britain) part of the Basin. It seems that nearly all, or at least most of the Oligocene-Pliocene large terebratulids belong to the genus *Pliothyrina* described by van Roy (1980) with type species *P. sowerbyana*. Lacourt (1983) identified 30 names for Terebratulidae species from the Neogene of the Netherlands (mentioning even some Mesozoic species). Later Voskuil (2004) revised Lacourt's (1983) work, and correctly synonymized nearly all of his terebratulids with *P. sowerbyana*. The only exception was "*Terebratula*" *distinguenda* Lacourt, 1984, which was separated with question mark also by Voskuil (2004). On the basis of some Dutch private collections (Freddie van Nieulande, Peter Mordijk, Harry Raad) this separate species with very small pedicle opening really exists, and its internal morphology


35
5 mm
36
38
39
5 mm
40
37
5 mm
43
44
41
5 mm
45
42
46
5 mm
47
1 cm
48

is also significantly different from *Pliothyrina*, and refers to a separate, new genus. This new taxon hopefully will be described in the near future, in the framework of the cooperation with the above mentioned private collectors.

After VAN ROY's (1980) description, the name *Pliothyrina sowerbyana* became widely accepted and well-known, and several papers used this name for large terebratulids in the North Sea Basin (e.g. VOSKUIL 2004; MOERDIJK 2007; RAAD 2004a, b, 2008; VAN NIEULANDE 2009). However, recently MOERDIJK (2016) discussed in detail the nomenclatural problems of Neogene *Pliothyrina* assemblages of the North Sea Basin. The correct name of the very common and wide-spread form is under discussion, and until the final decision the well-known name *P. sowerbyana* is used in this paper.

HERMAN in BOSSELAERS *et al.* (2004) indicated *Terebratula ampulla* together with *P. sowerbyana* and *Lingula* sp. (= *Glottidia*) in the Late Miocene of Belgium, illustrated by the dorsal view of a fragmentary specimen (p. 32, Fig. 5c). VAN NIEULANDE (2009) also mentioned *P. sowerbyana* and *Terebratula* sp. from the "seashore strands". However, until now, the presence of *Terebratula* or specifically *T. ampulla* has not been confirmed in the North Sea Basin; it is a typical Mediterranean taxon.

Pliothyrina? sp.

Material – Gedgrave (177 fragments); Goes (1 fragment).

Remarks – The Coralline Crag samples from Gedgrave contain several small-sized, unidentifiable smooth Terebratulidae fragments. As *Pliothyrina sowerbyana* specimens are common in these beds, these fragments are regarded as *Pliothyrina* sp. with question mark.

Superfamily Cancellothyridoidea Thomson, 1926
Family Cancellothyrididae Thomson, 1926
Subfamily Cancellothyrininae Thomson, 1926
Genus *Terebratulina* d'Orbigny, 1847
Type species – *Anomia retusa* Linnaeus, 1758

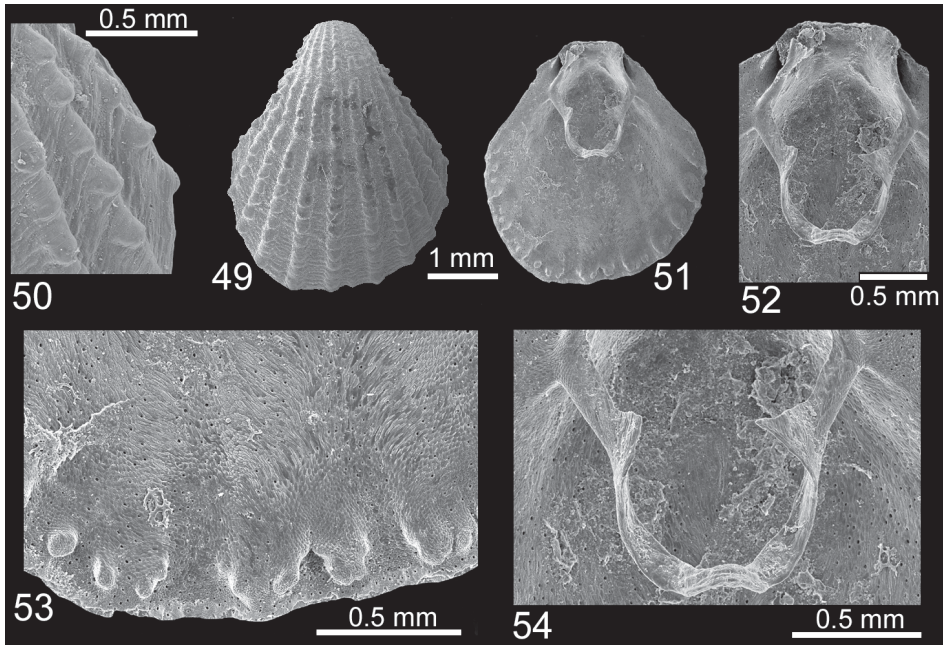
Figs 35–48. *Pliothyrina sowerbyana* (Nyst, 1843). – **35–37.** Nearly complete specimen, Gedgrave, 0.85–1.00 m, RGM.793908, England. – **35.** Dorsal view. – **36.** Lateral view. – **37.** Anterior view. – **38–40.** Complete juvenile specimen, Gedgrave, 0.55–0.85 m, England, RGM.793903. – **38.** Dorsal view. – **39.** Lateral view. – **40.** Anterior view. – **41–42.** Fragmentary brachial valve, Gedgrave, 1.7–1.9 m, England, RGM.793921. – **41.** Internal view. – **42.** Posterior view. – **43–45.** Fragmentary pedicle valve, Gedgrave, 0.85–1.0 m, England, RGM.793907. – **43.** Internal view. – **44.** External view. – **45.** Posterior view. – **46.** Internal view of fragmentary brachial valve, Cricqueville-en-Bessin, France, RGM.1309909. – **47–48.** 2 pedicle valves, 1 brachial valve, Goes, 74 m, the Netherlands, RGM.14604. – **47.** External view. – **48.** Internal view

