

**EVOLUTION AND STRATIGRAPHICAL DISTRIBUTION OF OLIGOCENE AND
MIOCENE SCAPHOPODA IN THE NORTH SEA BASIN—A PRELIMINARY REPORT**

by

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As a result of a taxonomical revision of Oligocene and Miocene scaphopods of the North Sea Basin observations on stratigraphical distribution as well as on evolutionary lineages of species are presented. There are two important lineages reaching from the Latdorfian, resp. the Rupelian, to the Vierlandian (*Fissidentalium novaki*-lineage and *Antalis geminata*-lineage) and one Miocene (Reinbekian to Syltian) lineage (based on *Fissidentalium "badense"* auct.). Assemblages of scaphopod species characterize different facies in the Rupelian, but stratigraphical units in the Hemmoorian. Most previous assumptions as to identity of species and their development in the North Sea Basin appeared to be incorrect.

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SAMENVATTING

Evolutie en stratigrafische verspreiding van oligocene en miocene Scaphopoda in het Noordzeebekken—een voorlopig rapport.

Door middel van een kritische taxonomische herziening van de oligocene en miocene Scaphopoda van het Noordzeebekken werd de mogelijkheid geschapen Scaphopoda toe te passen voor een stratigrafische ouderdomsbepaling. Zowel evolutiereeksen als kenmerkende soortenassociaties kunnen nu voor stratigrafische doeleinden worden gebruikt. Van belang zijn vooral drie ontwikkelingsreeksen, nl. *Fissidentalium novaki* (Von Koenen) - *novaki* n. subsp. - *polypleurum* Seifert (Latdorf tot Vierland), *Antalis* n. sp. - *geminata* Goldfuss — *geminata* n. subsp. - n. sp. (Rupel tot Vierland) en *Fissidentalium* n. sp. - *floratum* Zimmermann (= "badense" auct.) - *floratum* n. subsp. (Reinbek tot Sylt).

Karakteristieke soortengedenschappen zijn vooral kenmerkend voor verschillende niveau's van Hemmoor-ouderdom. Ook in het Rupelien komen typische soortcombinaties voor, die hier echter meer tot bepaalde facies beperkt zijn. Soortenuitwisselingen met andere Tertiairbekkens hebben alleen tijdens het Hemmoor bestaan met het Burdigalien van de Aquitaine. Directe betrekkingen tot het Mioceen van het Paratethys-gebied zijn, in tegenstelling tot bestaande opvattingen, niet aantoonbaar. Het is gebleken dat alle door Seifert in 1959 gemaakte veronderstellingen ten aanzien van de evolutie der soorten in het Noordzeebekken gebaseerd zijn op onjuiste soortdeterminaties en derhalve niet houdbaar.

ZUSAMMENFASSUNG

Durch eine kritische taxonomische Revision der Scaphopoden des Oligozäns und Miozäns im Nordseebecken wurde die Grundlage geschaffen für die Verwendung von Scaphopoden bei der stratigraphischen Altersbestimmung. Es lassen sich nunmehr sowohl evolutive Reihen als auch charakteristische Artenvergesellschaftungen für die Stratigraphie nutzen. Von Bedeutung sind vor allem drei Entwicklungslinien: *Fissidentalium novaki* (von Koenen) - *novaki* n. subsp. - *polypleurum* Seifert (Latdorfium bis Vierlandium), *Antalis* n. sp. - *geminata* Goldfuss - *geminata* n. subsp. - n. sp. (Rupelium bis Vierlandium) und *Fissidentalium* n. sp. - *floratum* Zimmermann ("badense" auct.) - *floratum* n. subsp. (Reinbekium bis Syltium).

Charakteristische Artenassoziationen kennzeichnen vor allem verschiedene Niveaus innerhalb der Hemmoor-Stufe. Auch in der Rupelstufe gibt es spezielle Artengesellschaften, die hier allerdings mehr auf bestimmte Faziesbereiche beschränkt sind. Beziehungen zu anderen Tertiärbecken bestehen nur während des Hemmooriums zum Burdigal der Aquitaine. Direkte Beziehungen zum Miozän der Paratethys lassen sich entgegen bisherigen Annahmen mit Scaphopoden nicht nachweisen. Es hat sich gezeigt, daß alle von Seifert 1959 vorgestellten Hypothesen über die evolutive Entwicklung der Arten im Nordseebecken auf falschen Artbestimmungen beruhen und somit nicht haltbar sind.

INTRODUCTION

Molluscs have always played an important role in Tertiary research. Especially gastropods and bivalves have attracted attention for purposes of stratigraphy. Contrary to that, however, the

scaphopods have been more or less neglected. The reason for that seems to be that scaphopod species usually look quite uniform in shell-form and sculpture, so that species discrimination often is very difficult. Moreover, scaphopod tubes are frequently broken, which renders species identification even more difficult. It is true that scaphopods of the North Sea Basin have been dealt with in several faunal monographs, e.g. Nyst (1845), von Koenen (1882, 1892), Speyer (1870), Kautsky (1925), Anderson (1964), R. Janssen (1978), A.W. Janssen (1984), but only one paper, Seifert (1959), deals exclusively with scaphopods of the North Sea Basin. In this paper only the species of the Late Oligocene and Miocene were taken into consideration and the taxonomical and nomenclatural results were mainly based on the ideas of older authors such as von Koenen (1882) and Kautsky (1925). Nevertheless, the revision of Seifert still is the only systematic base which has been followed by all later authors.

