

A review of the Oligocene Limopsidae of the North Sea Basin (Mollusca: Bivalvia)

Kritische Übersicht der oligozänen Limopsidae des Nordseebeckens (Mollusca: Bivalvia)

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Abstract

In the course of a review of the Limopsidae Dall 1895 from the Oligocene of the North Sea Basin 13 species and their generic assignment are discussed. The following five species are described as new: *Cosmetopsis latdorfensis* from the Late Eocene/Earliest Oligocene Latdorfian stage, *Paracratia magdeburgensis* and *P. muelleri* from the Early Oligocene Rupelian sands of Mammendorf, *Cosmetopsis mothsorum* from the Early Rupelian Rupel Clay Formation of Malliß and *Cosmetopsis glimmerodensis* from the Early Chattian. Neotypes are established for *Limopsis retifera* Semper 1861 and *L. iniquidens* Sandberger 1861 and priority of *L. retifera* is demonstrated. The genus *Nucunella* Orbigny 1850 is excluded from the Limopsidae and transferred to Glycymerididae Dall 1908. The nomenclature of some taxa is corrected: *Limopsis albrechtvalki* Marquet, Lenaerts & Laporte 2012 is a synonym of *Limopsis subscalaris* Orbigny 1852, and for the North Sea Basin Miocene species hitherto known as “*Limopsis anomala* Eichwald” the taxon *Aspalima decussata* (Nyst & Westendorp 1839) is suggested.

Kurzfassung

Aus dem Oligozän des Nordseebeckens werden 13 Arten Limopsidae und deren Gattungszuordnung diskutiert. Dabei werden folgende Arten neu beschrieben: *Cosmetopsis latdorfensis* aus dem Latdorfium (Obereozän/frühestes Oligozän), *Paracratia magdeburgensis* und *P. muelleri* aus den Sanden von Mammendorf (Rupelium), *Cosmetopsis mothsorum* aus der Rupelton-Formation von Malliß sowie *C. glimmerodensis* aus dem Eochattium. Für *Limopsis retifera* Semper 1861 und *L. iniquidens* Sandberger 1861 werden Neotypen aufgestellt und die Priorität von *L. retifera* wird nachgewiesen. Die Gattung *Nucunella* Orbigny 1850 wird von den Limopsidae zu den Glycymerididae Dall 1908 transferiert. *Limopsis albrechtvalki* Marquet, Lenaerts & Laporte 2012 ist ein Synonym von *Limopsis subscalaris* Orbigny 1852. Für die bisher als „*Limopsis anomala* Eichwald“ bestimmte Art aus dem Miozän des Nordseebeckens wird *Aspalima decussata* (Nyst & Westendorp 1839) als gültiger Name vorgeschlagen.

Introduction

Fossiliferous Oligocene deposits of Magdeburg and surroundings have been known already in the early 19th century. Molluscs from Osterweddingen were first described by Goldfuss (1833–1841). Later on, Philippi (1846–1847) reported on the fossils from the Magde-

burg region. In the 19th century numerous brown coal pits offered excellent occasions to study the Palaeogene sediments and their rich fossil content. Gastropods were described by Beyrich (1853–1856) and the molluscs have been monographed in total by Koenen (1889–1894).

It was mainly in the last two decades that Oligocene deposits and their faunal content especially from the Magdeburg region has been attracting attention again. Due to the activities pursued in particular by A. Müller from the Institut für Geophysik und Geologie of the Universität Leipzig, a considerable number of papers have been published, mainly by A. Müller and his collaborators (see Müller 2008, 2011, Müller et al. 2014, with many references). However, the molluscs of newly exploited localities like Mammendorf and Atzendorf have not been in the strict focus but are treated only in preliminary and incomplete inventories. Few local mollusc faunas have been treated by Welle (1998), Welle et al. (1999), Welle & Nagel (2003) and Welle (2009). The bivalves of the Latdorfian Grimmeringen sands in Belgium have been monographed by Marquet et al. (2012). In general, however, mollusc faunas of the Early Oligocene of the North Sea Basin have not yet been critically worked up and taxonomy and nomenclature are still confused and outdated.

Especially the new locality Mammendorf W of Magdeburg has yielded an extraordinary diverse and well preserved mollusc fauna of Latdorfian to Rupelian age (Müller 2011). During examination of taxodont bivalves from Mammendorf it became evident that previous identifications of limopsid species were wrong. Attempts to clarify their taxonomy led to an in-depth evaluation of various Oligocene limopsid taxa and resulted in the discovery of several new species. The descriptions of new species along with some observations on taxonomy and nomenclature of other Oligocene limopsid species are presented here as a review of the Oligocene Limopsidae of the North Sea Basin.

Material and methods

The studied material from Mammendorf was collected by A. Müller and collaborators. At present it is housed at the Geologisch-Paläontologische Sammlung of the Universität Leipzig but it will be incorporated in the Senckenberg Naturhistorische Sammlungen Dresden later on. Duplicate voucher specimens of the Mammendorf material kindly were donated by A. Müller to the Senckenberg Forschungsinstitut Frankfurt a. Main. All other examined material from various Oligocene and Miocene localities of the North Sea and Mainz Basins as well as Recent comparative material is housed in the malacological collection of the Senckenberg Forschungsinstitut Frankfurt a. M. For details on location, stratigraphy and faunal content of the Mammendorf quarry see Müller (2008, 2011), for details on Glimmerode see R. Janssen (1978), for details on Atzendorf see Müller (2008) and Müller et al. (2014). Descriptions and measurements are based on examined material in SMF. Paratypes of some new species have been deposited also in other collections (RGM, ISL, see below).

Acronyms used for collections

GPSL	Geologisch-Paläontologische Sammlung, Institut für Geophysik und Geologie, Universität Leipzig
IRNSB	Institut royal des Sciences naturelles de Belgique, Brussels
ISL	coll. Ingemann Schnetler, Langå, Denmark
RGM	Naturalis Biodiversity Center, Paleontology Department, Leiden, The Netherlands
SMF	Senckenberg Forschungsinstitut und Naturmuseum Frankfurt

Abbreviations used in the text:

C = convexity/inflation; H = height (measured in vertical direction from umbo to the line of the most distant point of ventral margin); L = length (measured horizontally from the most distant points of anterior to posterior margins); max = maximal.

Systematics

Bivalvia Linnaeus 1758

Arcida Gray 1854

Limopsoidea Dall 1895

Limopsidae Dall 1895

There is a number of genera in the Limopsidae (see Newell 1969) of which only *Limopsis* Sassi 1827 with its subgenera *Pectunculina* Orbigny 1843 and *Cosmetopsis* Rovereto 1898 have been used for fossil taxa of the North Sea Basin Oligocene (see Glibert & Van de Poel 1965, 1970). Principally species with smooth shells were placed in *Limopsis* s.s. and those with reticulate sculpture and a crenulate margin in *Pectunculina* (of which *Cosmetopsis* was regarded a synonym by Newell 1969). In the course of the present work the use of these generic taxa had to be evaluated again. Because of the seemingly mosaic distribution of conchological characters and the still insufficient knowledge on morphology of the soft parts there is still much controversy about the number of valid genera and subgenera in the family. Whereas Tevesz (1977) accepted two genera, *Limopsis* and *Empleconia* Dall 1908, Oliver (1981) recognised only *Limopsis* despite of arranging the various Recent species into 13 morphological groups. Coan et al. (2000) accepted *Limopsis*, *Empleconia* and *Nipponolimopsis* Habe 1951, assigning generic status to former subgenera. Beu (2006) also discussed the problems of

defining natural entities in the family and again accepted the only genus *Limopsis*. This is followed by the World Register of Marine Species (WoRMS). The most actual treatment of the Recent Limopsidae is of Huber (2010) who acknowledged, however, the morphological groups distinguished by Oliver as separate subgenera and added two further new subgenera. The (sub-)genera *Pectunculina* and *Cosmetopsis* were not discussed in any of these papers (except Beu 2006) because of being based on fossil type species. Beu (2006: 179) questioned the generic status of *Pectunculina* because “the variations on the *Limopsis-Pectunculina* theme all intergrade”. However, this is not convincing because own observations suggest that conchological characters are not distributed randomly.

An overview on the various Recent type species of genera in the Limopsidae (as figured by Oliver 1981, Lamprell & Healy 1998, Okutani 2000, Huber 2010) as well as examination of available material in SMF collections seem to confirm Huber’s view of recognizing a larger number of at least conchologically distinct groups. Therefore in this study Coan et al. (2000) is followed and former subgenera are considered as separate genera. As long as no molecular studies are available which could demonstrate natural relationships among species groups, conchologically separable groups should be treated as distinct on generic level for two reasons: uniting all species in a single genus *Limopsis* would obscure and neglect the existing morphological differences to an unreasonable degree, and use of subgenera, however, would suggest close relationships to *Limopsis* s.s. which actually are by no means proved. Therefore here a pragmatic and neutral position is preferred by using entities of generic level. According to their degree of conformity with conchological characters of the type species of various genera, the Oligocene species are grouped in this paper into six distinct genera: *Aspalima*, *Cosmetopsis*, *Limopsis*, *Oblimopa*, *Paracratia* and *Pectunculina*.

The genus *Nucunella* Orbigny 1850 was included in the Limopsidae by Newell (1969) only with a query. Tevesz (1977: 29) questioned its position in the Limopsidae and suggested a probable position in the Noetiidae where it had already been placed by Glibert (1936). However, examination of specimens of the type species *N. nystii* (Galeotti 1837) and of *N. taxandrica* (Vincent 1922) (material in SMF, but compare also Glibert 1936: 28, fig. 16 for *nystii*; Vincent 1922: figs. 2–5, Glibert & Heinzelin 1954: 321, pl. 1, fig. 10a–b, Berndt & Welle 1998: 7, pl. 1, figs. 1, 2, 3, 4, 5, 6a–b, 7a–b for *taxandrica*) shows that there is no ligamental pit as typical for Limopsidae nor a vertically striated ligamental area as in Noetiidae but a prosodetic ligament as shown by an obliquely ribbed ligamental area, very similar to the situation in certain Glycymerididae, e.g. *Axinactis* Mörch 1861 and *Glycymerella* Woodring 1925 (see figures in Newell 1969). Therefore the genus is transferred here to the family Glycymerididae Dall 1908.

Aspalima Iredale 1929

Type species (original designation): *Limopsis erecta* Hedley & Pterterd 1906 (Recent; S-Australia)

Remarks: Species are characterised by usually circular to slightly suboval shape, a well developed ligamental area and straight hinge line, a sculpture of raised concentric lamellae and radial riblets, and an interior margin with distinctly denticulated narrow internal seam.

Aspalima chattica (Schnetler in Schnetler & Beyer 1990)

Fig. 1

1990 *Limopsis (Pectunculina) lamellata chattica* Schnetler in Schnetler & Beyer: 50, pl. 1, figs. 2a–b, 3a–b (Mogenstrup)

Type material: Holotype MGUH 20023 (Geological Museum, University of Copenhagen), many paratypes in various collections (partly seen).

Locus typicus: Coastal cliff at Mogenstrup N of Skive, Jutland, Denmark.

Stratum typicum: Glauconitic sand of Brejning Clay Member, Vejle Fjord Formation; Late Eochattian (B).

Material examined: Denmark: Mogenstrup (paratypes SMF 308405/5).

Diagnostic characters: Very small ($H_{\max} = 2.2$ mm, $L_{\max} = 2.2$ mm, $C_{\max} = 0.5$ mm; H_{\max} ca. 3.0 mm according to original figures), circular in outline; exterior with sculpture of irregular but distinctly raised concentric lamellae with broad interstices, crossed by ca. 40 distant radial riblets which are particularly obvious in the interspaces of the concentric lamellae; hinge tiny, with 3 small teeth in each series; ligamental area well developed but low, ligamental pit minute, elongate triangular; edge of interior margin smooth, but internal narrow seam beset with ca. 30 fine denticles, very faintly radiating into the interior of shell.

Remarks: This small species is indeed very similar to *A. lamellata* (Lehmann 1885) known from the Middle Miocene of the North Sea Basin. This species reaches a larger size, is more convex and has a much stronger hinge line with stronger teeth, and a stronger crenulation of the internal margin. Up to now *A. chattica* is only known from the Danish Brejning clay (Chattian). It is distinguished from juvenile specimens of the other species discussed herein by its circular outline and the sculpture of raised concentric lamellae with a fine radial striation in the interstices of the lamellae. Because this group of

Fig. 1. *Aspalima chattica* (Schnetler in Schnetler & Beyer 1990). Denmark: Mogenstrup; Brejning Clay, Eochattian B; left valve (paratype SMF 308405a), H = 2.2 mm, × 20.

Figs. 2–7. *Cosmetopsis latdorfensis* n. sp. Germany (Sachsen-Anhalt): Atzendorf; Latdorf Beds, Latdorfian; coll. R. Janssen: Fig. 2 – right valve (holotype SMF 342605), H = 2.6 mm, × 20; Fig. 3 – right valve (paratype SMF 342606), H = 1.7 mm, × 25; Fig. 4 – left valve (paratype SMF 342607), H = 1.7 mm, × 25. Germany (Sachsen-Anhalt): Latdorf; Latdorf Beds, Latdorfian; coll. O. Boettger: Fig. 5 – left valve (paratype SMF 342609), H = 2.4 mm, × 20; Fig. 6 – right valve (paratype SMF 342610), H = 2.3 mm, × 20; Fig. 7 – right valve (paratype SMF 342611), H = 2.2 mm, × 25.

Abb. 1. *Aspalima chattica* (Schnetler in Schnetler & Beyer 1990). Dänemark: Mogenstrup; Brejning Ton, Eochattium B; linke Klappe (Paratypus SMF 308405a), H = 2,2 mm, × 20.

Abb. 2–7. *Cosmetopsis latdorfensis* n. sp. Deutschland (Sachsen-Anhalt): Atzendorf; Latdorf-Schichten, Latdorfium; coll. R. Janssen: Abb. 2 – rechte Klappe (Holotypus SMF 342605), H = 2,6 mm, × 20; Abb. 3 – rechte Klappe (Paratypus SMF 342606), H = 1,7 mm, × 25; Abb. 4 – linke Klappe (Paratypus SMF 342607), H = 1,7 mm, × 25. Deutschland (Sachsen-Anhalt): Latdorf; Latdorf-Schichten, Latdorfium; coll. O. Boettger: Abb. 5 – linke Klappe (Paratypus SMF 342609), H = 2,4 mm, × 20; Abb. 6 – rechte Klappe (Paratypus SMF 342610), H = 2,3 mm, × 20; Abb. 7 – rechte Klappe (Paratypus SMF 342611), H = 2,2 mm, × 25.

species is not yet known from the Early Miocene of the North Sea Basin, there is no proof that *chattica* is phylogenetically related to *lamellata*. Therefore it is preferred here to keep it as a species rather than a subspecies.

Regional distribution and stratigraphic range: Brejning Clay Member of Vejle Fjord Formation (Denmark). – Late Eochattian (B).

Cosmetopsis Rovereto 1898

Type species (original designation): *Limopsis retifera* Semper 1861 (Late Oligocene; Germany)

Remarks: This genus is conceived here as comprising small species with suboval to moderately trapezoidal shape, a straight hinge line, a well developed but fine to moderately coarse reticulate sculpture, and a distinctly crenulated interior margin without defined internal seam.

Cosmetopsis latdorfensis n. sp.