Terebratulina retusa (Linnaeus, 1758)
(Figs 49–54)

1852 *Terebratulina caput-serpentis* Linnaeus – Davidson, pp. 12–14, Pl. 1, Figs 3–6, 14–15.
1979 *Terebratulina retusa* (Linnaeus) – Brunton & Curry, p. 38, Text-Figs 17A-C.
1985a *Terebratulina retusa* (Linnaeus) – Gaetani & Saccà, pp. 15–16, Pl. 7, Figs 5–10, Pl. 9, Figs 6–9 (cum syn.).
2001 *Terebratulina retusa* (Linnaeus) – Borghi, p. 52, Pl. 4, Figs 4, 5, 6, 7, 8.
2003 *Terebratulina retusa* (Linnaeus) – Bitner & Moissette, p. 472, Figs 6A-F.
2004 *Terebratulina retusa* (Linnaeus) – Voskuil, p. 49, Text-Figs 4A-G.
2004 *Terebratulina retusa* (Linnaeus) – García Ramos, p. 28, Pl. 1, Figs 1–3.
2007 *Terebratulina retusa* (Linnaeus) – Koskeridou, pp. 124–125, Pl. 1, Figs 5–6.

Material – Apricena (1 complete specimen); Kreekrak (1 complete specimen, 1 brachial valve).

Remarks – *T. retusa* is a common member of Neogene and Recent benthic assemblages, however, much more frequent in deeper water environments. Depth range of Recent *T. retusa* is very wide (18–2157 m; Logan 2007), but it is the most common between 100 and 500 m (Curry 1982). According to Logan (1979)



Figs 49–54. *Terebratulina retusa* (Linnaeus, 1758), Kreekrak, the Netherlands, separated valves of the same specimen, RGM.1309923. – **49–50.** Pedicle valve. – **49.** External view. – **50.** Detail of external surface ornamentation. – **51–54.** Brachial valve. – **51.** Internal view. – **52.** Brachidium. – **53.** Detail of the anterior margin of brachial valve. – **54.** Detail of brachidium

and Logan *et al.* (2004) *Terebratulina* (together with *Gryphus*, *Platidia* and *Megerlia*) belongs to the eurybathic species which are more typical of the bathyal zone in the Recent Mediterranean. Probably this is the reason that this species is very rare in the studied samples, both in the Mediterranean and the North Sea Basin. *T. retusa* is consistently cited from the Neogene of the Mediterranean (e.g. Gaetani & Saccà 1985a; Taddei Ruggiero 1994; Borghi 2001; Bitner & Moissette 2003; García Ramos 2004; Koskeridou 2007) and known from the Central Paratethys (e.g. Bitner & Dulai 2004). More rarely it was also mentioned from the North Sea Basin Neogene (Davidson 1852; Wood 1872) and Recent (Brunton & Curry 1979; Curry 1982) assemblages, sometimes under the name *T. caputserpentis*. The complex nomenclatural history of the *retusa* – *caputserpentis* problem was discussed recently in detail by Emig *et al.* (2015).

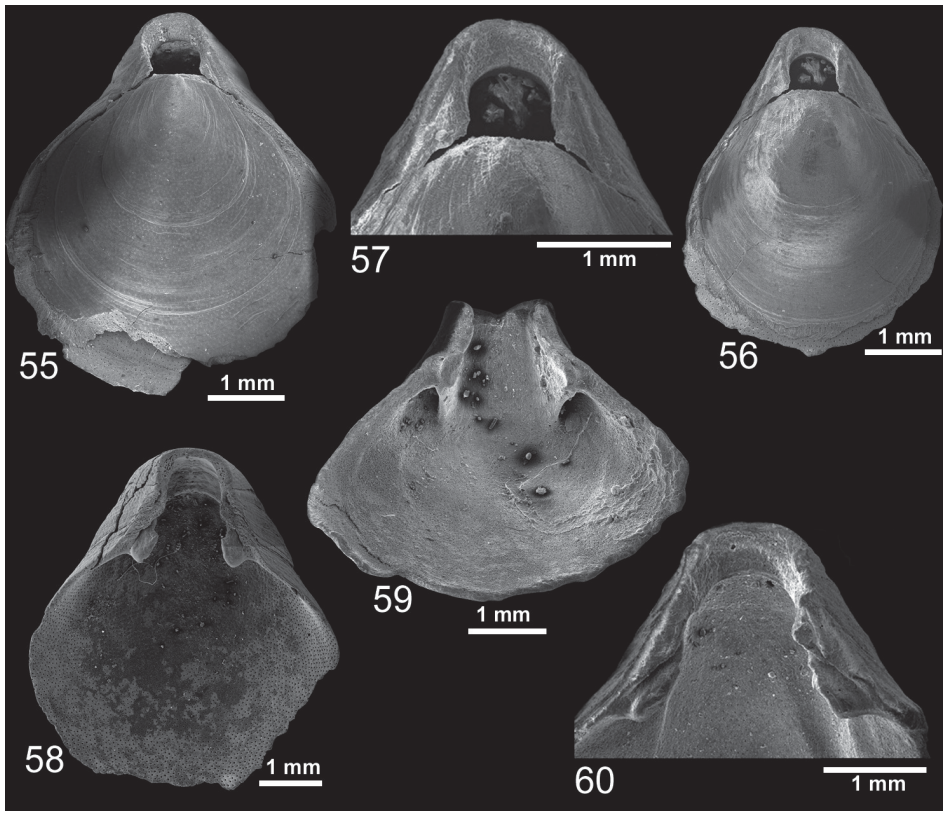
Suborder Terebratellidina Muir-Wood, 1955
Superfamily Zeillerioidea Allan, 1940
Family Zeilleriidae Allan, 1940
Subfamily Macandreviinae Cooper, 1973
Genus *Macandrevia* King, 1859
Type species – *Terebratula cranium* Müller, 1776

Macandrevia cranium (Müller, 1776)
(Figs 55–60)

1886 *Waldheimia* (*Macandrevia*) *cranium* (Müller) – Davidson, pp. 61–66, Pl. 12, Figs 11–23, Pl. 13, Figs 1–2.
1979 *Macandrevia cranium* (Müller) – Brunton & Curry, p. 58, Figs 30A-C.
1990 *Macandrevia cranium* (Müller) – Thomsen, p. 25, Text-Fig. 1.
2001 *Macandrevia cranium* (Müller) – Thomsen, pp. 121–123, Text-Fig.
2004 *Macandrevia cranium* (Müller) – Voskuil, pp. 49–50, Text-Figs 5A-G.
2012 *Macandrevia cranium* (Müller) – Zezina, p. 86.