Figs. 2–7

- 1868 *Limopsis retifera* – Koenen: 237 partim, pl. 28, fig. 1f–i (Lattorf) (non fig. 1a–e = *retifera*) (non Semper)
- 1893 *Limopsis retifera* – Koenen: 1075 partim, pl. 74, fig. 8a–d (Lattorf) (non figs. 6a–b, 7a–b = aff. *muelleri* n. sp.) (non Semper)
- 1954 *Limopsis (Pectunculina) anomala* – Glibert & Heinzelin: 320, pl. 1, fig. 9a–b (Grimmerten) (non Eichwald 1830)
- 1997 *Limopsis (Pectunculina) retifera* – Welle: 15 partim (Sophia Jacoba 8) (non Semper)
- 2012 *Limopsis (Pectunculina) retifera* – Marquet et al.: 27, pl. 9, fig. 1a–b, c (Grimmerten) (non Semper)

2014 *Limopsis iniquidens* – Müller et al.: 99 (Atzendorf) (non Sandberger)

Type material: Holotype (right valve): SMF 342605; paratypes SMF 342606/1, SMF 342607/1, SMF 342608/26, RGM.1008159/4, coll. ISL/2 from type locality, all coll. R. Janssen 2009; paratypes SMF 342609/1, 342610/1, 342611/1, SMF 342612/21 from Latdorf, Sachsen-Anhalt, all coll. O. Boettger ex A. von Koenen.

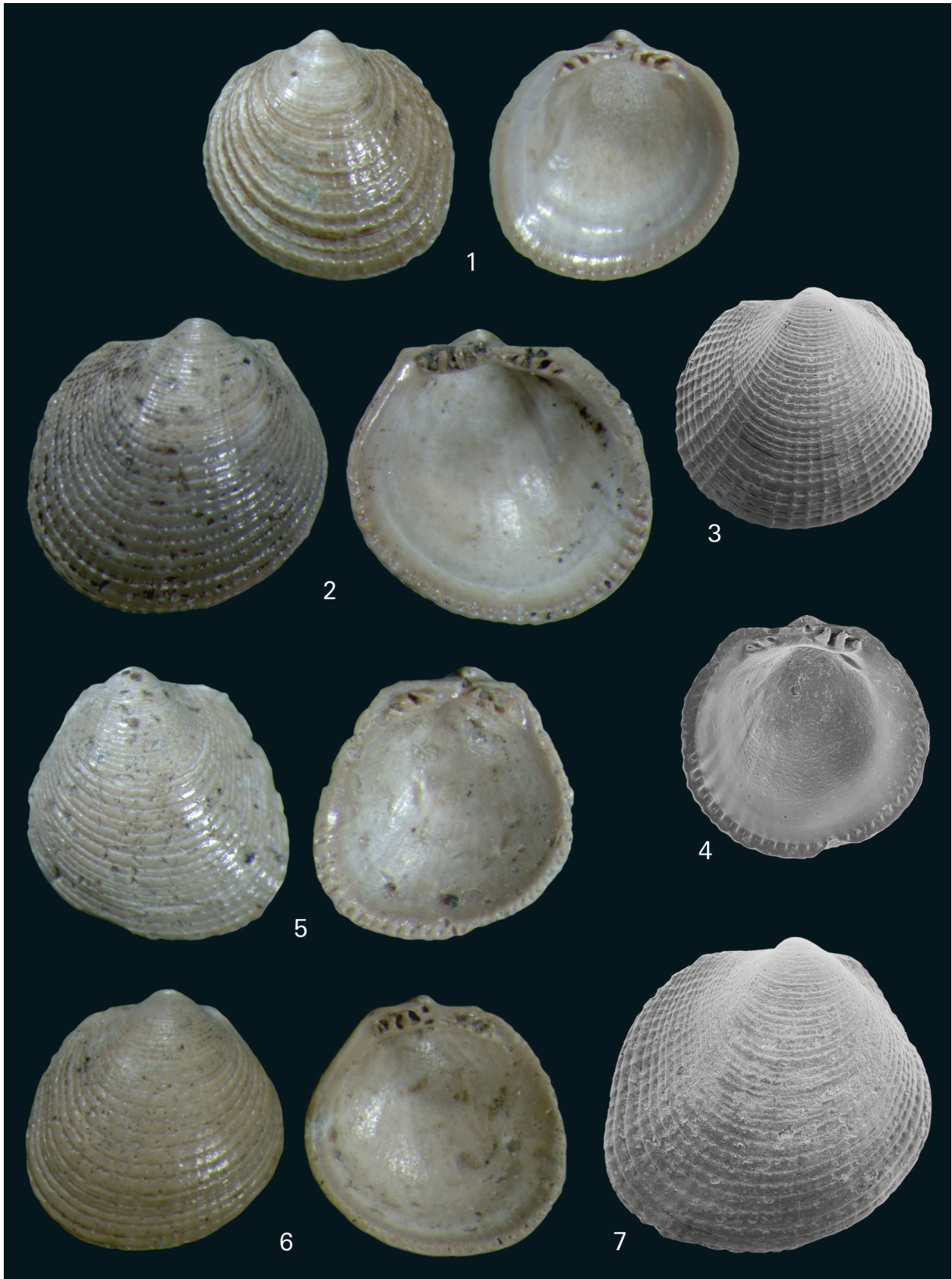
Locus typicus: Atzendorf N Stassfurth: former gravel pit Marbeschacht SW of Atzendorf at road to Löderburg (excavation IV, 2009), federal state of Sachsen-Anhalt, Germany.

Stratum typicum: Grey glauconitic marly sands of Silberberg Formation (Latdorf beds); Late Eocene (Priabonian) or Earliest Rupelian = Latdorfian of the regional stratigraphy (nannoplankton zone NP 21).

Derivatio nominis: After the stratigraphic occurrence.

Other material examined (ca. 200 specimens, SMF): Lower Rhine region: mineshaft Sophia Jacoba 6 near Hückelhoven; Westfalen: Bünde (Doberg-Böseberg); Sachsen-Anhalt: Atzendorf (excavations 2009), Latdorf (borehole 2012); Belgium: Grimmerten.

Description: Small, oval-trapezoidal, weakly postero-ventrally elongated, strongly inflated; anterior part of shell very narrow and steeply descending from the convex central part of shell to the anterior margin; anterior margin usually convex, rarely straight or slightly concave, obliquely descending, dorsal and posterior margins forming distinct angle; exterior usually with coarse cancellation of broad concentric ridges and ca. 33–35 irregularly developed widely spaced radial riblets which are stronger on anterior and posterior parts of shell; hinge with



3 strong anterior and 3–4 posterior teeth; ligamental area very low, ligamental pit minute, elongated triangular, narrow; interior margin irregularly crenulated with about 25–35 denticles which are more distinctly developed in

the anterior and posterior parts of the margin and always form faint ridges radiating into the interior of shell.

There is some variability as to the strength of the hinge line which is rather bold in most of the Latdorf specimens

but much weaker in specimens from Atzendorf. Also the crenulation of the inner margin is very variable, usually it is strong but in some specimens it is weak and nearly absent ventrally. Also the sculpture, especially the concentric ridges, is rather coarse in Latdorf specimens but weaker in material from Atzendorf or Bünde.

Measurements: Holotype: H = 2.6 mm, L = 2.6 mm, C = 0.9 mm; H_{max} = 3.2 mm, L_{max} = 3.3 mm, C_{max} = 1.0 mm (Atzendorf), H_{max} = 5.6 mm, L_{max} = 5.1 mm (Grimmertingen).

Remarks: Latdorfian populations hitherto have been regarded as identical with the Chattian *C. retifera* (Semper). But already Welle (1997: 16) remarked that the Latdorfian population differs from the Late Oligocene form in several shell characters. From *C. retifera retifera* (Semper 1861) it is distinct, as it has a more trapezoidal shape, a coarser sculpture with rather broad concentric ridges and a much smaller number of radial riblets, a smaller and narrower ligamental pit, and (in equal sized specimens) one hinge tooth less in each series. The Rupelian *C. retifera iniquidens* (Sandberger 1861) is much more similar, but has a larger and broader ligamental pit, a more flattened anterior part of the shell, and a much more finely cancellate exterior, with faint and dense radial riblets. From *Paracratis magdeburgensis* n. sp. it is easily distinguished by the smaller size, the less transverse elongated shape, the stronger convexity, and by the coarser and less regular sculpture.

Because the differences between *latdorfensis* and *iniquidens* are more clearly expressed than between *iniquidens* and *retifera*, *latdorfensis* is treated here as a distinct species rather than as a further subspecies of *retifera*. However, there is no doubt that *latdorfensis* is the earliest member of the *retifera*-lineage.

Regional distribution and stratigraphic range: Belgium: Grimmertingen Member of Sint-Huibrechts-Hern Formation; Nordrhein-Westfalen: Brandhorst Beds, Ratheim Formation; Sachsen-Anhalt: Silberberg Formation (Latdorf Beds). – Latdorfian.

***Cosmetopsis retifera iniquidens* (Sandberger 1861)**

Figs. 8–11

- 1861 *Limopsis iniquidens* Sandberger: pl. 29, fig. 5a–b; 1863: 347 (Welschberg, Mandel)
- 1864 *Limopsis tridens* Speyer: 309 (Waldböckelheim)
- ? 1907 *Limopsis retifera* – Ravn: 264, pl. 4, fig. 1a–b (Branden; Rupelian ?)
- 1973 *Limopsis (Pectunculina) retifera* – Neuffer: 21, pl. 3, figs. 1a–b, 2a–b (Welschberg) (non Semper 1861)
- 1983 *Limopsis (Pectunculina) retifera* – Müller: 27 (Zwenkau)
- 1995 *Pectunculina iniquidens* – Gürs: 204
- 1998 *Limopsis (Pectunculina) cf. iniquidens* – Berndt & Welle: 9 (Schacht Rheinberg; Walsum-Schi.)

- ? 1998 *Limopsis (Pectunculina) cf. iniquidens* – Welle: 143 (Amsdorf) (non Sandberger)
- 1999 *Limopsis (Pectunculina) iniquidens* – Welle et al.: 17 (Cospuden)
- 2003 *Limopsis (Pectunculina) iniquidens* – Welle & Nagel: 43 partim, pl. 2, figs. 15–16, 17 (Magdeburg) (non figs. 13–14 = *muelleri* n. sp., fig. 18 = *magdeburgensis* n. sp.)

Type material: Already Schöndorf (1907) was not able to trace original specimens of Sandberger. The species was described after material from the collection of H.C. Weinkauff which later had become part of the Bavarian Palaeontological and Geological State Collection at Munich (Bayerische Staatssammlung für Geologie und Paläontologie München). There it was destroyed during World War II. Even Neuffer (1973) and Gürs (1995) who both generally searched for type material did not mention any types. Because of the confused taxonomy and for sake of stability of nomenclature, a neotype needs to be established.

Neotype (left valve): SMF 342613, coll. O. Boettger 1880, H = 3.1 mm, L = 3.1 mm, C = 1.0 mm; paraneotypes SMF 342614/1, 342615/1, 342616/25, all from same lot as the neotype.

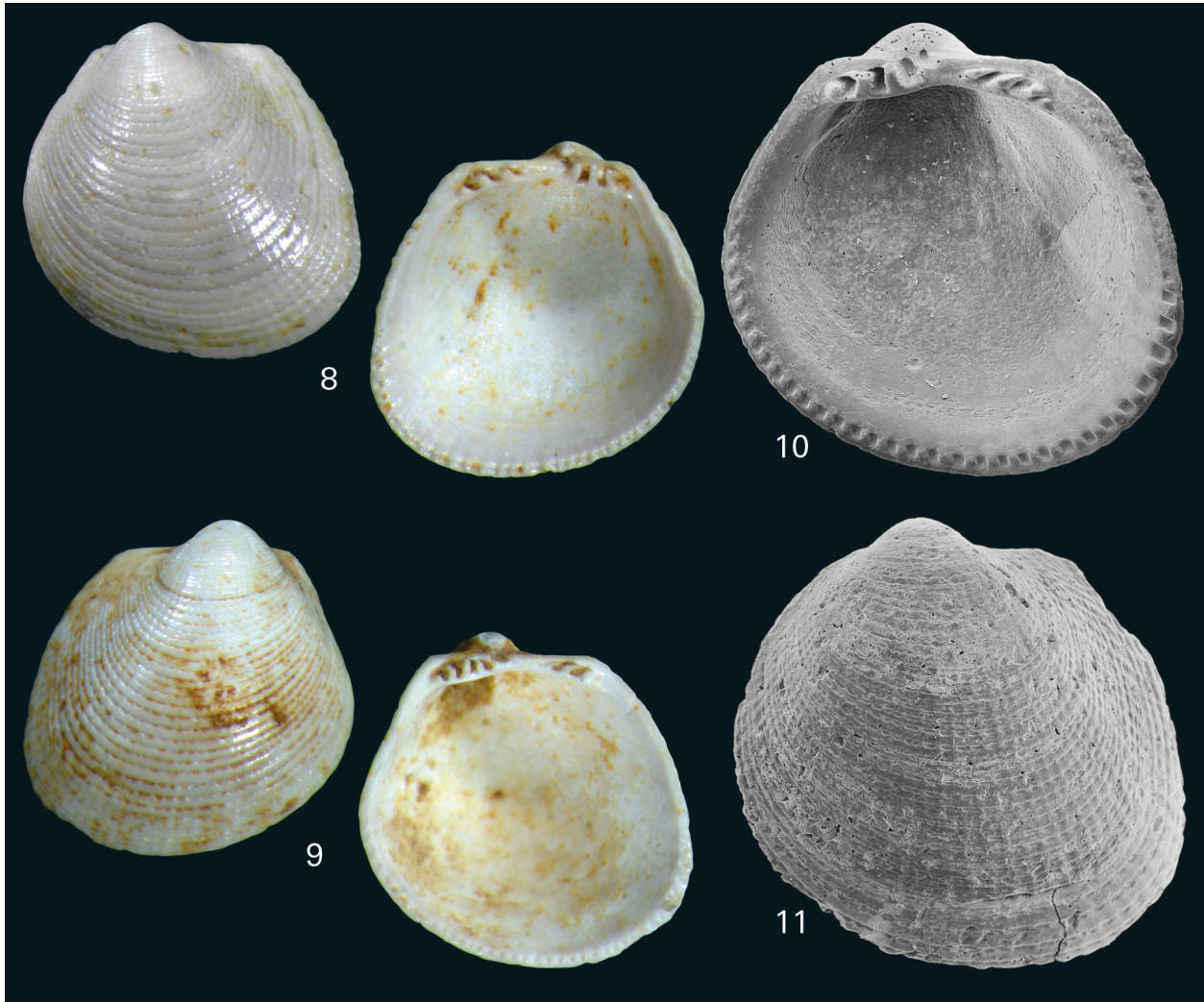
Locus typicus: Welschberg near Waldböckelheim, SW of Bad Kreuznach, federal state of Rheinland-Pfalz, Germany.

Stratum typicum: Marine sands of the Alzey Formation; Rupelian.

Other material examined (ca. 100 specimens, SMF): Lower Rhine region: mineshaft Walsum; Sachsen-Anhalt: Magdeburg; Mainz Basin: Bretzenheim, Weinheim, Weinheim (Trift), Weinheim (above Würzmühle), Waldböckelheim, Waldböckelheim (Welschberg).