Material – Gedgrave (2 complete specimens, 3 pedicle valves); Cricqueville-en-Bessin (2 pedicle valves); Kreekrak (1 pedicle valve, 1 brachial valve).

Remarks – Today *Macandrevia cranium* is known mainly from the Arctic region (Western Arctic, Greenland, Norway, Northern Atlantic, Spitzbergen, Greenland, Rhode Island, and Western Sahara) but may occur also in the Mediterranean (Lion Bay, France) (Zezina 2012). *M. cranium* has a long nomenclatural history, and earlier it was attributed to different genera: *Terebratula* (Müller 1776; Jeffreys 1878), *Waldheimia* (Davidson 1886; Fischer & Oehlert 1891; Posselt 1898); *Waldheimiathyris* (Wesenberg-Lund 1941). Dall (1920) described a new species, *M. novangliae* which is generally synonymized with *M. cranium* (e.g. Zezina 2012). Thomsen (1990) studied *M. cranium* and its usefulness



Figs 55–60. *Macandrevia cranium* (Müller, 1776). – **55.** Dorsal view of juvenile specimen, Gedgrave, 1.7–1.9 m, England, RGM.1309906. – **56-57.** Juvenile specimen, Gedgrave, 0.55–0.85 m, England, RGM.1309904. – **56.** Dorsal view. – **57.** Detail of Fig. 56 showing the pedicle opening. – **58.** Internal view of pedicle valve, Cricqueville-en-Bessin, France, RGM.1309914. – **59.** Internal view of fragmentary pedicle valve, Gedgrave, 0.55–0.85 m, England, RGM.1309905. – **60.** Internal view of pedicle valve showing the beak area, Gedgrave, 1.00–1.25 m, England, RGM.1309917

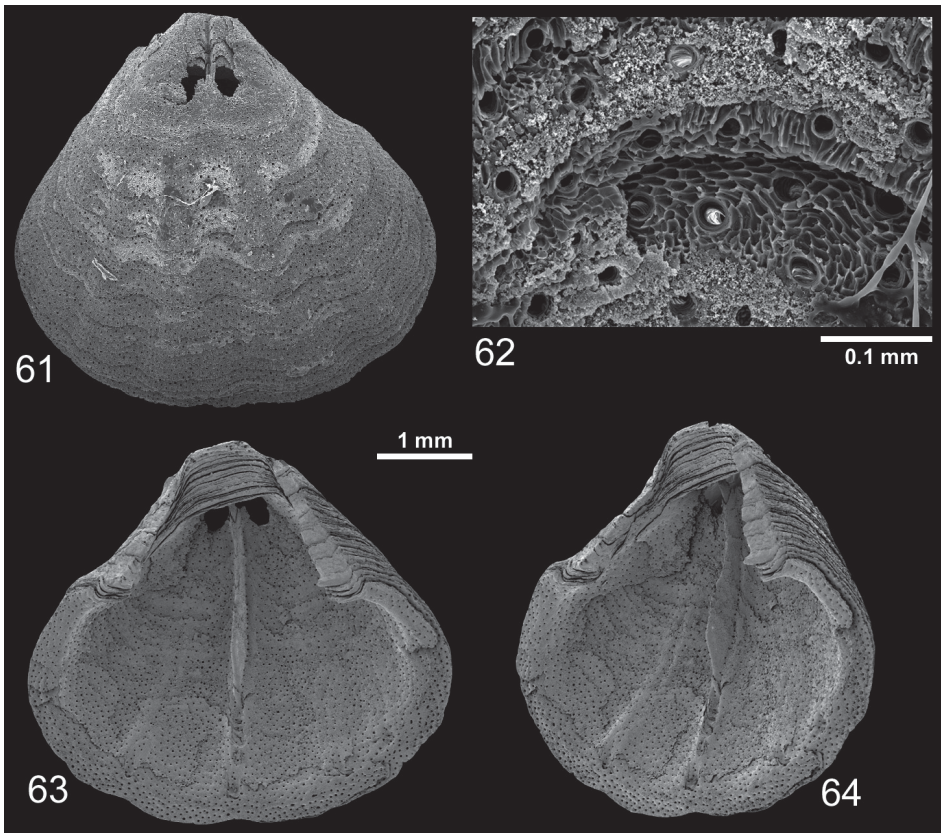
in palaeoceanographic reconstructions. It belongs to the deep-water forms, the recent representatives are known from 9–2951 m (Zezina 2012). In the studied North Sea Basin samples it consistently occurs in small specimen numbers.

Superfamily Megathyridoidea Muir-Wood, 1955
Family Megathyrididae Dall, 1870
Genus *Argyrotheca* Dall, 1900
Type species – *Terebratula cuneata* Risso, 1826

Argyrotheca cf. *plicata* (de Morgan, 1915)
(Figs 61–64)

Material – Cricqueville-en-Bessin (1 pedicle valve).