Diagnostic characters: Small (H_{max} = 3.1 mm, L_{max} = 3.1 mm, C_{max} = 1.1 mm at type locality; specimens from Weinheim reach H and L of 4 mm); suboval, weakly postero-ventrally elongated, anterior margin weakly convex or straight; exterior with well developed fine cancellate sculpture of about 40 radial riblets and dense concentric ridges, radial threads visible over whole shell; hinge usually with 3 teeth in both series, rarely 4 teeth in the anterior series; ligamental area nearly invisible, ligamental pit short, not well demarcated; ventral margin always distinctly crenulated with ca. 30–40 denticles.

Remarks: There has been long controversy about the synonymy of this Rupelian species with *Limopsis retifera* Semper 1861, described from the Late Oligocene Kassel and Sternberg Formations, and about priority of the names. Koenen (1868) was the first to state explicitly the identity of the two taxa and name it *retifera*. This was followed by most later authors. Gürs (1995) believed



Figs. 8–11. *Cosmetopsis retifera iniquidens* (Sandberger 1861). Germany (Mainz Basin, Rheinland-Pfalz): Waldböckelheim (Welschberg); Alzey Formation, Rupelian: Fig. 8 – left valve (neotype SMF 342613, coll. O. Boettger), H = 3.1 mm, $\times 15$; Fig. 9 – right valve (paraneotype SMF 342614, coll. O. Boettger), H = 3.1 mm, $\times 15$; Fig. 10 – right valve (paraneotype SMF 342615, coll. O. Boettger), H = 2.5 mm, $\times 25$; Fig. 11 – left valve (SMF 342618, coll. R. Janssen), H = 2.5 mm, $\times 25$.

Abb. 8–11. *Cosmetopsis retifera iniquidens* (Sandberger 1861). Deutschland (Mainzer Becken, Rheinland-Pfalz): Waldböckelheim (Welschberg); Alzey-Formation, Rupelium: Abb. 8 – linke Klappe (Neotypus SMF 342613, coll. O. Boettger), H = 3,1 mm, $\times 15$; Abb. 9 – rechte Klappe (Paraneotypus SMF 342614, coll. O. Boettger), H = 3,1 mm, $\times 15$; Abb. 10 – rechte Klappe (Paraneotypus SMF 342615, coll. O. Boettger), H = 2,5 mm, $\times 25$; Abb. 11 – linke Klappe (SMF 342618, coll. R. Janssen), H = 2,5 mm, $\times 25$.

both species to be separable, used again *iniquidens* for the Rupelian population, and stated that *retifera* Semper dates from 1862. Because the characters used by Gürs to separate both taxa were not accepted as useful by other authors (Welle et al. 1999 and later authors, see under *retifera*) *iniquidens* Sandberger was used because of assumed priority over *retifera*. However, whereas Gürs was right in stating that vol. 15 of the journal with Semper's paper appeared in 1862, he was in error when stating priority of Sandberger over Semper because he overlooked that Semper's paper had been published privately already in 1861. Priority of this publication over Sandberger is

proved even by Sandberger himself, who in the part of his work published in 1861 several times referred to Semper's paper, e.g. (: 321) he cited *Cardium kochi* Semper ("Palaeontol. Unters. I, S. 136 ff.") in the synonymy of *Cardium scobinula* "Merian". Therefore the priority of Semper 1861 can not be doubted.

C. iniquidens indeed is related to *C. retifera* but as a population it can be separated from *retifera* by a more trapezoidal shape, the usually more distinctly crenulated ventral margin, the nearly constant number of only 3 hinge teeth in each series (compared in specimens of same size), the better developed sculpture, a much steeper

descending anterior part of the shell, and the more inflated umbo. However, single specimens can be almost indistinguishable. Therefore, while there is no doubt that the two populations are morphologically and stratigraphically separable, the two can not be kept as separate on species level but are here regarded as subspecifically distinct and forming a lineage. For distinction from *C. glimmerodensis* n. sp. and *C. latdorfensis* n. sp. see the remarks given there.

Regional distribution and stratigraphic range: Nordrhein-Westfalen: Walsum Formation; Sachsen-Anhalt: Magdeburg Sand; Sachsen: Böhlen Beds; Mainz Basin (Rheinland-Pfalz): Alzey Formation. – Rupelian.

***Cosmetopsis retifera retifera* (Semper 1861)**

Figs. 12–17

- 1835 *Pectunculus pygmaeus* Münster: 439 (nomen nudum)
- 1837 *Pectunculus pygmaeus* – Goldfuss: 162, pl. 126, fig. 11a–c (Cassel) (non Philippi 1836)
- 1841 *Pectunculus minutus* – Philippi: 14 (non Philippi 1836)
- 1843 *Pectunculus minutus* – Philippi: 14, 48, 72
- 1849 *Pectunculus granulatus* – Boll: 217 (non Lamarck 1805)
- 1861 *Limopsis retifera* Semper: 150; 1862: 316 (Cassel, Sternberg)
- 1864 *Limopsis retifera* – Speyer: 308 (Söllingen)
- 1866 *Limopsis retifera* – Speyer: 44, pl. 3, fig. 6a–d (Göttertrup)
- 1868 *Limopsis retifera* – Koenen: 237 partim, pl. 28 fig. 1a–d, 1e (Söllingen) (non fig. 1f–i = *latdorfensis*)
- 1878 *Limopsis retifera* – Wiechmann: 143 (Sternberg)
- 1884 *Limopsis retifera* – Koenen in Speyer: pl. 19, fig. 9a–e (Hohenkirchen)
- ? 1907 *Limopsis retifera* – Ravn: 264, pl. 4, fig. 1a–b (Branden; Rupelian ?)
- 1942 *Limopsis retifera* – Heering: 33, pl. 4, figs. 5–7, 8 (Peel wells)
- 1952 *Limopsis retifera* – Görges: 16
- 1965 *Limopsis (Limarca) retifera* – Glibert & Van de Poel: 76 partim (not localities of “Anversien”)
- 1979 *Limopsis (Pectunculina) retifera* – Janssen: 30 partim, pl. 1, fig. 15 (Ahnetal) (non fig. 16 = *vonderhochti*)
- 1997 *Limopsis (Pectunculina) retifera* – Welle: 15 partim (Sophia Jacoba 8)
- 1998 *Limopsis (Pectunculina) retifera* – Moths et al.: 8, pl. 3, fig. 1a–b (Sternberg boulders)
- 2008 *Limopsis (Pectunculina) retifera* – Schnetler & Palm: 13, pl. 1, fig. 5a–b (Branden)

Type material: The collection of J.O. Semper, housed in the museum of Hamburg-Altona, was totally destroyed during World War II. Neither in the Geological Institute of the University of Hamburg (Institut für Geologie, Universität Hamburg), nor in other collections (Museum für Naturkunde Berlin, Palaeontological collections of the Bundesanstalt für Geowissenschaften und Rohstoffe at

Spandau, SMF) specimens from Semper could be traced (personal observation). The type material therefore is considered completely lost. Because of the confused taxonomy and in order to stabilize the nomenclature a neotype is established here.

Neotype (left valve): SMF 342619, coll. T. Schellmann ca. 1955–1965; H = 3.3 mm, L = 3.5 mm, C = 1.0 mm; paraneotypes: SMF 342620/27 coll. T. Schellmann ca. 1955–1965; SMF 342621/1, 342622/25 coll. R. Janssen 1973, all from type locality.

Locus typicus: Upper Ahne valley in the Habichtswald W of Kassel: excavation near top of the Brandkopf, federal state of Hessen, Germany.

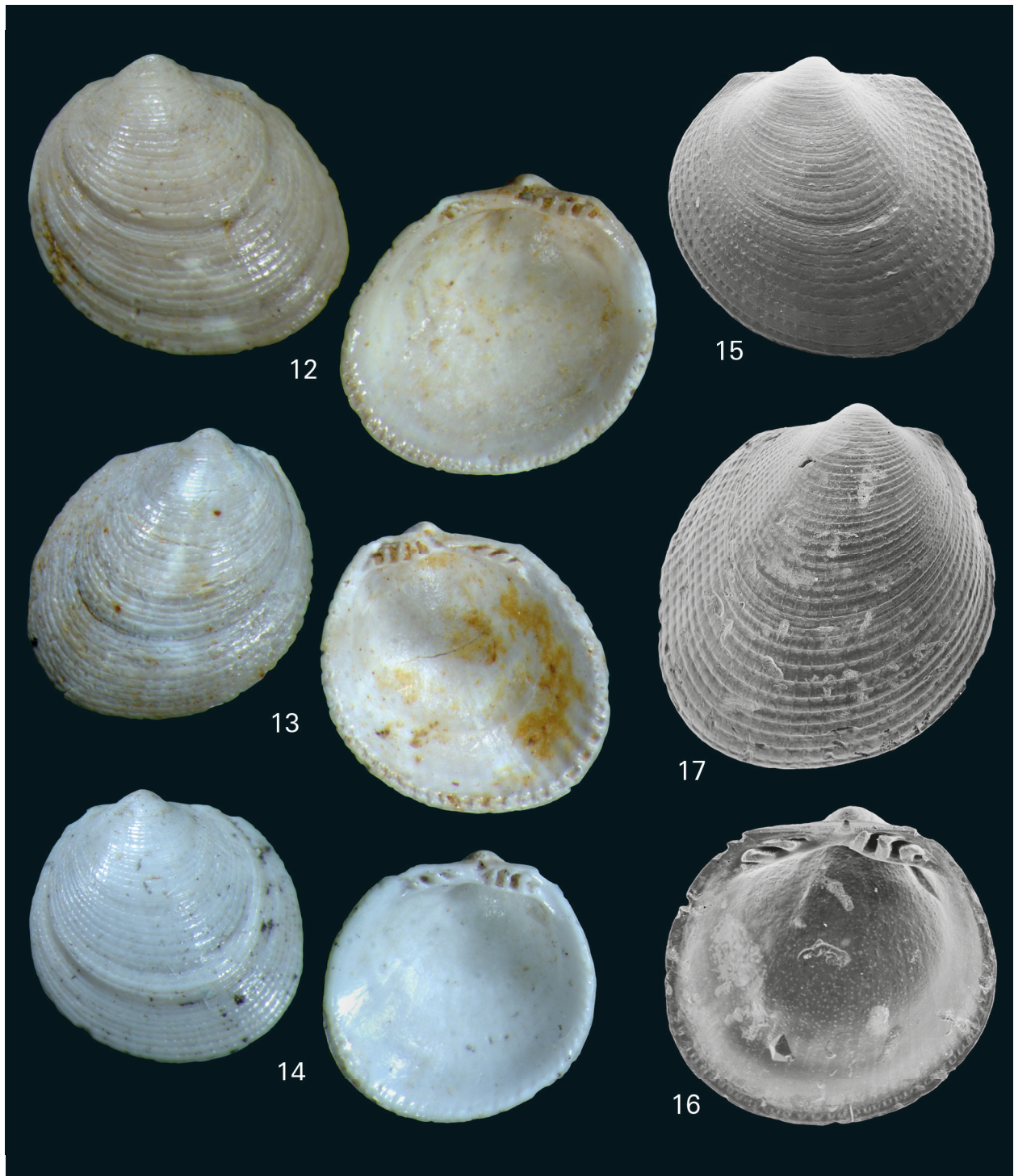
Stratum typicum: Yellow glauconitic marine sands of Kassel Formation; Early Eochattian (level A according to pectinid stratigraphy).

Other material examined (several thousand specimens, SMF): Denmark: Brejning, Kirstinebjerg Skov; Mecklenburg-Vorpommern: Sternberg Erratic Boulders; Lower Rhine region: Krefeld, Lintfort, Rumeln, and various other boreholes and mineshafts; Westfalen: Doberg near Bünde; Niedersachsen: Freden, Söllingen; Hessen: Ahnetal, Baunatal, Glimmerode, Harleshausen, Kassel, Kassel-Wilhelmshöhe, Niederkaufungen, Oberkaufungen, Zierenberg.

Diagnostic characters: Small ($H_{\max} = 5.0$ mm, $L_{\max} = 5.1$ mm, $C_{\max} = 1.5$ mm), suboval, moderately convex; anterior margin always evenly rounded; exterior with weakly cancellated sculpture of rather faint and ill defined concentric ridges and numerous weak radial riblets, riblets hardly visible on the middle part of shell but about 20 riblets are more apparent on the posterior part of shell; hinge with 4–5 teeth in the anterior series and 3–4 in the posterior series, anterior teeth strongly hooked; ligamental area very low, ligamental pit narrow, triangular, oblique; interior shell margin with about 38–46 crenulations, often forming a weak radial striation of the interior side of shell.

Remarks: The description of this species was based by Semper on specimens from “Cassel” because he referred to its common occurrence there whereas from the Sternberg boulders he had only one abraded specimen. “Cassel” was used in that time to denote a number of localities in the neighbourhood of Kassel. Therefore the neotype was selected from material of one of the best known localities near Kassel.

C. retifera is closely related to the Rupelian *iniquidens* Sandberger. It differs from that subspecies by its more rounded suboval shape, the number of hinge teeth (usually 4/4 in contrast to 3/3), the much weaker reticulated sculpture, the dense crenulation of the interior margin, and the more flattened anterior part of the shell. For dis-



Figs. 12–17. *Cosmetopsis retifera retifera* (Semper 1861). Germany (Hessen): Ahnetal; Kassel Formation, Eochattian A.: Fig. 12 – left valve (neotype SMF 342619, coll. T. Schellmann), H = 3.3 mm, $\times 15$; Fig. 13 – right valve (paraneotype SMF 342621, coll. R. Janssen), H = 3.2 mm, $\times 15$. Germany (Hessen): Glimmerode; Kassel Formation, Eochattian A.; coll. T. Schellmann: Fig. 14 – left valve (SMF 342623), H = 3.0 mm, $\times 15$; Fig. 15 – left valve (SMF 342624), H = 2.0 mm, $\times 25$; Fig. 16 – left valve (SMF 342625), H = 2.1 mm, $\times 25$; Fig. 17 – right valve (SMF 342626), H = 3.0 mm, $\times 20$.

Abb. 12–17. *Cosmetopsis retifera retifera* (Semper 1861). Deutschland (Hessen): Ahnetal; Kassel-Formation, Eochattium A.: Abb. 12 – linke Klappe (Neotypus SMF 342619, coll. T. Schellmann), H = 3,3 mm, $\times 15$; Abb. 13 – rechte Klappe (Paraneotypus SMF 342621, coll. R. Janssen), H = 3,2 mm, $\times 15$. Deutschland (Hessen): Glimmerode; Kassel-Formation, Eochattium A.; coll. T. Schellmann: Abb. 14 – linke Klappe (SMF 342623), H = 3,0 mm, $\times 15$; Abb. 15 – linke Klappe (SMF 342624), H = 2,0 mm, $\times 25$; Abb. 16 – linke Klappe (SMF 342625), H = 2,1 mm, $\times 25$; Abb. 17 – rechte Klappe (SMF 342626), H = 3,0 mm, $\times 20$.

inction from the other species discussed here see there. There are populations from the basal Chattian (Söllingen, and Branden Clay of Denmark) which are intermediate between *iniquidens* and typical *retifera* in that they often have a coarser concentric ridging, have often only 3/3 hinge teeth and in that some larger specimens can be of a more subquadrate shape with rather strong crenulations on the internal margin (as the specimen figured by Koenen 1868: pl. 28, fig. 1a, d, e). However, the whole population, e.g. from Söllingen, is more close to *retifera* and most specimens are typical *retifera* with a subcircular shape and convex anterior margin. Koenen's (1868) records from the Rupel Clay Formation very probably refer to *C. mothsorum* n. sp.