Remarks – Unfortunately, the available material is very limited, contains only a pedicle valve. It is very similar to DE MORGAN's (1915) species, which was described from the Middle Miocene (Langhian) of Pontlevoy as a rare new species. This species was also listed by PACAUD (2014) among brachiopod type specimens of the Natural History Museum in Paris, without any additional information. The main difference between them that de Morgan's specimen has rounded outline, while the Cricqueville-en-Bessin specimen is more subtrigonal. The other characters are the same (few weak and rounded ribs, lack of tubercles along the in-



Figs 61–64. *Argyrotheca* cf. *plicata* (de Morgan, 1915), Cricqueville-en-Bessin, France. – **61.** External view of pedicle valve. – **62.** Detail of Fig. 61, showing the shell structure. – **63.** Internal view of pedicle valve. – **64.** Oblique lateral view of pedicle valve

ternal margin of the valve, short and low median septum in the pedicle valve). Reasonable interpretation of this form requires much more available material.

CONCLUSIONS

The Cenozoic Mollusc collection of the Naturalis Biodiversity Center has rich and diverse Pliocene materials which contain some brachiopods, too. The numerous and diverse brachiopod collections (e.g. "Redonian" of France, or "Kattendijkian" of Belgium) will be published in separate papers, but some rare and sporadic samples are also worthwhile to publish. These sporadic samples are from the Italian part of the Mediterranean and from different parts of the North Sea Basin (Coralline Crag and Red Crag samples from England, single sample from North France, and some borehole materials from the Netherlands).

The studied samples altogether yielded more than 1000 specimens which represent 8 species of 8 genera. The Italian Pliocene assemblage is dominated by large terebratulids (all of them belong to *Terebratula ampulla*), while characteristic rhynchonellids (some *Aphelesia bipartita*) and cancellothyridids (only one *Terebratulina retusa*) are rare. The Coralline Crag samples of England are characterized by the very fragmentary specimens of large terebratulids. For the present the well-known and widely applied name *Pliothyrina sowerbyana* is used but the correct name for North Sea Basin Pliocene large terebratulids is under discussion (see e.g. Moerdijk 2016). Fragmentary lingulids are also common in these samples, and until now only the presence of *Glottidia dumortieri* has been confirmed in the Neogene of the North Sea Basin. The zeilleriid *Macandrevia cranium* is rarely found in Crag samples. The only French locality, Cricqueville-en-Bessin yielded few brachiopods, but relatively higher diversity. The terebratulid *P. sowerbyana* is more common, while all the others are rare: *G. dumortieri*, *M. cranium*, *Argyrotheca* cf. *plicata*. The Dutch Pliocene samples are dominated by mostly fragmentary lingulids, *G. dumortieri*. The others are much less common (*Notosaria nysti*, *P. sowerbyana*, *T. retusa*, *M. cranium*). *N. nysti* is rare and only shortly discussed from these samples, and will be described in detail in the near future on the basis of French ("Redonian") and Belgian ("Kattendijkian") materials. However, this is the first photo documentation of this species, as until now it has rarely been described, and has been illustrated only by drawings (Davidson 1974b; Nyst 1881; Ottema & in't Hout 1987).

*

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REFERENCES

Andri E., Tagliamacco A., Testa M. & Marchini A. 2005: *Le malacofaune fossili del Rio Torsero. Regione Liguria. Catalogo dei Beni Naturali.* – Comune di Ceriale, Nuova Editrice Genovese, Genova, 286 pp.

Balson P. S., Mathers S. J. & Zalasiewicz J. A. 1993: The lithostratigraphy of the Coralline Crag (Pliocene) of Suffolk. – *Proceedings of the Geologists Association* **104**(1): 59–70. http://dx.doi.org/10.1016/S0016-7878(08)80155-1

Baumiller T. K., Bitner M. A. & Emig C. C. 2006: High frequency of drill holes in brachiopods from the Pliocene of Algeria and its ecological implications. – *Lethaia* **39**: 313–320. http://dx.doi.org/10.1080/00241160600847546

Bell A. 1921: Notes on the Later Tertiary Invertebrata. – *Annual Report of the Yorkshire Philosophical Society for 1920*: 1–21.

Benigni C. & Robba E. 1990: A Pliocene Micromorph Brachiopod-Pectinid Community. Atti del Quarto Simposio di Ecologia e Paleoecologia delle Communitá Bentoniche, Sorrento, 1–5 Novembre 1988. – *Museo Regionale di Scienze Naturali Torino* n. ser. **604**: 341–356.

Berggren W. A. & Couvering J. A. van 1974: The Late Neogene: Biostratigraphy, geochronology and paleoclimatology of the last 15 million years in marine and continental sequences. – *Palaeogeography, Palaeoclimatology, Palaeoecology* **16**: 1–216. https://doi.org/10.1016/0031-0182(74)90032-7

Bertolaso L., Borghi E. & García Ramos D. 2009: Brachiopodi Neogenici e Pleistocenici dell'Emilia (Parte seconda). – *Parva Naturalia* **8**: 3–42.

Bitner M. A. 1990: Middle Miocene (Badenian) brachiopods from the Roztocze Hills, southeastern Poland. – *Acta Geologica Polonica* **40**: 129–157.

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

Bitner M. A. & Martinell J. 2001: Pliocene brachiopods from the Estepona Area (Málaga, South Spain). – *Revista Espanola de Paleontología* **16**(2): 177–185.

Bitner M. A. & Moissette P. 2003: Pliocene brachiopods from north-western Africa. – *Geodiversitas* **25**(3): 463–479.

Bitner M. A. & Schneider S. 2009: The Upper Burdigalian (Ottnangian) brachiopod fauna from the northern coast of the Upper Marine Molasse Sea in Bavaria, Southern Germany. – *Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen* **254**: 117–133. http://dx.doi.org/10.1127/0077-7749/2009/0006

Bitner M. A., Zágoršek K., Halásová E., Hudáčková N. & Jamrich M. 2014: Brachiopods and bryozoans from Sandberg section (Vienna Basin, Central Paratethys) and their significance for environmental interpretation of the Early Sarmatian (= Middle Miocene) Sea. – *Neues Jahrbuch für Geologie und Paläontologie* **273**(2): 207–219. https://doi.org/10.1127/0077-7749/2014/0424

Borghi E. 2001: Osservazioni sui Brachiopodi neogenici e pleistocenici dell'Emilia. – *Parva Naturalia* **2000–2001**: 45–81.

Bosch J. & Wesselingh F. P. 2006: On the stratigraphic position of the Delden Member (Breda Formation, Overijssel, the Netherlands) with implications for the taxonomy of *Pygocardia* (Mollusca, Bivalvia). – *Cainozoic Research* **4**: 109–117.

Bosch M. van den, Cadée M. C. & Janssen A. W. 1975: Lithostratigraphical and biostratigraphical subdivision of Tertiary deposits (Oligocene–Pliocene) in the Winterswijk-Almelo region (eastern part of the Netherlands). – *Scripta Geologica* **29**: 1–169.

Bosselaers M., Herman J., Hoedemakers K., Lambert O., Marquet R. & Wouters K. 2004: Geology and palaeontology of a temporary exposure of the Late Miocene Deurne Sand Member in Antwerpen (N. Belgium). – *Geologica Belgica* **7**(1–2): 27–39.

Brunton C. H. C. & Curry G. B. 1979: British brachiopods. – *Synopses of the British Fauna (New Series)* **17**: 1–64.

Buckman S. S. 1908: Brachiopod nomenclature: the Terebratulae of the Crag. – *Annals and Magazine of Natural History* (London), ser. **8**(1): 444–447. https://doi.org/10.1080/00222930808692430

Calzada S. 1978: Braquiópodos tortonienses de Murcia. – *Estudios Geologicos* **34**: 351–358.

Calzada S. 1997: Miscelánea sobre braquiópodos. – *Batalleria* **7**: 31–34.

Casolari E., Negri A., Picotti V. & Bertotti G. 2000: Neogene Stratigraphy and Sedimentology of the Gargano Promontory (Southern Italy). – *Eclogae Geologicae Helvetiae* **93**: 7–23.

Chapman F. & Crespin I. 1923: The Austral Rhynchonellacea of the "Nigricans Series" with a special description of the new genus *Tegulorhynchia*. – *Proceedings of the Royal Society of Victoria* **35**(2): 170–193.

Charlesworth E. 1837: Observation upon *Voluta lamberti*, with description of a gigantic species of *Terebratula* from the Coralline Crag. – *Magazine of Natural History and Journal of Zoology, Botany, Mineralogy, Geology and Meteorology*, Ser. 2, **1**: 90–97.

Chuang S. H. 1964: The affinity of *Lingula dumortieri* Nyst with *Glottidia*. – *Journal of Paleontology* **38**: 155–157.

Cooper G. A. 1959: Genera of Tertiary and Recent Rhynchonelloid brachiopods. – *Smithsonian Miscellaneous Collections* **139**(5): 1–90.

Cooper G. A. 1983: The Terebratulacea (Brachiopoda), Triassic to Recent. – *Smithsonian Contributions to Paleobiology* **50**: 1–291. https://dx.doi.org/10.5479/si.00810266.50.1

Curry G. B. 1982: Ecology and population structure of the Recent brachiopod *Terebratulina* from Scotland. – *Palaeontology* **25**: 227–246.

Dall W. H. 1920: Annotated list of the recent Brachiopoda in the collections of the US National Museum with description of 33 new forms. – *Proceedings of the United States National Museum* **57**(2314): 261–377.

Dautzenberg P. 1909: Description d'une espèce nouvelle de Brachiopode du Pliocène algérien. – *Journal de Conchyliologie* **56**: 271–272.

Dautzenberg P. & Dolfuss G. F. 1896: Du nom à adopter pour la grande Térébratule du Pliocène inférieur d'Anvers. – *Annales de la Société Royale Malacologique de Belgique* **31**: 17–19.

Davidson T. 1852: *A Monograph of British Tertiary Brachiopods. Part 1*. – The Paleontographical Society, 23 pp.

Davidson T. 1870: On Italian Tertiary Brachiopoda. – *Geological Magazine* **7**(8–10): 359–370, 399–408, 460–466. https://doi.org/10.1017/S0016756800209138; https://doi.org/10.1017/S0016756800209497; https://doi.org/10.1017/S0016756800209394

Davidson T. 1874a: A monograph of the British fossil brachiopods, 4(1): supplement to the Recent, Tertiary and Cretaceous species. – *Monographs of the Palaeontological Society* **27**: 1–72.

Davidson T. 1874b: On the Tertiary Brachiopoda of Belgium. – *Geological Magazine* **11**: 150–159. https://doi.org/10.1017/S0016756800169286

Davidson T. 1886–1888: A monograph of Recent Brachiopoda. – *Transactions of the Linnean Society of London* (2nd ser.) **4**: 1–248. https://doi.org/10.1111/j.1096-3642.1886.tb00655.x

Dermitzakis M. 1969: Geological researches of the Neogene deposits of the Hierapetra Province in Crete. – *Annales Géologiques des Pays Helléniques* **21**: 342–484. (in Greek)

Dollfus G. & Dautzenberg P. 1901: Nouvelle listes des Pélécypodes et des Brachiopodes Fossiles du Miocène Moyen du Nord-Ouest de la France. – *Journal de Conchyliologie* **49**: 1–52.

Dreger J. 1911: Miocene brachiopoden aus Sardinien. – *Verhandlungen der kaiserlich-königlichen Geologischen Reichsanstalt* **6**: 131–138.

Dulai A. 2010: Early Messinian (Late Miocene) micromorphic brachiopods from Borelli (Italy, Piemonte). – *Fragmenta Palaeontologica Hungarica* **28**: 21–31.

Dulai A. 2013: Sporadic Miocene brachiopods in the Naturalis Biodiversity Center (Leiden, the Netherlands): Records from the Mediterranean, the North Sea, and the Atlantic Ocean. – *Fragmenta Palaeontologica Hungarica* **30**: 15–51.