Heering (1942) and Glibert & Van de Poel (1965: 76) suggested identity of the Miocene species usually misidentified as *Limopsis anomala* (Eichwald 1830) with *retifera*. However, as pointed out by Glibert & Van de Poel (1965: 73) and R. Janssen (1979: 32) *Limopsis anomala*, described from the Badenian Miocene of the Paratethys can be clearly separated from the species of the Northern Miocene (compare also Friedberg 1933: pl. 1, figs. 16–19; topotypes). Therefore at this occasion some remarks on the Northern Miocene species may be given: The misidentified North Sea Basin species was already described as *Trigonocoelia decussata* by Nyst & Westendorp (1839: 405, pl. 2, fig. 16a–c) from Anvers (= Antwerp) and redescribed by Nyst (1845: 245, pl. 7 [= 18], fig. 7a–d). Kautsky (1925: 20) and following him also Glibert (1945: 49, pl. 2, fig. 3) cited *decussata* in the synonymy of the Miocene species which they named *minuta* (Philippi 1836), a however unrelated Recent species from the Mediterranean Sea. Ijspeert (1942: 59) identified it as *anomala* (Eichwald 1830), citing *decussata* as well as *minuta* (Philippi 1836) as synonyms. She was followed then by most later authors dealing with this North Sea Basin species. But Janssen (1984: 46) and following him Wienrich (1999) and Schnetler (2005) again doubted this identification yet did not suggest a proper name for this species. Although the taxon *decussata* Nyst & Westendorp was never discussed again in recent literature, the original description and figures leave no doubt that this name must be applied to that common species of the North Sea Basin Miocene which probably belongs to the genus *Aspalima* Iredale.

There is a Japanese species *Nipponolimopsis decussata* (A. Adams 1862) which would become an invalid secondary homonym if both taxa are grouped together in *Limopsis* (as preferred by authors working on Recent Limopsidae, see introduction to the systematic part). In this case that species has to be named by its junior synonym *Limopsis nipponica* Yokoyama 1922.

According to Glibert & Van de Poel (1965) both, the *Limopsis anomala* species group and *retifera* belong to *Limarca* Tate 1886 for which *Cosmetopsis* Rovereto 1898 was regarded as synonym. Later Glibert & Van de Poel (1970: 177) corrected their view and used *Cosmetopsis* as a subgenus. However, the genus *Aspalima* seems to be a better placement for the Miocene species.

Regional distribution and stratigraphic range: Denmark: Branden Member and Brejning Clay Member of Vejle Fjord Formation; Mecklenburg-Vorpommern: Sternberg Erratic Boulders; Nordrhein-Westfalen: Grafenberg Formation, Doberg Beds; Niedersachsen: marly sands of Freden, glauconitic marls of Söllingen; Hessen: Kassel Formation. – Chattian.

***Cosmetopsis glimmerodensis* n. sp.**

Figs. 18–24

1979 *Limopsis* (*Pectunculina*) *retifera* – Janssen: 30 partim (non Semper 1861)

Type material: Holotype (right valve): SMF 342627, coll. T. Schellmann ca. 1959–1966; paratypes SMF 342828/1, 342629/1, 342630/1, 342631/1, 342632/50 coll. T. Schellmann, RGM.1008160/10 ex coll. T. Schellmann, coll. ISL/6 ex coll. T. Schellmann, all from stratum typicum; SMF 342633/1, 342634/1, 342635/18 coll. R. Janssen 1972 (all bed no. 8), SMF 342636/4 coll. R. Janssen 1972 (bed no. 4).

Locus typicus: Former open cast-mining Höllkopf near Glimmerode S of Hessisch-Lichtenau, federal state of Hessen, Germany.

Stratum typicum: Grey marly sands of Kassel Formation; Early Eochattian (A).

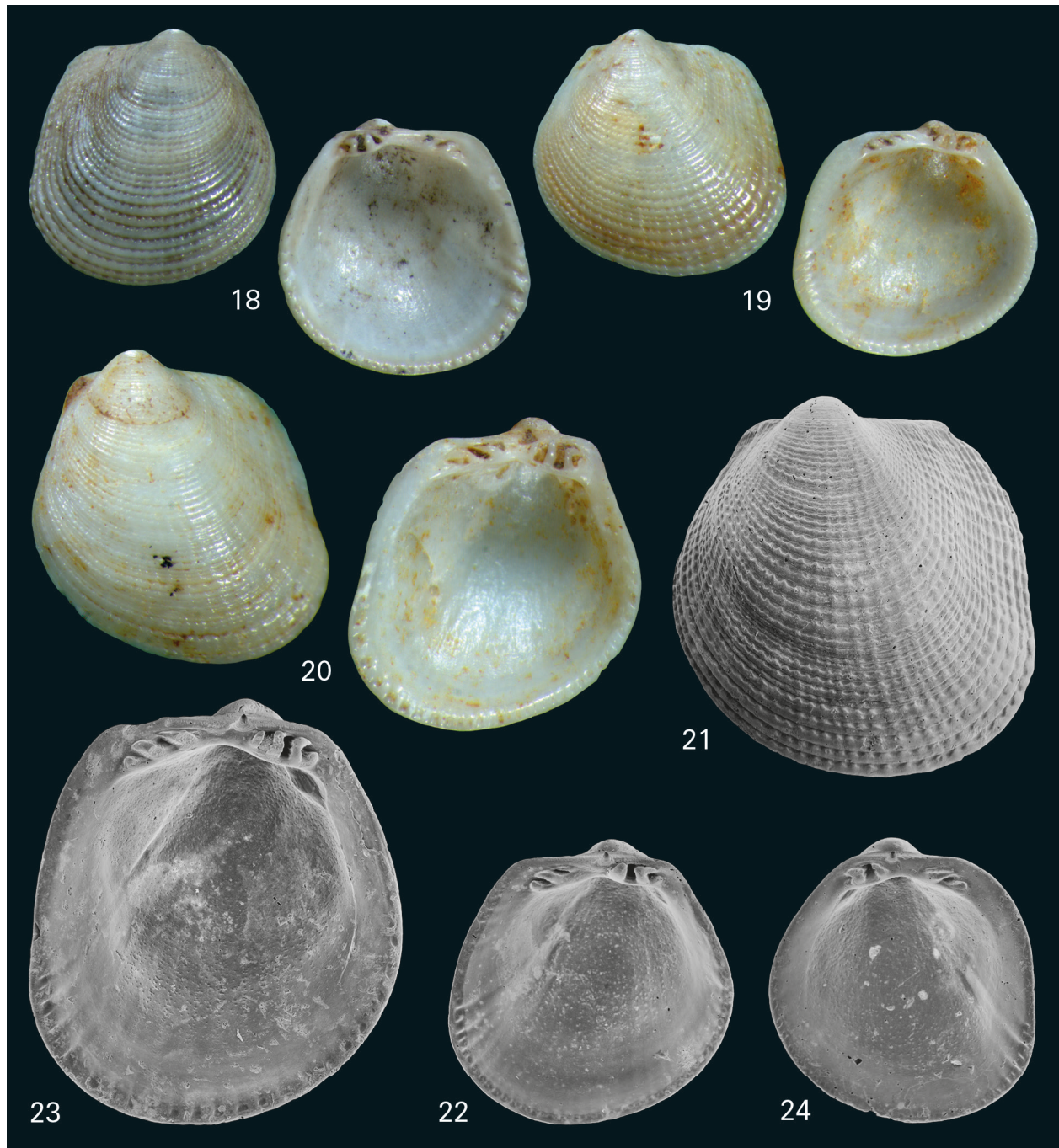
Derivatio nominis: After the type locality.

Other material examined (several hundred specimens, SMF): Hessen: Glimmerode.

Description: Small, strongly inflated, rounded trapezoidal, slightly postero-ventrally elongate. Anterior margin always straight or concave, dorsal and posterior margins forming a well marked angle; anterior third of the shell very steeply sloping to the anterior margin; exterior distinctly decussated by about 50 dense radial riblets and concentric threads; hinge line rather bold, with usually 3 teeth in the anterior series, sometimes with a very minute fourth teeth immediately in front of the ligamental pit, the two central teeth strongly hooked, posterior series with 3–4 slightly oblique teeth; ligamental area very low, ligamental pit very small, short, broadly triangular; interior margin strongly crenulated with about 30–33 denticulations, posterior margin with 3–4 stronger teeth, radiating into the interior of shell.

Measurements: Holotype: H = 2.7 mm, L = 2.9 mm, C = 0.8 mm; H_{max} = 3.8 mm, L_{max} = 4.0 mm, C_{max} = 1.2 mm.

Remarks: The species is distinct from the similar *C. retifera iniquidens*, as it is more trapezoidal in shape, has a stronger reticulated sculpture with higher number of radial riblets, a straight or concave anterior margin, a



Figs. 18–24. *Cosmetopsis glimmerodensis* n. sp. Germany (Hessen): Glimmerode; Kassel Formation, Eochattian A: Fig. 18 – right valve (holotype SMF 342627, coll. T. Schellmann), H = 2.7 mm, $\times 15$; Fig. 19 – left valve (paratype SMF 342633, coll. R. Janssen, bed no. 8), H = 2.6 mm, $\times 15$; Fig. 20 – left valve (paratype SMF 342634, coll. R. Janssen, bed no. 8), H = 3.3 mm, $\times 15$; Fig. 21 – left valve (paratype SMF 342628, coll. T. Schellmann), H = 2.4 mm, $\times 25$; Fig. 22 – left valve (paratype SMF 342629, coll. T. Schellmann), H = 1.8 mm, $\times 25$; Fig. 23 – left valve (paratype SMF 342630, coll. T. Schellmann), H = 2.7 mm, $\times 25$; Fig. 24 – right valve (paratype SMF 342631, coll. T. Schellmann), H = 1.8 mm, $\times 25$.

Abb. 18–24. *Cosmetopsis glimmerodensis* n. sp. Deutschland (Hessen): Glimmerode; Kassel-Formation, Eochattium A: Abb. 18 – rechte Klappe (Holotypus SMF 342627, coll. T. Schellmann), H = 2,7 mm, $\times 15$; Abb. 19 – linke Klappe (Paratypus SMF 342633, coll. R. Janssen, Schi. 8), H = 2,6 mm, $\times 15$; Abb. 20 – linke Klappe (Paratypus SMF 342634, coll. R. Janssen, Schi. 8), H = 3,3 mm, $\times 15$; Abb. 21 – linke Klappe (Paratypus SMF 342628, coll. T. Schellmann), H = 2,4 mm, $\times 25$; Abb. 22 – linke Klappe (Paratypus SMF 342629, coll. T. Schellmann), H = 1,8 mm, $\times 25$; Abb. 23 – linke Klappe (Paratypus SMF 342630, coll. T. Schellmann), H = 2,7 mm, $\times 25$; Abb. 24 – rechte Klappe (Paratypus SMF 342631, coll. T. Schellmann), H = 1,8 mm, $\times 25$.

more expressed angle between dorsal and posterior margin, and a stronger hinge line. From *C. retifera retifera* with which it occurs together at Glimmerode it can be separated by its more subquadrate-trapezoidal shape, the stronger inflation, the coarser and distinctly reticulated and granulated sculpture, and the very steep descent of the anterior part of the shell to the anterior margin. From *C. latdorfensis* it is separated by its finer granulated sculpture, the narrower concentric ridges, and the steeper slope of the anterior part of the shell.

From *Paracratis magdeburgensis* n. sp. it is distinguished by much stronger convexity of the shell, the rounded trapezoidal but not obliquely elongated shell, the less regularly decussated exterior, and the lack of well developed internal radial striation.

This species obviously is confined to the shallow water sediments as exposed at Glimmerode and has not yet been found elsewhere. Probably it was byssally fixed to hard substrate.

Regional distribution and stratigraphic range: Hessen: Kassel Formation. – Early Eochattian (A)

***Cosmetopsis mothsorum* n. sp.**

Figs. 25–28

- 1868 *Limopsis retifera* – Koenen: 237 partim (non pl. 28, fig. 1a–e = *retifera*, fig. 1f–i = *latdorfensis*) (non Semper 1861)
2000 *Pectunculina retifera* – Moths: 44, pl. 16, fig. 2a–b (MalliB) (non Semper)

Type material: Holotype (left valve): SMF 342637, coll. H.G. Moths; paratypes SMF 342638/1, 342639/1, 342640/1, 342641/21, 342643/1 (specimen figured by Moths 2000: fig. 2a–b), RGM.1008161/3, coll. ISL/2, all from type locality ex coll. H.G. Moths.

Locus typicus: Former brickyard at the Wanzeberg near MalliB, N of Dömitz, federal state of Mecklenburg-Vorpommern, Germany.

Stratum typicum: Rupel Clay Formation; Rupelian.

Derivatio nominis: After Herbert and Ellenore Moths (Geesthacht) who donated their rich collection from MalliB to SMF.

Other material examined (ca. 80 specimens, SMF): Mecklenburg-Vorpommern: MalliB; Brandenburg: Hermsdorf near Berlin (1 valve; coll. von Koenen, Geowissenschaftliches Museum, Universität Göttingen).

Description: Very small, suboval, slightly postero-ventrally elongated, tiny, thin shelled, very weakly inflated; anterior margin distinctly convex; exterior with weak sculpture consisting of obscure concentric ridges crossed by ca. 20–35 much more distinct, rather widely spaced,

rounded undulating ribs; hinge line delicate and narrow, right valve with usually 2, sometimes up to 4 very small and curved teeth in the anterior series and 2 oblique lamellar teeth in the posterior series, left valve with 3 teeth in each series; ligamental area very low, nearly invisible, ligamental pit very minute, oval; interior margin extremely weakly crenulated by about 30–40 very faint denticles which form fine riblets radiating far into the interior of the shells.

Measurements: Holotype: H = 2.1 mm, L = 2.1 mm, C = 0.5 mm; H_{max} = 2.1 mm, L_{max} = 2.1 mm, C_{max} = 0.5 mm.

Remarks: This new species is distinguished from all other species discussed herein by their tiny and very weakly inflated shells, the differing number of hinge teeth in the right valve (compared to equally sized specimens of other species), and the well developed rounded radial ribs on the exterior side. By their peculiar characters *C. mothsorum* stands apart and can not be compared to any other species of the North Sea Basin.

The tiny and fragile shells and minute size probably are due to the clay facies in which this species is found. Nevertheless its characters are so distinct that they can not simply be interpreted as caused by facies and falling into the variability of one of the other species (e.g. *iniquidens* or *retifera*). Of the few specimens mentioned by Koenen (1868) from Rupel Clay localities, only one right valve from Hermsdorf could be traced. This valve is very badly preserved but could well belong to the new species.

Regional distribution and stratigraphic range: Mecklenburg-Vorpommern and Brandenburg (?): Rupel Clay. – Rupelian.