Dulai A. 2015: Central Paratethyan Middle Miocene brachiopods from Poland, Hungary and Romania in the Naturalis Biodiversity Center (Leiden, the Netherlands). – *Scripta Geologica* **149**: 185–211.

Dulai A. & Mulder H. in prep.: Pliocene brachiopods from Estepona (Spain).

Dulai A. & Stachacz M. 2011: New Middle Miocene *Argyrotheca* (Brachiopoda; Megathyrididae) species from the Central Paratethys. – *Földtani Közlöny* **141**(2): 445–468.

Dulai A., Gatt M., Moissette P. & Janssen A. W. in prep.: Oligocene and Miocene brachiopods of the Maltese Islands: taxonomy, diversity, distribution and paleoecology.

Emig C. C. 1990: Examples of post-mortality alteration in Recent brachiopod shells and (paleo) ecological consequences. – *Marine Biology* **104**: 233–238. https://doi.org/10.1007/BF01313263

Emig C. C. & Bitner M. A. 2005: The brachiopod *Lingula* in the Middle Miocene of the Central Paratethys. – *Acta Palaeontologica Polonica* **50**(1): 181–184.

Emig C. C., Bitner M. A. & Álvarez F. 2015: Scientific death-knell of databases? Errors induced by database manipulations and its consequences. – *Carnets de Geologie* **15**(16): 321–328.

Emig C. C., Bitner M. A. & Cahuzac B. 2007: First record of Lingula (Brachiopoda) from the Miocene of France, with diagnosis of *L. dregeri*. – *Comptes Rendus Palevol* **6**: 261–267. http://dx.doi.org/10.1016/j.crpv.2007.02.002

Encinas E. & Martinell J. 1992: Braquiópodos del Pliocene del Emporda (Catalunya). – III Congreso Geologico de España y VIII Congreso Latinoamericano de Geologia, Salamanca 1992, **1**: 501–505.

Fischer P. & Oehlert D. P. 1891: *Brachiopodes. Expéditions scientifiques du "Travailleur" bet du "Talisman" pendant les années 1880, 1881, 1882, 1883*. – Paris, G. Mason, 140 pp.

Foresti L. 1893: Enumerazione dei Brachiopodi e dei Molluschi Pliocenici dei dintorni di Bologna. – *Bollettino della Società Malacologica Italiana* **18**: 55–72.

Gaetani M. 1986: Brachiopod palaeocommunities from the Plio/Pleistocene of Calabria and Sicily (Italy). – In: Racheboeuf P. R. & Emig C. C. (eds): Les Brachiopodes fossils et actuels, *Biostratigraphie du Paléozoïque* **4**: 477–483.

Gaetani M. & Saccà D. 1984: Brachiopodi batiali nel Pliocene e Pleistocene di Sicilia e Calabria. – *Rivista Italiana di Paleontologia e Stratigrafia* **90**(3): 407–458.

Gaetani M. & Saccà D. 1985a: Brachiopodici neogenici e pleistocenici della provincia di Messina e della Calabria meridionale. – *Geologica Romana* **22**(1983): 1–43.

Gaetani M. & Saccà D. 1985b: Il genere *Aphelesia* (Rhynchonellida, Brachiopoda) nel Mio-Pliocene italiano. – *Rivista Italiana di Paleontologia e Stratigrafia* **91**: 357–378.

García Ramos D. 2004: Braquiópodos pliocenos de Águilas. – *Boletín de la Asociación Cultural Paleontológical Murciana* **3**: 18–39.

García Ramos D. 2005: Notes on some Neogene Brachiopods from south-eastern Spain. – *Cidaris* **21–22**: 25–36.

García Ramos D. 2006: Nota sobre Terebratulinae del Terciario de Europa y su relación con los representantes neógenos del sureste español. – *Boletín de la Asociación Cultural Paleontológical Murciana* **5**: 23–83.

Harper E. M. 2005: Evidence of predation damage in Pliocene *Apletosia maxima* (Brachiopoda). – *Palaeontology* **48**(1): 197–208. https://doi.org/10.1111/j.1475-4983.2004.00433.x

Janssen A. W. 2012: Systematics and biostratigraphy of holoplanktonic Mollusca from the Oligo-Miocene of the Maltese Archipelago. – *Bollettino del Museo Regionale di Scienze Naturali Torino* **28**(2): 197–601.

Jeffreys J. G. 1878: On the Mollusca procured during the 'Lightning' and 'Porcupine' Expeditions, 1868–70. – *Proceedings of the Zoological Society of London* **46**(1): 393–416. https://doi.org/10.1111/j.1096-3642.1884.tb02813.x

Kocsis L., Dulai A., Bitner M. A., Vennemann T. & Cooper M. 2012: Geochemical composition of Neogene phosphatic brachiopods: Implications for ancient environmental and marine conditions. – *Palaeogeography, Palaeoclimatology, Palaeoecology* **326-328**: 66–77. http://dx.doi.org/10.1016/j.palaeo.2012.02.004

Koskeridou E. 2007: Pliocene brachiopods from Rhodes Island (Cape Vagia section). – *Bulletin of the Geological Society of Greece* **40**: 121–133.

Lacourt A. W. 1983: De fossiele Brachiopoda van Z. W. Nederland met aantekeningen over *Terebratula grandis* Blumenbach. – *Vita Marina, Ampotigen* **1984**(nov-dec): 9–50.

Laga P. & Louwye S. (2006): Disused Neogene and Quaternary regional stages from Belgium: Bolderian, Houthalenian, Antwerpenian, Diestian, Deurnian, Kasterlian, Kattendijkian, Scaldisian, Poederlian, Merksemian and Flandrian. – *Geologica Belgica* **9**(1–2): 215–224.

Lee D. E. & Smirnova T. N. 2006: Terebratuloidea. – In: Kaesler R. L. (ed.): *Treatise on Invertebrate Paleontology, Part H Brachiopoda Revised, Volume 5: Rhynchonelliformea (part)*, The Geological Society of America and The University of Kansas, Boulder, Colorado and Lawrence, Kansas, pp. 2054–2081.

Lee D. E. & Wilson J. B. 1979: Cenozoic and Recent Rhynchonellide Brachiopods of New Zealand: Systematics and Variation in the Genus *Notosaria*. – *Journal of the Royal Society of New Zealand* **9**(4): 437–463. http://dx.doi.org/10.1080/03036758.1979.10421831

Lee D. E., Brunton C. H. C., Taddei Ruggiero E., Caldara M. & Simone O. 2001: The Cenozoic brachiopod *Terebratula*: Its type species, neotype, and other included species. – *Bulletin of the Natural History Museum* (*Geology*) **57**(2): 83–93.

Llompart C. & Calzada S. 1982: Braquiópodos messinienses de la isla de Menorca. – *Boletin de la Real Sociedad Española de Historia Natural* **80**: 185–206.

Logan A. 1979: The Recent Brachiopoda of the Mediterranean Sea. – *Bulletin de l'Institut Océanographique Monaco* **72**: 1–112.

Logan A. 2007: Geographic distribution of extant articulated brachiopods. – In: Selden P. A. (ed.): *Treatise on Invertebrate Paleontology. Part H. Brachiopoda Revised. Volume 6,* The Geological Society of America and The University of Kansan, Boulder, Colorado and Lawrence, Kansas, pp. 3082–3115.

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 Millennium. – *Scientia Marina* **68**(suppl. 1): 163–170.

Manceñido M. O., Owen E. F., Dong-Li S. & Dagys A. S. 2002: Hemithiridoidea. – In: Kaesler R. L. (ed.): *Treatise on Invertebrate Paleontology, Part H. Brachiopoda Revised, Volume 4*, The Geological Society of America and The University of Kansas, Boulder, Colorado and Lawrence, Kansas, pp. 1326–1369.

Martinell J. 1982: Borings produced by presumed Pliocene brachiopods from l'Empordà (Catalonia, Spain). – *Butlletí de la Institució Catalana d'Història Natural* **48** (Secció de Geologia, 3): 91–97.

Meznerics I. 1944: Die Brachiopoden des ungarischen Tertiärs. – *Annales historico-naturales Musei Nationalis Hungarici* **36**: 10–60.

Moerdijk P. 2007: Indrukken uit het Mioceen. – *Afzettingen WTKG* **28**(4): 78–81.

Moerdijk P. 2016: Een naam voor de Miocene *Pliothyrina* uit de Westerschelde. – *Afzettingen WTKG* **37**: 106–113.

Monegatti P., Raffi S., Roveri M. & Taviani M. 2001: *A one day trip in the outcrops of the Castell'Arquato Plio-Pleistocene Basin: from the Badlands of Monte Giogo to the Stirone River*. – Paleobiogeography & Paleoecology International Conference, May 31 – June 2, 2001, Piacenza & Castell'Arquato, Italy, pp. 1–22.

Morgan J. de 1915: Note sur les Mollusques brachiopods des faluns de la Touraine. – *Bulletin de Société Géologique de France*, t. 4, **15**: 260–273.

Muir-Wood H. 1938: Notes on British Eocene, and Pliocene Terebratulas. – *Annals and Magazine of Natural History, Series 11,* **2**(8): 154–181. http://dx.doi.org/10.1080/03745481.1938.9755448

Müller O. F. 1776: *Zoologiae Danicae Prodromus, seu Animalium Daniae et Norvegiae Indigenarum Characteres, Nomina, et Synonyma Imprimis Popularium*. – Havniae, 282 pp.

Nieulande F. van 2009: Strandfossiel – *Terebratula* of *Pliothyrina*, het blijft vragen oproepen. – *Voluta* **15**(2): 9–12.

Nyst P.-H. 1843: Description des coquilles et des polypiers fossils des terrains Tertiaries de la Belgique. – *Mémoires Couronnés et Mémoires des savants étrangers de l'Académie royale de Bruxelles* **17**: 1–676.

Nyst P.-H. 1881: Conchyliologie des terrains Tertiaires de Belgique. Première Partie, Terrain Pliocène Scaldisien. – *Annales du musée royal d'Histoire naturelle des Belgique, Série Paléontologique* **3**: 1–263.

Ottema J. & in't Hout W. 1987: *Fossilien uit het 4e havendok bij Kallo, Belgie*. – Geologisch Museum Universiteit van Amsterdam: 1–111.

Pacaud J.-M. 2014: Catalogue des types de brachiopodes conservés dans les collections de Paléontologie du Muséum national d'Histoire naturelle de Paris. – *Fossiles, hors-série* **5**: 82–98.

Pajaud D. 1976: Les Brachiopodes du Pliocène l de la Sierra de Santa Pola (Sud d'Alicante, Espagne): *Terebratula terebratula* (Linné, 1758) et *Phapsirhynchia sanctapaulensis* nov. gen., nov. sp. – *Annales de la Société Géologique du Nord* **96**(2): 99–106.

Pajaud D. 1977: Les brachiopodes du Pliocène l de' la région d'Aguilas (Sud d'Almeria, Espagne). – *Annales de Paléontologie* (*Invertébrés*) **63**(1): 59–75.

Pareyn C., Brebion P., Buge E., Carriol R.-P., Lauriat-Rage A., le Calvez Y. & Roman J. 1983: Le gisement pliocène de Cricqueville-en-Bessin (Calvados). Étude géologique et paléontologique. – *Bulletin du Muséum national d'histoire naturelle, Paris, 4e série*, **5**, section C(4): 367–405.