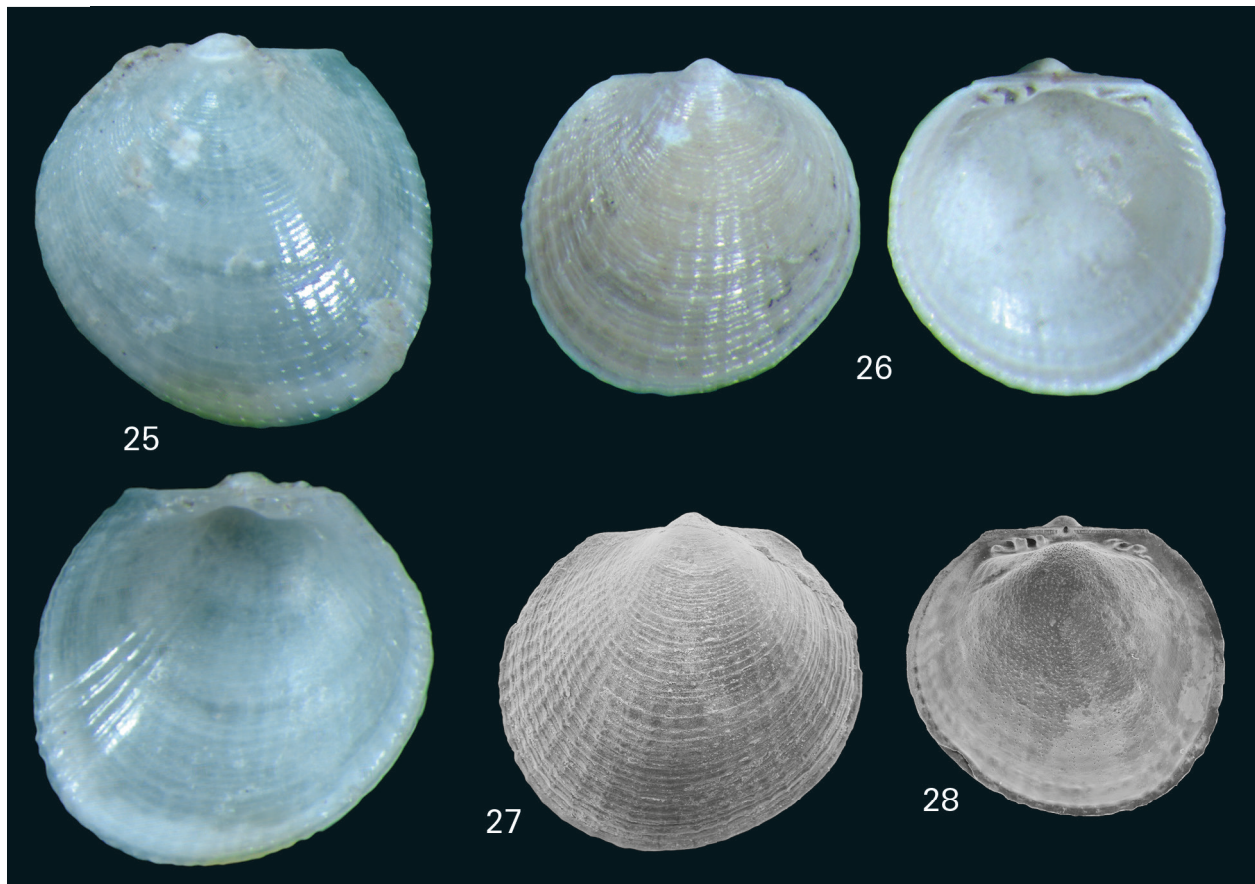
***Limopsis* Sassi 1827**

Type species (original designation): *Arca aurita* Brocchi 1814 (Pliocene; Italy)

***Limopsis parva* (Harder 1913)**

Figs. 29, 30

- 1843 *Pectunculus granulatus* – Philippi: 48, 72 partim (non Lamarck 1805)
1843 *Pectunculus auritus* – Philippi: 47, 72 (non Brocchi 1814)
1849 *Pectunculus auritus* – Boll: 217 (Sternberg) (non Brocchi)
1861 *Limopsis Goldfussi* – Semper: 314 (Sternberg) (non Nyst 1845)
1878 *Limopsis Goldfussi* – Wiechmann: 142 (Sternberg) (non Nyst)
1913 *Limopsis aurita* var. *parva* Harder: 53, 122, pl. 3, figs. 19a–c, 20a–b, c–d, 21a–b, c–d (Aarhus)



Figs. 25–28. *Cosmetopsis mothsorum* n. sp. Germany (Mecklenburg-Vorpommern): Malliö; Rupel Clay, Rupelian; coll. H.G. Moths: Fig. 25 – left valve (holotype SMF 342637), $H = 2.1$ mm, $\times 25$; Fig. 26 – right valve (paratype SMF 342638), $H = 1.8$ mm, $\times 25$; Fig. 27 – right valve (paratype SMF 342639), $H = 1.6$ mm, $\times 25$; Fig. 28 – right valve (paratype SMF 342640), $H = 1.8$ mm, $\times 25$.

Abb. 25–28. *Cosmetopsis mothsorum* n. sp. Deutschland (Mecklenburg-Vorpommern): Malliö; Rupelton, Rupelium; coll. H.G. Moths: Abb. 25 – linke Klappe (Holotypus SMF 342637), $H = 2,1$ mm, $\times 25$; Abb. 26 – rechte Klappe (Paratypus SMF 342638), $H = 1,8$ mm, $\times 25$; Abb. 27 – rechte Klappe (Paratypus SMF 342639), $H = 1,6$ mm, $\times 25$; Abb. 28 – rechte Klappe (Paratypus SMF 342640), $H = 1,8$ mm, $\times 25$.

- 1941 *Limopsis Goldfussi* – Görges: 160 (Rumeln) (non Nyst)
 1942 *Limopsis aurita* – Heering: 30, pl. 4, figs. 9–10, 11–12, 13–14, 15–16 (Peel wells) (non Brocchi)
 1965 *Limopsis* (s.s.) *aurita* cf. *woodi* – Glibert & Van de Poel: 69 (Krefeld) (non Mayer 1868)
 1965 *Limopsis* (s.s. ?) *goldfussi* – Glibert & Van de Poel: 70 partim (loc. Sternberg) (non Nyst)
 1979 *Limopsis* (*Limopsis*) *aurita* – R. Janssen: 29 (non Brocchi)
 1997 *Limopsis* (*Limopsis*) *aurita* – Welle: 14, pl. 1, fig. 10a–b (SJ 8), 11 (Rheinberg) (non Brocchi)
 1998 *Limopsis* (*Limopsis*) *aurita* – Moths et al.: 8, pl. 3, fig. 2a–b (Sternberg boulders) (non Brocchi)
 2008 *Limopsis* (*Limopsis*) *aurita* – Schnetler & Palm: 12, pl. 1, fig. 6a–b (Branden) (non Brocchi)

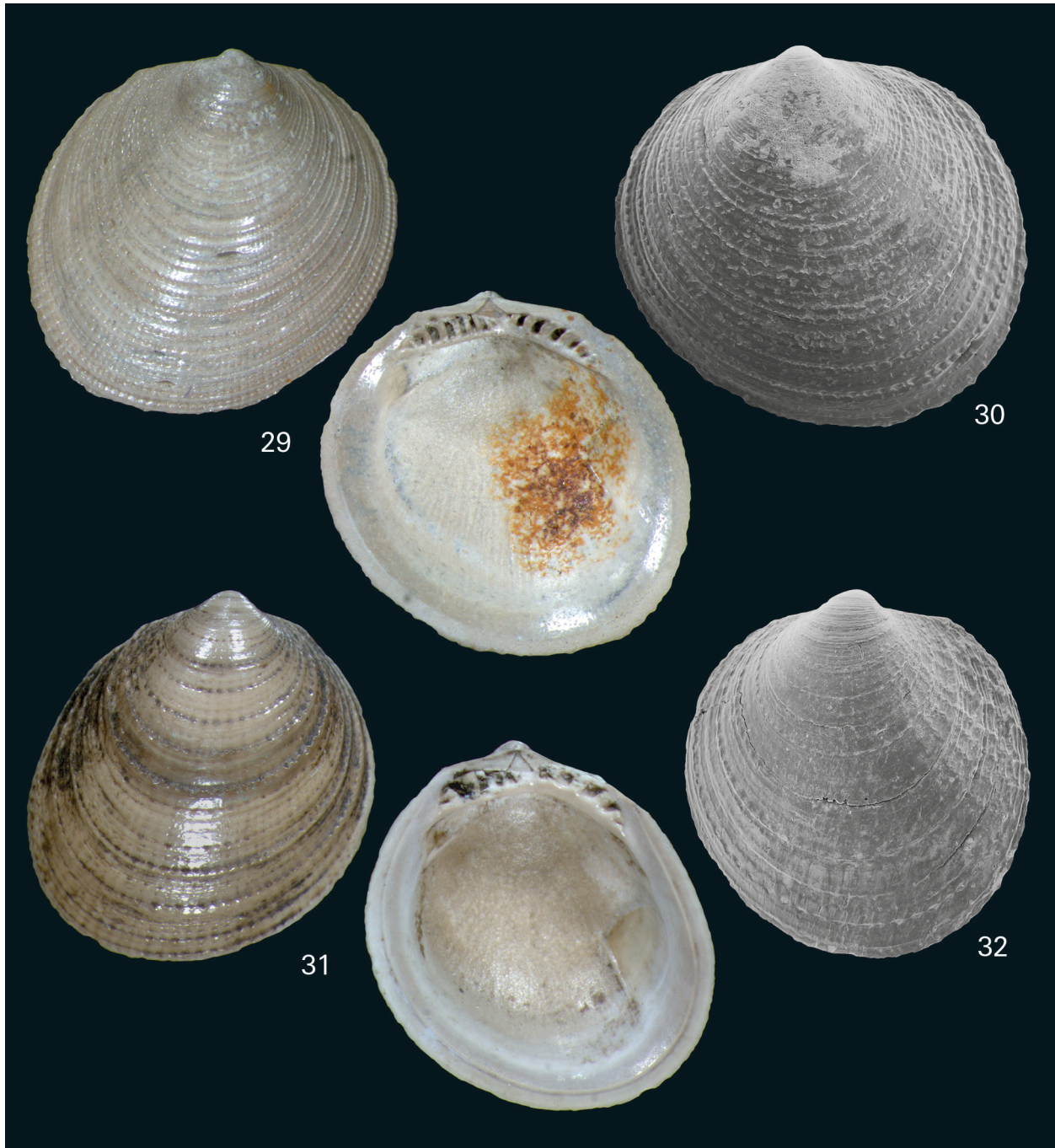
Type material: Syntypes in coll. Harder (Geological Survey of Denmark, Copenhagen; not seen).

Locus typicus: Railway excavation near railway station of Aarhus, Jutland, Denmark.

Stratum typicum: Branden Clay s. l. = Brejning Clay Member, Vejle Fjord Formation; Late Eochattian (B).

Material examined (many hundred specimens, SMF): Denmark: Brejning, Jensgard, Kirstinebjerg Skov, Nørre Vissing, Skanderborg, Skovbo; Mecklenburg-Vorpommern: Sternberg Erratic Boulders; Lower Rhine region: Traar, Krefeld-Linn, various other boreholes near Krefeld, mineshafts Rumeln, Lintfort, Hoerstgen; Niedersachsen: Freden.

Diagnostic characters: Medium sized ($H_{\max} = 7.8$ mm, $L_{\max} = 7.8$ mm, $C_{\max} = 1.2$ mm [Sternberg]; $H_{\max} = 10.5$ mm, $L_{\max} = 9.5$ mm, $C_{\max} = 2.6$ mm [Krefeld-Linn]); suboval, only slightly postero-ventrally elongated, flat to mod-



Figs. 29, 30. *Limopsis parva* Harder 1913. Germany (Lower Rhine region, Nordrhein-Westfalen): Krefeld-Linn (borehole, 12.5–22m); Grafenberg Formation, Eochattian B; coll. W. Lappann: Fig. 29 – right valve (SMF 342644), H = 7.2 mm, $\times 8$; Fig. 30 – left valve (SMF 342645), H = 3.0 mm, $\times 20$.

Figs. 31, 32. *Limopsis aurita* (Brocchi 1814). Germany (Niedersachsen): Twistringen; Twistringen Beds, Reinbekian, Middle Miocene; coll. R. Janssen. Fig. 31 – right valve (SMF 342646), H = 7.3 mm, $\times 8$; Fig. 32 – left valve (SMF 342647), H = 2.9 mm, $\times 20$.

Abb. 29, 30. *Limopsis parva* Harder 1913. Deutschland (Niederrhein, Nordrhein-Westfalen): Krefeld-Linn (Bohrung, 12.5–22m); Grafenberg-Formation, Eochattium B; coll. W. Lappann: Abb. 29 – rechte Klappe (SMF 342644), H = 7,2 mm, $\times 8$; Abb. 30 – linke Klappe (SMF 342645), H = 3,0 mm, $\times 20$.

Abb. 31, 32. *Limopsis aurita* (Brocchi 1814). Deutschland (Niedersachsen): Twistringen; Twistringen-Schichten, Reinbekium, Mittelmiozän; coll. R. Janssen. Abb. 31 – rechte Klappe (SMF 342646), H = 7,3 mm, $\times 8$; Abb. 32 – linke Klappe (SMF 342647), H = 2,9 mm, $\times 20$.

erately inflated; exterior with well defined but irregular concentric ridges and a very fine but distinct and dense radial striation, spaces between concentric ridges often pitted by the radial striation; broad hinge line, hinge with 6–9 teeth in the anterior series and 4–6 in the posterior series; well developed moderately high ligamental area, ligamental pit medium to large, rather broad, triangular and distinctly excavated; interior margin with broad and flat seam, smooth.

Remarks: Especially in the Sternberg Erratic Boulders (“Sternberger Gestein”) a particular variety occurs which is characterised by very flat and thick shells, with an almost circular or suboval shape and bold hinge line with rather strong teeth. This form occasionally also can be found among “normal” specimens in the Lower Rhine area. Probably they represent a variety of coarser grained sediments.

L. parva can be clearly distinguished from the Miocene to Recent *L. aurita* (Brocchi 1814) by the sculpture of the outer surface (see Figs. 31, 32 for comparison): *L. parva* always has a very fine and dense striation of radial ridglets, mainly visible in the interspaces between the well defined concentric ridges. In *aurita* the radial striation is much coarser and much more widely spaced; furthermore the Oligocene specimens are not as strongly inflated as the Miocene specimens which usually are distinctly postero-ventrally elongated, too. These differences are so considerable that it seems even impossible to suggest close phylogenetical linkage of these two species. Therefore *parva* is understood here as a species of its own.

Glibert & Van de Poel (1965) recorded the Late Oligocene form from Krefeld under the name of *L. cf. woodi* (Mayer 1868). However, *L. woodi* was described originally from the Late Burdigalium/Langhium of the Aquitan Basin (Saint-Jean-de-Marsacq) and most probably is an earlier name for *Limopsis dumasi* Cossmann & Peyrot 1913 and a synonym of *L. aurita* (Brocchi 1814).

R. Janssen (1979) discussed the identity of late Oligocene material and the relationships of *L. goldfussii* (Nyst 1845) and “*aurita*”. He believed “*aurita*” to be an offshoot of *L. goldfussi*. *L. parva* is undoubtedly very similar to *goldfussi* and therefore it could be speculated about a phylogenetic relationship to the Rupelian *goldfussii*. Both species share the general shape, weak to moderate convexity and especially the dense and fine radial striation between the lamellar ridges. However, characters like the curved hinge line, the development of distinct radial threads (observable in well preserved specimens) and the more or less developed nodulation of the interior margin separate *goldfussii* from *parva*. The sparse denticulation on the interior margin of *goldfussii* is, however, very obscure and often nearly invisible, especially in the mostly abraded specimens from Kleine Spouwen. If *goldfussii* would be linked to *parva* phylogenetically, it would be difficult to explain why *parva* does not appear in the Early Eochattian but makes its sudden appearance (together with a number of other mollusc species) only in

the Late Eochattian (B). Here, *goldfussii* is classified provisionally in the genus *Oblimopa* (see below). For further remarks see under *O. goldfussii*.

Regional distribution and stratigraphic range: Denmark: Branden Clay, Brejning Clay Member of Vejle Fjord Formation; Mecklenburg-Vorpommern: Sternberg Erratic Boulders; Nordrhein-Westfalen: Grafenberg Formation; Niedersachsen: marly sands of Freden. – Late Eochattian (B) and Neochattian.

Oblimopa Iredale 1939

Type species (original designation): *Oblimopa macgillivrayi* *acta-viva* Iredale 1939 = *Limopsis macgillivrayi* A. Adams 1863 (Recent; Australia, Japan)

Remarks: In this genus a number of Recent species is united which are characterised by oblique circular shape of thick shells, a reticulate sculpture of well developed concentric ribbles and often strong radial ribs, a curved hinge line, and a smooth or fluted crenulate interior margin. Oligocene species discussed here mainly share these characters but their sculpture is much weaker and the seam of the interior margin can be distinctly denticulated or noded. Therefore they are only tentatively placed in that genus instead in *Pectunculina* from which they are separated by their oval shape, the stronger curved hinge line, the much finer sculpture and the much weaker and less regular nodulation or denticulation of the interior margin.

Oblimopa (?) *costulata* (Goldfuss 1837)

Figs. 33, 34

- 1837 *Pectunculus granulatus* – Goldfuss: 162, pl. 126, fig. 12a–c (Osterweddingen) (non Lamarck 1805)
- 1837 *Pectunculus costulatus* Goldfuss: 163, pl. 126, fig. 13 (Osterweddingen)
- 1893 *Limopsis costulata* – Koenen: 1073, pl. 74, figs. 9a–b, 10a–c, 11a–c, 12a–c (all Lattorf)
- 1944 *Limopsis costulata* – Albrecht & Valk: 114 partim, pl. 24, figs. 945–946, 949–950 (wells and mineshafts in Dutch Limburg) (non figs. 943–944, 947–948 = *subscalaris* Orbigny)
- 1954 *Limopsis* (s.s.) *costulata* – Glibert & Heinzelin: 320 partim (non pl. 1, fig. 8a–b = *subscalaris* Orbigny)
- 1997 *Limopsis* (*Pectunculina*) *costulata* – Welle: 17 partim, pl. 2, fig. 1a–b (Var. 2) (Sophia Jacoba 8) (non fig. 2a–b = *subscalaris* Orbigny)
- ? 1998 *Limopsis* (*Pectunculina*) *costulata* – Berndt & Welle: 9, pl. 2, fig. 1a–b (Rheinberg) (non Goldfuss 1837?)
- 2008 *Limopsis costulata* – Müller: pl. 2, figs. 22a–b, 23a–b (Lattorf)
- 2012 *Limopsis* (*Pectunculina*) *costulata* – Marquet et al.: 26, pl. 8, fig. 3a–b, c–d (Grimmerten)

Figs. 33, 34. *Oblimopa* (?) *costulata* (Goldfuss 1837). Fig. 33 – Germany (Sachsen-Anhalt): Latdorf; Latdorf Beds, Latdorfian; left valve (SMF 342649), H = 9.0 mm, × 6; Fig. 34 – Germany (Sachsen-Anhalt): Latdorf (borehole, 17.53–17.7 m); Latdorf Beds, Latdorfian; right valve (SMF 342650, coll. R. Janssen), H = 2.8 mm, × 15.

Abb. 33, 34. *Oblimopa* (?) *costulata* (Goldfuss 1837). Abb. 33 – Deutschland (Sachsen-Anhalt): Latdorf; Latdorf-Schichten, Latdorfium; linke Klappe (SMF 342649), H = 9,0 mm, × 6; Abb. 34 – Deutschland (Sachsen-Anhalt): Latdorf (Bohrung, 17.53–17.7 m); Latdorf-Schichten, Latdorfium; rechte Klappe (SMF 342650, coll. R. Janssen), H = 2,8 mm, × 15.

Figs. 35, 36. *Oblimopa* (?) *goldfussii* (Nyst 1845). Fig. 35 – Belgium (Limburg province): Kleine Spouwen; Bilzen Formation: Berg Sand Member, Rupelian; right valve (SMF 342652), H = 8.0 mm, × 6; Fig. 36 – Germany (Mainz Basin, Rheinland-Pfalz): Weinheim; Alzey Formation, Rupelian; left valve (SMF 342654, coll. H. Neuenhaus), H = 14.7 mm, × 4.

Abb. 35, 36. *Oblimopa* (?) *goldfussii* (Nyst 1845). Abb. 35 – Belgien (Provinz Limburg): Kleine Spouwen; Bilzen-Formation: Berg-Sand-Member, Rupelium; rechte Klappe (SMF 342652), H = 8,0 mm, × 6; Abb. 36 – Deutschland (Mainzer Becken, Rheinland-Pfalz): Weinheim; Alzey-Formation, Rupelium; linke Klappe (SMF 342654, coll. H. Neuenhaus), H = 14,7 mm, × 4.

Figs. 37, 38. *Oblimopa* (?) *vonderhochti* (Schnetler in Schnetler & Beyer 1990). Fig. 37 – Germany (Hessen): Ahnetal; Kassel Formation, Eochattian A; right valve (SMF 251423, coll. R. Janssen), H = 8.9 mm, × 6; Fig. 38 – Germany (Hessen): Glimmerode; Kassel Formation, Eochattian A; left valve (SMF 342655, coll. T. Schellmann), H = 2.4 mm, × 15.

Abb. 37, 38. *Oblimopa* (?) *vonderhochti* (Schnetler in Schnetler & Beyer 1990). Abb. 37 – Deutschland (Hessen): Ahnetal; Kassel-Formation, Eochattium A; rechte Klappe (SMF 251423, coll. R. Janssen), H = 8,9 mm, × 6; Abb. 38 – Deutschland (Hessen): Glimmerode; Kassel-Formation, Eochattium A; left valve (SMF 342655, coll. T. Schellmann), H = 2,4 mm, × 15.

Type material: coll. Goldfuss (Goldfuss-Museum, Universität Bonn; not seen).

Locus typicus: Osterweddingen S of Magdeburg, Sachsen-Anhalt, Germany.

Stratum typicum: Silberberg Formation (Latdorf Beds); Late Eocene (Priabonian or Earliest Rupelian) = Latdorfian of the regional stratigraphy (nannoplankton zone NP 21).

Material examined (ca. 100 specimens, SMF): Belgium: Grimmertingen; Lower Rhine region: mineshaft Sophia Jacoba 6 near Hückelhoven; Westfalen: Bünde (Doberg-Böseberg), Brandhorst; Sachsen-Anhalt: Latdorf, Unseburg, Westeregeln, Nachterstedt.

Diagnostic characters: Medium to large sized ($H_{\max} = 13.7$ mm, $L_{\max} = 14.0$ mm, $C_{\max} = 3.9$ mm), suboval to moderately postero-ventrally elongated, moderately to strongly convex; exterior with distinct reticulate sculpture of dense concentric threads or riblets with distinct interspaces, crossed by numerous radial riblets, ca. 30 in juveniles, number rapidly increasing then by intercalation of secondary riblets, intercalation of secondary ribs starting at a size of ca. 2 mm, secondary riblets rapidly becoming equally strong as the primary riblets, radial riblets nearly of same strength as concentric riblets; hinge line usually curved, with up to 9 anterior and up to 12 posterior teeth; ligamental area well developed, moderately high, ligamental pit very broad, triangular; interior margin with broad seam, edge smooth but whole interior seam beset with ca. 40–50 usually distinct elongate denticles.

Remarks: Welle (1997) distinguished already two morphologically distinct forms which correspond to *costu-*

lata resp. to the distinct species *Pectunculina subscalaris* (Orbigny 1852) (see there). The stratigraphic occurrence of *O. costulata* usually is restricted to the Latdorfian. But Berndt & Welle (1998) recorded it from the Early Rupelian Walsum Beds, too, and suggested the possibility that part of these beds are still of Latdorfian age. However, their specimens are not fully grown and they remarked that it lacks the crenulation of the interior margin. A completely smooth interior margin, however, would exclude such an identification, but would rather point to *O. goldfussii*. But this species has not such a coarse cancellated sculpture as shown by the specimen figured by Berndt & Welle (1998). Without close examination and comparisons actually the specimens in question can not be positively identified and the stratigraphic range of the species must remain unclear.

Regional distribution and stratigraphic range: The Netherlands: Klimmen Member; Belgium: Grimmertingen Member of Sint-Huibrechts-Hern Formation; Nordrhein-Westfalen: Ratheim Formation, ? Walsum Formation, Brandhorst Beds; Sachsen-Anhalt: Silberberg Formation (Latdorf Beds). – Latdorfian – ? Rupelian.

Oblimopa (?) *goldfussii* (Nyst 1845)

Figs. 35, 36

1837 *Pectunculus minutus* – Goldfuss: 163 partim, pl. 127, fig. 1a–c (Klein-Spouwen) (non loc. Bünde = *costulata* Goldfuss) (non Philippi 1836)

1845 *Trigonocaelia Goldfussii* Nyst: 243, pl. 19, fig. 4a–c (Kleyn-Spauwen, Vieux-Jonc, Hoesselt etc.)

1851 *Limopsis Goldfussiana* “Nyst” Braun in Walchner: 1118 (unjustified emendation)



- 1861 *Limopsis Goldfussii* – Sandberger: pl. 29, fig. 6, 6a, 6b; 1863: 346 (Weinheim)
 1913 *Limopsis Goldfussi* – Harder: 52, pl. 3, fig. 18a–c (Aarhus; Rupelian)
 1945 *Limopsis goldfussi* – Glibert: 48, pl. 2, fig. 4 (“Vieux-Jones” = Berg!)
 1954 *Limopsis* (s.s.) *goldfussi* – Glibert & Heinzelin: 320 (Neotype; Berg)
 1973 *Limopsis* (*Limopsis*) *goldfussi* – Neuffer: 20, pl. 1, fig. 13a–b (Weinheim; Trift)
 1983 *Limopsis* (*Limopsis*) *goldfussi* – Müller: 27, pl. 6, fig. 5a–b (Zwenkau)
 1995 *Limopsis goldfussii* – Gürs: 203, pl. 37, fig. 4a–b (Weinheim), pl. 62, fig. 8a–b (Neotype; Berg)
 2003 *Limopsis* (*Limopsis*) *goldfussi* – Welle & Nagel: 44, pl. 2, figs. 19, 20, 21 (Magdeburg)
 2008 *Limopsis* (*L.*) *goldfussi* – Müller: pl. 9, fig. 9 a–b (Zwenkau)
 2012 *Limopsis* (*Limopsis*) *goldfussi* – Marquet et al.: 24, pl. 8, fig. 1a, b–c (Grimmerten)

Type material: Neotype IRSNB no.1912 (not seen); syntypes: coll. Goldfuss no. 781 b (from Klein-Spouwen = figured specimen Goldfuss: pl. 127, fig. 1c), coll. Goldfuss no. 781 a (not figured, from “Bünde” = Brandhorst near Bünde, is *costulata* Goldfuss) (Goldfuss-Museum, Universität Bonn; vidi).

Locus typicus: Kleyn-Spauwen (= Kleine Spouwen) SE of Hoeselt, province of Limburg, Belgium.

Stratum typicum: Berg Sand Member, Bilzen Formation; Rupelian.

Other material examined (> 100 specimens, SMF): Belgium: Kleine Spouwen, Berg; Mainz Basin: Weinheim, Weinheim (Trift), Wöllstein.

Diagnostic characters: Medium sized to large (H_{\max} = 12.0 mm, L_{\max} = 11.3 mm, C_{\max} = 3.6 mm (Klein-Spouwen); H_{\max} = 14.7 mm, L_{\max} = 14.5 mm, C_{\max} = 4.3 mm (Weinheim)), suboval to slightly postero-ventrally elongated, moderately convex; very weak sculpture of concentric ridges and a faint dense radial striation; hinge line strongly curved, with up to 9 anterior and up to 12 posterior teeth; ligamental area very well developed, moderately high, ligamental pit broadly triangular; edge of interior margin smooth, but in well preserved specimens with very obscure and hardly visible coarse denticulation on the narrow internal seam, otherwise appearing smooth.

Remarks: The species was described by Nyst using his own material but he included also the specimen figured by Goldfuss as “*Pectunculus minutus*” in his species. Therefore the specimens of Goldfuss constitute part of the type series. Because these specimens are still preserved in the Goldfuss collection, the validity of the neotype established by Glibert & Heinzelin (1954) is very questionable.

As for the difficulty to assess the relationships of this species see the discussion under *Limopsis parva*. The characters of Belgian specimens are rather similar to those of *parva* and could point to the possibility that both species are members of a lineage. However, better preserved specimens from the Rupelian Alzey Formation of the Mainz Basin differ from Belgian specimens, as they show a more distinct fine reticulation of the exterior and an usually well developed coarse nodulation of the ventral interior margin, often prolonged to weak radial ribs extending into the interior of the shells. With these characters those specimens display some affinities to the Latdorfian *costulata* and the Eochattian *O. vonderhochti*. However, at present it seems impossible to regard them as linked to each other in form of a phylogenetic lineage and the true affinities of *goldfussii* remain unresolved.

Regional distribution and stratigraphic range: Denmark: Branden Clay; Belgium: Grimmerten Member of Sint-Huibrechts-Hern Formation, Berg Sand Member of Bilzen Formation; Nordrhein-Westfalen: Walsum Formation; Sachsen-Anhalt: Magdeburg Sand; Sachsen: Böhlen Beds; Mainz Basin (Rheinland-Pfalz): Alzey Formation. Latdorfian – Rupelian.

***Oblimopa (?) vonderhochti* (Schnetler in Schnetler & Beyer 1990)**

Figs. 37, 38

- 1835 *Pectunculus auritus* – Münster: 438 (Cassel) (non Brocchi 1814)
 1843 *Pectunculus granulatus* – Philippi: 48, 72 partim (non Lamarck 1805)
 1884 *Limopsis Goldfussi* – Koenen in Speyer: pl. 31, figs. 9, 9a–c, 10 (Hohenkirchen) (non Nyst 1845)
 1952 *Limopsis goldfussi* – Görges: 17 (non Nyst)
 1979 *Limopsis* (*Pectunculina*) *retifera* – R. Janssen: 30 partim, pl. 1, fig. 16 (Ahnetal) (non Semper 1861)
 1990 *Limopsis* (*Pectunculina*) *vonderhochti* Schnetler in Schnetler & Beyer: 51, pl. 1, figs. 4a–b, 5a–b (Mogenstrup), 6a–b (Krefeld-Linn), 7a–b (Ahnetal)
 1997 *Limopsis* (*Pectunculina*) *vonderhochti* – Welle: 16, pl. 1, fig. 12a–b (Sophia Jacoba 8)

Type material: Holotype MGUH 20025 (Geological Museum, University of Copenhagen), many paratypes in various collections (partly seen).