Pavia G., Bertok C., Ciampo G., di Donato V., Martire L., Masini F., Pavia M., Santangelo N., Taddei Ruggiero E. & Zunino M. 2010: Tectono-sedimentary evolution of the Pliocene to Lower Pleistocene succession of the Apricena-Lesina-Poggio Imperiale quarrying district (western Gargano, southern Italy). – *Italian Journal of Geosciences* **129**(1): 132–155. http://dx.doi.org/10.3301/IJG.2009.11

Pedley H. M. 1976: A Palaeoecological Study of the Upper Coralline Limestone, *Terebratula-Aphelesia* Bed (Miocene, Malta) based on bryozoan growth-form studies and brachiopod distributions. – *Palaeogeography, Palaeoclimatology, Palaeoecology* **20**: 209–234. http://dx.doi.org/10.1016/0031-0182(76)90003-1

Piller W. & Harzhauser M. 2005: The myth of the brackish Sarmatian Sea. – *Terra Nova* **17**(5): 450–455. http://dx.doi.org/10.1111/j.1365-3121.2005.00632.x

Popiel-Barczyk E. & Barczyk W. 1990: Middle Miocene (Badenian) brachiopods from the southern slopes of the Holy Cross Mountains, Central Poland. – *Acta Geologica Polonica* **40**(3–4): 159–181.

Posselt H. J. 1898: Grønlands Brachiopoder og Bløddyr. – *Meddelelser om Grønland* **23**: 1–9.
Raad H. 2004a: Kijken naar fossile brachiopoden. – *Voluta* **10**(1): 13–18.
Raad H. 2004b: Kijken naar fossile brachiopoden, vervolg 1. – *Voluta* **10**(2): 19–22.
Raad H. 2008: Brachiopoden. – *Voluta* **14**(1): 20–22.
Roy A. van 1980: *Pliothyrina*, genre Terebratulide (Brachiopode) nouveau du Néogène. – *Bulletin de l'Institut royal des Sciences naturelles de Belgique, Sciences de la Terre* **52**(3): 1–9.
Saccà D. 1986: *Megerlia echinata* (Terebratulida, Brachiopoda) nel Pliocene della Sicilia e della Calabria Meridionale. – *Rivista Italiana di Paleontologia e Stratigrafia* **92**(2): 281–292.
Sacco F. 1902: *I Brachiopodi dei terreni terziarii del Piemonte e della Liguria*. – Torino, pp. 1–50.
Taddei Ruggiero E. 1994: Neogene Salento brachiopod palaeocommunities. – *Bollettino della Società Paleontologica Italiana* **33**: 197-213.
Taddei Ruggiero E. 1996: Biostratigrafia e paleoecologia delle Calcareniti di Gravina nei dintorni di Cerignola (brachiopodi e foraminiferi). – *Memorie della Società Geologica Italiana* **51**: 197–207.
Taddei Ruggiero E., Raia P. & Buono G. 2008: Geometric morphometrics species discrimination within the genus *Terebratula* from the Late Cenozoic of Italy. – *Fossils and Strata* **54**: 209–217.
Thomsen E. 1990: Application of brachiopods in palaeoceanographic reconstructions; *Macandrevia cranium* (Müller, 1776) from the Norwegian shelf. – *Boreas* **19**: 25–37. http://dx.doi.org/10.1111/j.1502-3885.1990.tb00418.x
Thomsen E. 2001: Brachiopoda in the Faroe Islands area. – *Fróðskaparrit* **49**: 109–126.
Thomson J. A. 1927: Brachiopod Morphology and Genera (Recent and Tertiary). – *N. Z. Board of Science and Art Manual* **7**: 1–338.
Toscano-Grande A., García-Ramos D., Ruiz-Muñoz F., González-Regalado M. L., Abad M., Civis-Llovera J., González-Delgado J. A., Rico-García A., Martínez-Chacón M. L., García E. X. & Pendón-Martín J. G. (2010): Braquiópodos neógenos del suroeste de la depresión del Guadalquivir (sur le España). – *Revista Mexicana de Ciencias Geológicas* **27**(2): 254–263.
Vincent E. 1893: Contribution a la paléontologie des terrains Tertiaires de la Belgique. Brachiopodes. – *Annals de la Société Royale Malacologique de Belgique* **28**: 38–64.
Voskuil R. P. A. 2004: De Recente en Tertiaire Brachiopoden van het Nederlandse strand – Een inventarisatie van de literatuur en commentaar op het vermeende voorkomen van *Gwynia capsula* (Jeffreys, 1859) in Zeeuws-Vlaanderen. – *Het Zeepard* **64**(2): 45–58.
Wesenberg-Lund E. 1941: Brachiopoda. – *Danish Ingolf-Expedition* **4**(12): 1–17.
Wesselingh F. P. 2003: Een doublet van *Terebratula grandis* uit de Westerschelde. – *Afzettingen WTKG* **24**(3): 49.
Wesselingh F. P., Peters W. J. M. & Munsterman D. K. (2013): A brachiopod-dominated seafloor assemblage from the Late Pliocene of the eastern Netherlands. – *Netherlands Journal of Geosciences* **92**(2–3): 171–176. https://doi.org/10.1017/S0016774600000111
Wood S. V. 1872: Supplement to the monograph of the Crag Mollusca or description of shells from the Middle and Upper Tertiaires of the east of England, 3: Univalves and Bivalves. – *Monographs of the Palaeontological Society London*, pp. 99–231.
Zalasiewicz J. A., Mathers S. J., Hughes M. J., Gibbard P. L., Peglar S. M., Harland R., Nicholson R. A., Boulton G. S., Cambridge P. & Wealthall G. P. 1988: Stratigraphy and Palaeoenvironments of the Red Crag and Norwich Crag Formations Between Aldeburgh and Sizewell, Suffolk, England. – *Philosophical Transactions of the Royal Society B* **322**: 221–272. https://doi.org/10.1098/rstb.1988.0125
Zezina O. N. 2012: Deep-sea fauna of European seas: An annotated species check-list of benthic invertebrates living deeper than 2000 m in the seas bordering Europe. Brachiopoda. – *Invertebrate Zoology* **11**(1): 83–88.