Locus typicus: Coastal cliff at Mogenstrup N of Skive, Jutland, Denmark.

Stratum typicum: Glauconitic sand of Brejning Clay Member, Vejle Fjord Formation; Late Eochattian (B).

Material examined (> 100 specimens, SMF): Denmark: Mogenstrup (paratypes SMF 308406/2); Lower Rhine region: borehole Krefeld-Linn (paratype SMF 309204/1),

Rumeln (paratypes SMF 342670/3); Hessen: Ahnetal (paratypes SMF 308407/1, SMF 308408/10; many other specimens), Glimmerode, Niederkaufungen (paratype SMF 308409/1), Harleshausen.

Diagnostic characters: Medium to large sized ($H_{\max} = 13.1$ mm, $L_{\max} = 12.3$ mm, $C_{\max} = 4.7$ mm), suboval; anterior margin convex; exterior with network of distinct but very irregular concentric threads crossed by more than 50 weak radial riblets; hinge very bold, usually 4–5 (up to 8) strong teeth in the anterior series, 5–7 in the posterior series; ligamental area well developed, moderately high, ligamental pit very broad, triangular, distinctly demarcated; interior margin with broad seam, edge smooth, only ventral part of seam with 6–8 very coarse nodules, obscurely radiating into the interior of shell.

Remarks: This species could be an offshoot of the Rupelian *O. goldfussii*. It is more similar to the Mainz Basin population of that species than to the Belgian one (see discussion under *goldfussii*). *O. vanderhochti* differs from *goldfussii* by the usually stronger and fewer hinge teeth (anteriorly 5, posteriorly 5–8 as compared to 6–7 and 6–14), by the well developed and very coarse nodulation of the ventral margin (6–8) and the somewhat more apparent reticulation by concentric threads and radial riblets of about equal strength.

Regional distribution and stratigraphic range: Denmark: Brejning Clay Member of Vejle Fjord Formation; Nordrhein-Westfalen: Grafenberg Formation; Niedersachsen: marly sands of Freden; Hessen: Kassel Formation. – Eo-chattian (A–B).

Paracratitis Huber 2010

Type species (original designation): *Limosis natalis* Barnard 1963 (Recent; S-Africa)

Remarks: Species grouped by Oliver (1981) in his morphological groups VII (with *L. minuta* (Philippi 1836) and *L. abyssicola* A. Adams 1863)) and VIII (with *L. antillensis* Dall 1881, *L. natalis* Barnard 1963 and *L. elachista* Sturany 1899) have been merged by Huber (2010) in his new genus *Paracratitis*. Characters of this group are the distinctly transversely elongated shape, the fine and regular reticulated sculpture usually consisting of slightly raised radial riblets and concentric ridges, the internal margin with narrow seam which can be wholly or partly denticulated, and the denticles forming more or less distinct radial ribs radiating into the interior of the shell. The Oligocene species described below fit very well to species like *minuta* Philippi and *abyssicola* Adams and therefore are here included in *Paracratitis* although they seem not to be related equally close to the type species *natalis* Barnard. In case that it should turn out that both species groups of Oliver can not be classified in the same

genus, a new genus could be necessary to accommodate *minuta* and similar species. *Paracratitis* in the strict sense of the type species then eventually could turn out to be a synonym of *Cosmetopsis* to which it resembles. However, much more comparative work on Recent and fossil material would be needed to unravel those problems.

Paracratitis magdeburgensis n. sp.

Figs. 39–42

- 2003 *Limopsis* (*Pectunculina*) *iniquidens* – Welle & Nagel: 43 partim, pl. 2, fig. 18 (non figs. 13–14 = *muelleri* n. sp., non figs. 15–17 = *iniquidens*) (Magdeburg) (non Sandberger 1861)
- 2011 *Limopsis iniquidens* – Müller: 31 partim (non pl. 15, fig. 6a–c = *muelleri* n. sp.) (Mammendorf) (non Sandberger)

Type material: Holotype (left valve): GPSL MM_0868; paratypes: GPSL MM_0869/50, MM_0870/10, SMF 342656/1, 342657/1, 342658/1, 342659/50; all from type locality.

Locus typicus: Mammendorf quarry W of Magdeburg, federal state of Sachsen-Anhalt, Germany.

Stratum typicum: Magdeburg Sand, bed M 7 (Müller 2011); Rupelian.

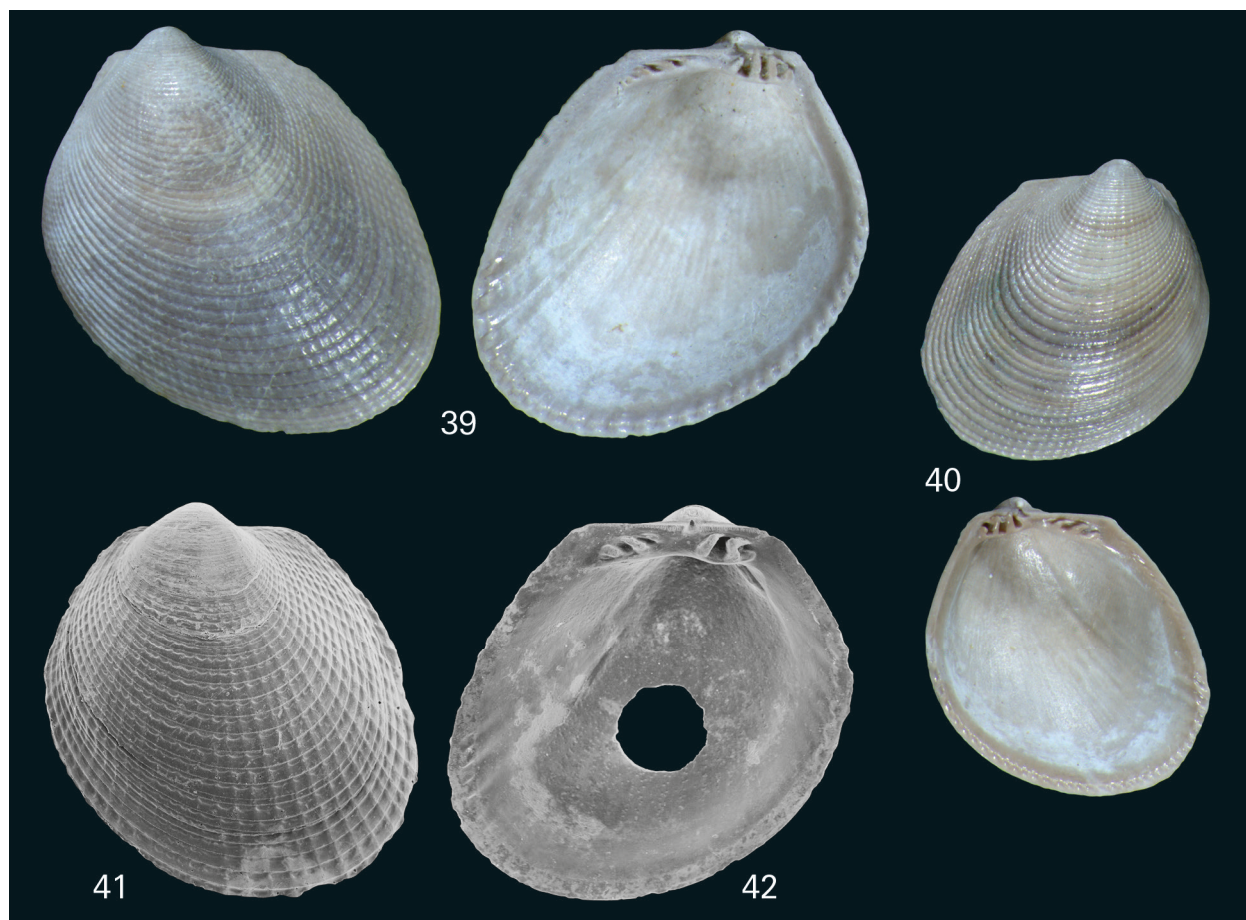
Derivatio nominis: After the occurrence in the Magdeburg sands.

Other material examined (> 300 specimens, Universität Leipzig, SMF): Mammendorf.

Description: Small to medium sized, transversely oval, postero-ventrally elongated; with distinct angulation between dorsal margin and lateral margins, anterior margin in its upper part straight and vertically descending or slightly concave, then rounded; exterior with strong and very regular reticulation of regular concentric lamellar ridges and faint but obvious radial riblets, ca. 35 in juveniles, ca. 50 in adults; hinge line straight, hinge with 3 or 4 teeth in each series (juveniles with 2 anterior and 2–3 posterior teeth); with a narrow ligamental area and short and broad triangular ligamental pit; whole interior shell margin densely crenulated, denticles always prolonged into fine riblets radiating into the interior of the shell, the 4–5 posterior riblets more distinctly developed.

Measurements: Holotype: $H = 5.4$ mm, $L = 5.3$ mm, $C = 1.4$ mm; $H_{\max} = 6.3$ mm, $L_{\max} = 6.5$ mm, $C_{\max} = 2.0$ mm

Remarks: This species on first glance resembles very much the species *P. muelleri* n. sp. described below. However, it can be easily distinguished from that species by its smaller size, the regular radial riblets which are not divided into some more prominent ribs and bundles



Figs. 39–42. *Paracratris magdeburgensis* n. sp. Germany (Sachsen-Anhalt): Mammendorf; Magdeburg Sand, bed M 7, Rupelian. Fig. 39 – left valve (holotype GPSL MM_0868, coll. A. Müller), H = 5.4 mm, × 10; Fig. 40 – right valve (paratype SMF 342656, ex coll. A. Müller), H = 4.0 mm, × 10; Fig. 41 – left valve (paratype SMF 342657, ex coll. A. Müller), H = 2.1 mm, × 25; Fig. 42 – left valve (paratype SMF 342658, ex coll. A. Müller), H = 2.1 mm, × 25.

Abb. 39–42. *Paracratris magdeburgensis* n. sp. Deutschland (Sachsen-Anhalt): Mammendorf; Magdeburger Sand, Schicht M 7, Rupelium. Abb. 39 – linke Klappe (Holotypus GPSL MM_0868, coll. A. Müller), H = 5,4 mm, × 10; Abb. 40 – rechte Klappe (Paratypus SMF 342656, ex coll. A. Müller), H = 4,0 mm, × 10; Abb. 41 – linke Klappe (Paratypus SMF 342657, ex coll. A. Müller), H = 2,1 mm, × 25; Abb. 42 – linke Klappe (Paratypus SMF 342658, ex coll. A. Müller), H = 2,1 mm, × 25.

of finer riblets in between, the straight hinge line with much smaller teeth, and the always distinct crenulation of the whole interior margin in contrast to the few coarse nodulations of the anterior-ventral margin of *P. muelleri*.

From the reticulated *Cosmetopsis* species (in particular *iniquidens*) it is separated by the distinctly transversally elongate shape, the much weaker inflation, the very regular sculpture, the distinct radial riblets formed by the denticles of the shell margin and radiating far into the interior of the shell, and by only two anterior hinge teeth compared to 3 in equally sized specimens (of *iniquidens*). However, some small specimens from bed M 7 with less transversely elongated and more convex shells resemble *C. iniquidens* but are separated by their distinctly coarser reticulation, especially the much broader concentric ridges. Typical *C. iniquidens* have not yet been seen from Mammendorf but are present in Magdeburg.

Regional distribution and stratigraphic range: Sachsen-Anhalt: Magdeburg Sand. – Rupelian.

***Paracratris muelleri* n. sp.**

Figs. 43–48

- 2003 *Limopsis* (*Pectunculina*) *iniquidens* – Welle & Nagel: 43 partim, pl. 2, figs. 13–14 (non figs. 15–17 = *iniquidens*, non fig. 18 = *magdeburgensis* n. sp.) (Magdeburg) (non Sandberger 1861)
- 2008 *Limopsis* aff. *iniquidens* – Müller: pl. 8, fig. 9a–c (Mammendorf) (non Sandberger)
- 2011 *Limopsis iniquidens* – Müller: 31 partim, pl. 15, fig. 6a–c (Mammendorf) (non Sandberger)

Type material: Holotype (left valve): GPSL MM_0871; paratypes: GPSL 048 (= Müller 2011: pl. 15, fig. 6a–c), MM_0872/2, SMF 342662/1, 342663/1 (all bed M 6); GPSL MM_0873/1, MM_0874/1, MM_0875/10, SMF 342664/1, 342665/1, SMF 342666/5 (all bed M 7).

Locus typicus: Mammendorf quarry W of Magdeburg, federal state of Sachsen-Anhalt, Germany.

Stratum typicum: Magdeburg Sand, bed M 6 (Müller 2011); Rupelian.

Derivatio nominis: In honour of Arnold Müller, Universität Leipzig, who contributed so much to the knowledge of the Rupelian of the North Sea Basin and collected the rich material from Mammendorf.

Other material examined (ca. 30 specimens, Universität Leipzig, SMF): Mammendorf.

Description: Medium to large sized, moderately convex, dorsally compressed, ventrally broadened, distinctly postero-ventrally elongated, with a “*Pteria*-like” appearance caused by the distinct angulation between dorsal and anterior margins and the broadly rounded posterior margin; anterior dorsal margin rather short, transition of posterior dorsal margin into posterior margin not angulated but more or less broadly rounded; upper anterior margin straight and vertically descending, then distinctly concave, especially in larger specimens; exterior sculptured with a very regular network of many narrow and dense concentric ridges, clearly separated by fine commarginal furrows, crossed and granulated by ca. 10–12 very widely spaced and well pronounced radial riblets; in between these more prominent riblets there are bundles of ca. 5–7 very fine but well developed radial striae; hinge line bold, distinctly curved, right valve with 3–4 strong, vertical or curved and erected teeth in the anterior series, and 7 horizontal to oblique teeth in the posterior series; left valve with 3–4 anterior and 7–8 posterior teeth; juvenile specimens with 2–3 hinge teeth in each series; ligamental area very low, ligamental pit short, very broad and triangular; interior margin with broad and flat seam, in the posterior half smooth, in the anterior half with 4–6 coarse nodular teeth which are riblike and extend to just below the umbo; interior of juveniles smooth except of 2–3 very weak radial ribs.

Measurements: Holotype: H = 9.3 mm, L = 8.0 mm, C = 2.7 mm; H_{max} = 14.4 mm, L_{max} = 11.1 mm, C_{max} = 3.8 mm.

Remarks: This species is easily separated from the other species discussed here by its transversely elongated and winged shape, the regular network sculpture with alternating coarser ribs and finer riblets in between, and the coarse rib-like nodules in the anterior half of the interior of the shell. From the very similar and co-existing *P. magdeburgensis* it is always separable by its large size, the strong hinge teeth, the particular distribution of the

radial riblets, and the characters of the interior margin with only few coarse nodules in the anterior part.

In material from the Latdorf borehole executed by A. Müller in 2012, some badly preserved fragments and a single juvenile valve of a species very similar to *P. muelleri* have been discovered. Specimens probably belonging here have been figured from Latdorf by Koenen (1893: pl. 74, figs. 6a–b, 7a–b as *L. retifera*). This species has an oval shape, ca. 40 regular radial riblets, a straight anterior margin, only 3 small hinge teeth in each series, and in the interior of the shell there are 6 distinct radial ribs in the posterior part. Probably this shell represents another yet undescribed species, maybe the Latdorfian precursor of one of the two Rupelian *Paracratids* species described here. However, more and better material is needed to evaluate its relationships.

The usually well developed concave indentation of the anterior margin of *P. muelleri* points to an epibysate mode of live, probably attached to hard substrates in the litoral of the Mammendorf locality. The fact that such striking species like *P. muelleri* and *P. magdeburgensis* have not been found elsewhere most probably is an artefact caused by rare preservation of sediments of such particular environments. Many species confined to such environments usually are known only as “local endemites”. *P. muelleri* as well as *P. magdeburgensis* have no close relatives in the North Sea Basin Oligocene nor can they be compared to any of the Miocene species of that basin.

Regional distribution and stratigraphic range: Sachsen-Anhalt: Magdeburg Sand. – Rupelian.

Pectunculina Orbigny 1843

Type species (original designation): *Pectunculus scalaris* Sowerby 1825 (Late Eocene; England)

Remarks: Species of this genus are characterized by an orbicular glycymeridid shape, a distinct ligamental area and a broad hinge line, a reticulate sculpture consisting of fine concentric threads and coarser, predominant and distinctly spaced radial ribs or riblets, and an interior margin with smooth edge but an interior seam beset with distinct denticles.

Pectunculina subscalaris (Orbigny 1852)

Fig. 49

- 1845 *Trigonocaelia scalaris* – Nyst: 242, pl. 19, fig. 2a–c (Vliermael, Lethen) (non Sowerby 1824)
- 1852 *Limopsis subscalaris* Orbigny: 22 (pro *Trigonocaelia scalaris* sensu Nyst 1845: 242, pl. 19, fig. 2)
- 1944 *Limopsis costulata* – Albrecht & Valk: 114 partim, pl. 24, figs. 943–944, 947–948 (boreholes and mine-shafts of Dutch Limburg) (non Goldfuss 1837)

Figs. 43–48. *Paracratys muelleri* n. sp. Germany (Sachsen-Anhalt): Mammendorf; Magdeburg Sand, bed M 6, Rupelian: Fig. 43 – left valve (holotype GPSL MM_0871, coll. A. Müller), H = 9.3 mm, × 6; Fig. 44 – left valve (paratype SMF 342662, ex coll. A. Müller), H = 12.0 mm, × 5. Germany (Sachsen-Anhalt): Mammendorf; Magdeburg Sand, bed M 7, Rupelian. Fig. 45 – right valve (paratype GPSL MM_0873, coll. A. Müller), H = 9.8 mm, × 6; Fig. 46 – right valve (paratype GPSL MM_0874, coll. A. Müller), H = 4.8 mm, × 10; Fig. 47 – left valve (paratype SMF 342664, ex coll. A. Müller), H = 2.8 mm, × 20; Fig. 48 – left valve (paratype SMF 342665, ex coll. A. Müller), H = 2.6 mm, × 20.

Abb. 43–48. *Paracratys muelleri* n. sp. Deutschland (Sachsen-Anhalt): Mammendorf; Magdeburger Sand, Schicht M 6, Rupelium: Abb. 43 – linke Klappe (Holotypus GPSL MM_0871, coll. A. Müller), H = 9,3 mm, × 6; Abb. 44 – linke Klappe (Paratypus SMF 342662, ex coll. A. Müller), H = 12,0 mm, × 5. Deutschland (Sachsen-Anhalt): Mammendorf; Magdeburger Sand, Schicht M 7, Rupelium. Abb. 45 – rechte Klappe (Paratypus GPSL MM_0873, coll. A. Müller), H = 9,8 mm, × 6; Abb. 46 – rechte Klappe (Paratypus GPSL MM_0874, coll. A. Müller), H = 4,8 mm, × 10; Abb. 47 – linke Klappe (Paratypus SMF 342664, ex coll. A. Müller), H = 2,8 mm, × 20; Abb. 48 – linke Klappe (Paratypus SMF 342665, ex coll. A. Müller), H = 2,6 mm, × 20.

- 1954 *Limopsis* (s.s.) *costulata* – Glibert & Heinzelin: 320 partim, pl. 1, fig. 8a–b (Grimmertingen) (non Goldfuss)
 1997 *Limopsis* (*Pectunculina*) *costulata* – Welle: 17 partim, pl. 2, fig. 2a–b (Var. 1; Sophia Jacoba 8) (non Goldfuss)
 2012 *Limopsis* (*Pectunculina*) *albrechtvalki* Marquet et al.: 25, pl. 8, fig. 2a–b, c–d, e–f (Grimmertingen)

Type material: Syntypes *L. subscalaris* (fide Glibert & Heinzelin 1954) IRSNB no. 3789–3790; holotype *L. albrechtvalki*: IRSNB IST 7339, paratype IRSNB IST 7337 (not seen).

Locus typicus: Grimmertingen = Vliermaal (now municipality of Kortesseem) NW of Tongeren or Lethen (now municipality of Bilzen) NE of Hoeselt, province of Limburg, Belgium.

Stratum typicum: Grimmertingen Member, Sint-Huibrechts-Hern Formation; Late Eocene (Priabonian) or Earliest Rupelian = Latdorfian (nannoplankton zone NP 21).

Material examined (ca. 20 specimens, SMF): Belgium: Grimmertingen; Lower Rhine region: mineshaft Sophia Jacoba 6 near Hückelhoven; Sachsen-Anhalt: Latdorf, Unseburg.

Diagnostic characters: Medium to large sized (H_{\max} = 11.0 mm, L_{\max} = 10.8 mm, C_{\max} = 3.5 mm), usually circular or slightly suboval, moderately convex; exterior with sculpture of ca. 30 predominant and distant radial ribs, dense concentric riblets and wavy growth lines, intercalation of secondary radial riblets starting at a size of ca. 4–5 mm, secondary riblets remaining always much weaker than primary ribs; hinge line strong, with usually 7 anterior and 8–9 posterior teeth; ligamental area distinct, moderately high, ligamental pit large, broad, triangular; interior shell margin with smooth edge but whole internal seam beset with ca. 40–50 denticles which are more distinct on the ventral margin.

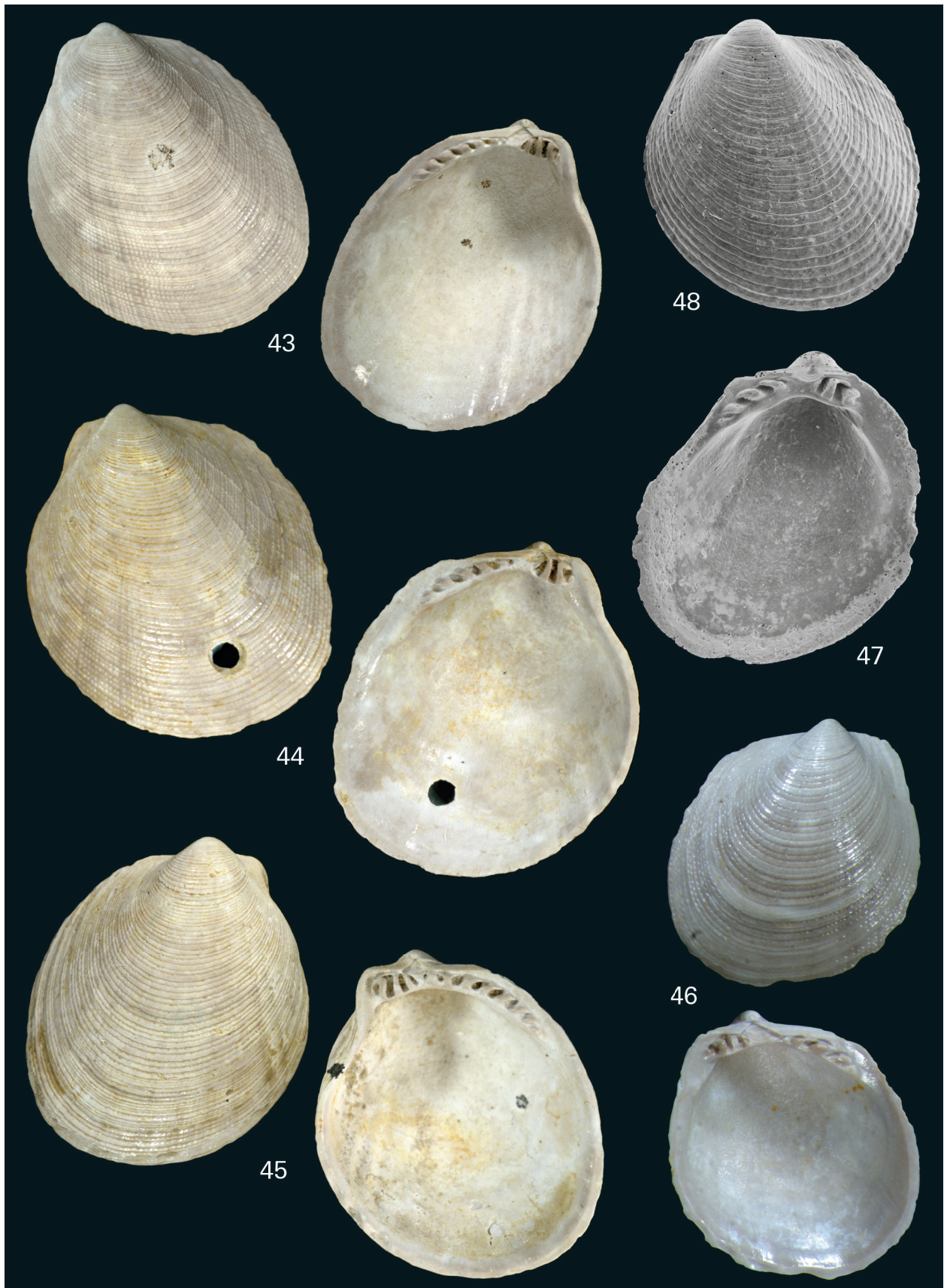
Remarks: This species is distinguished from *O. costulata* (Goldfuss) by its more circular outline, the higher ligamental area and stronger hinge, and especially by the much coarser sculpture with prominent distant radial ribs. Both species occur together at most localities of Latdorfian age. Figures 947–950 of Albrecht & Valk (1944) were considered “too small to be identified” by Marquet et al. (2012). However, these figures represent only the natural sizes of the enlarged Figures 943–944 and 945–946 (Albrecht & Valk 1944). When describing this species as new, Marquet et al. (2012) cited the reference of Nyst’s “*scalaris*” in their synonymy but they overlooked that this misidentification had already been corrected by Orbigny (1852). Under the provisions of Art. 23.9 ICZN the name *subscalaris* can not be discarded as an unused senior synonym.

Regional distribution and stratigraphic range: The Netherlands: Klimmen Member; Belgium: Grimmertingen Member of Sint-Huibrechts-Hern Formation; Nordrhein-Westfalen: Ratheim Formation; Sachsen-Anhalt: Silberberg Formation (Latdorf Beds). – Latdorfian.

Conclusions

Diversity of molluscs of even well-known local faunas often is underestimated and still there is much need for in-depth taxonomic studies. This is demonstrated by the discovery of several undescribed species with a very restricted occurrence at single localities or being confined to particular environments, such as *Cosmetopsis glimmerodensis*, *C. mothsorum* and the two *Paracratys* species. But also a greater diversity at the generic level can be observed as shown by the fact that the species can be grouped into clearly separable morphological entities.

As a further result of the present study it becomes obvious that stratigraphic ranges of species need to be



evaluated more carefully as it has been the case so far. The distribution of benthic molluscs is often related to facies rather than to occurrence in time. Therefore benthic

molluscs usually are considered to have only restricted value for stratigraphic purposes. However, as shown by the present study, a detailed discrimination of spe-



Fig. 49. *Pectunculina subscalaris* (Orbigny 1852). Germany (Sachsen-Anhalt): Latdorf; Latdorf Beds, Latdorfian; left valve (SMF 342669), H = 11.0 mm, $\times 6$.

Abb. 49. *Pectunculina subscalaris* (Orbigny 1852). Deutschland (Sachsen-Anhalt): Latdorf; Latdorf-Schichten, Latdorfium; linke Klappe (SMF 342669), H = 11,0 mm, $\times 6$.

cies nevertheless will allow to use these as stratigraphic marker species. Moreover, at least the small *Cosmetopsis* species form a lineage which reaches from the Latdorfian *C. latdorfensis* over the Rupelian *C. retifera iniquidens* to the Chattian *C. retifera retifera*.

It might be a matter of discussion whether these stratigraphically distinct populations should be kept as separate taxa. However, by examination of rich material it is possible to detect differences in the various characters which allow to separate the populations. *C. glimmerodensis* and *C. mothsorum* anyway stand apart, the former because of its strongly trapezoidal to subquadrate shape and granulated sculpture, the latter because of its very small and tiny shells and the particular pattern of sculpture. These new species can not be linked directly to other species of the North Sea Basin Oligocene but could be offshoots from species of the *retifera*-lineage.

Pectunculina subscalaris forms a well characterized group for its own which obviously is related to the Late Eocene type species *P. scalaris* (Sowerby 1825). Another distinct group is formed by the species here grouped under *Paracratis*. They have no close relationships to the other Oligocene species of the North Sea Basin, probably because of their particular habitat in the litoral sediments hitherto known only from the Magdeburg region.

A third group (here referred to *Oblimopa*) is formed by "*Limopsis*" *costulata*, *goldfussii* and *vonderhochti*. Although these taxa occur in stratigraphic sequence it is impossible to link them in a lineage because each species shows conchological differences which can not be derived directly from each other.

In general it has to be noted that the Oligocene species of the North Sea Basin (with the exception of *Limopsis*

parva and *Aspalima chattica*) have no obvious affinities to the Miocene species of the same basin. After correcting the misidentification of Miocene specimens of "*retifera*", no longer any Oligocene species has a stratigraphic range extending into the Miocene. Thus Oligocene and Miocene limopsid faunas of the North Sea Basin have a distinctly different specific composition. The limitation of the stratigraphic range of most Oligocene species to one of the stages (Latdorfian, Rupelian or Chattian) and the fact that all Chattian species have no earlier appearance suggest a marked change in the composition of the faunas, especially at the base of the Chattian. The sudden appearance of *Limopsis parva* and *Aspalima chattica* in the Late Eochattian (B) characterize another striking faunal change within the Chattian. These species obviously are not related to any of the other Oligocene species. Therefore it seems very probable that they must have migrated into the basin from somewhere outside. However, at present it is an open question where they have come from. It would be necessary to examine the species of the Atlantic Tertiary of North America as well as those of the Northern Pacific Tertiary, e.g. of Japan, to possibly get answered this question. The problem has already been discussed by Janssen & Von der Hocht (2009) with regard to several gastropod species.

As for the habitats of the species it can be concluded that with few exceptions they are confined to sublittoral soft bottoms, as it is known also for most of the Recent species. However, species like *Cosmetopsis glimmerodensis*, *Paracratis magdeburgensis* and *P. muelleri* have been found in sediments of very shallow environments, close to rocky shores, as demonstrated by the composition of the whole fauna (see Müller 2011 for Mammendorf, Janssen

1978 for Glimmerode). It is not surprising that just from those seldomly preserved environments new species have been discovered which are very different from the usually known soft bottom species. These species are characterised by distinct trapezoidal, postero-ventrally elongated shapes and more or less developed byssal indentation in the anterior margin. These features are characteristic for species with an epibyssate mode of life, often byssally attached to harder substrates (Oliver 1981).

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