For the first time, Seifert tried to elaborate specific differences by means of statistical methods. Resting upon the stratigraphical distribution of the species as known to him and according to their morphological similarity he proposed a scheme of the evolutionary development of that group in the North Sea Basin. These hypotheses on the evolution of species have been referred to by other authors dealing with scaphopods from other basins, e.g. Caprotti (1979). Later on, Goddeeris (1976, 1978) started a critical re-evaluation of some Miocene species, but this work was not continued. So there is no modern critical and comprehensive revision of Tertiary scaphopods of the North Sea Basin and adjacent areas.

When curating Recent as well as fossil scaphopod material in the collections of the Senckenberg-Museum (Frankfurt am Main) I realized that a number of hitherto generally accepted species identifications (e.g. of Miocene species from Northern Germany with Recent species like *D. entalis* Linné or with those originally described from the Miocene of the Vienna Basin, like *D. badense* Hörnes or *mutabile* Hörnes) can no longer be maintained. This led me to start a comprehensive revision of all Oligocene and Miocene scaphopods of the North Sea Basin and adjacent basins (Mayence Basin, Paris Basin). Especially the examination of microsculptural patterns with a Scanning Electron Microscope (SEM) facilitated a refined species discrimination and recognition of complexes of very similar, but different species. One important result is that all previous hypotheses on the identity and evolutionary relationships of species were found to be totally untenable.

The work is based mainly on material from classical outcrops and on an evaluation of samples from the borehole Broekhuizenvorst (see van Rooijen et al., 1984). It was possible to establish some well-founded evolutionary lineages which can be used in stratigraphy, as well as some well-defined species assemblages. However, in some details, particularly in transitional zones of lineages, the observations may need some closer stratigraphical control by densely sampled material from borings. Insofar it may be possible that some amendments will turn out to be necessary, especially with regard to the exact stratigraphical range of the species. But nevertheless the results presented here allow the use of scaphopods in stratigraphy, be it as members of evolutionary lineages or in form of defined species assemblages, in a much better way than it has been possible up to now.

The taxonomical-nomenclatural revision of the scaphopods of the North Sea Basin will be published in the near future in the "Archiv für Molluskenkunde". In the present paper only the results concerning stratigraphical, geographical and facies-connected distribution, as well as the evolution of the more important species shall be presented. If new species are involved they will be mentioned in open nomenclature, just to avoid the introduction of nomina nuda. As far as necessary for understanding, remarks on some species are given as annotations at the end of this paper.

EVOLUTIONARY DEVELOPMENT OF SCAPHOPODS IN THE NORTH SEA BASIN

Seifert (1959) listed five species for the Middle and Late Oligocene and ten species for the Miocene. The ribbed species according to Seifert form a single evolutionary lineage which leads from the Rupelian *Dentalium kickxii* Nyst, via the Late Oligocene *D. geminatum* Goldfuss, to the Miocene *D. badense* Hörnes. From this main stem the line of *D. polypleurum* Seifert - *D. bouei* Deshayes splits off during the Late Oligocene. Miocene offshoots should be the species *D. dollfusi* von Koenen and *D. novemcostatum mutabile* Hörnes. Among the unsculptured species the Miocene *D. vitreum* Gmelin is supposed to descend from the Oligocene *D. fissura* Lamarck. This comparatively simple picture can, however, no longer be maintained since it turned out that neither the taxonomical assumptions (correct species identifications), nor the supposed relationships between species are right. Especially the "central" species *kickxii* and *badense* in the sense of Seifert are not independent species, but merely complexes of several quite distinct taxa.

— the *kickxii* complex

Antalis kickxii (Nyst) is a species restricted to the facies of the Rupel Clay. It apparently disappeared at the end of the Rupelian. Populations from the basal Rupelian sandy facies (Meeressand of the Mayence Basin, Berg Sands in Belgium), which have hitherto been attributed to *kickxii*, belong in reality to two different species of two separate evolutionary lineages: the first can be regarded as a Middle Oligocene subspecies of the Early Oligocene *Fissidentalium novaki* (von Koenen) (note 1) and leads to the Late Oligocene species *polypleurum* Seifert. The second is an as yet undescribed species (note 2), which seems to be the precursor of the Chattian *Antalis geminata* (Goldfuss). From *geminata* the youngest Chattian populations can be separated as an independent subspecies, which gave rise to a further new species in the Vierlandian. So there are two different lineages, ranging from Early, resp. Middle Oligocene, to the Early Miocene Vierlandian. Both have nothing to do with true *Antalis kickxii* (Nyst).

— the *badense* complex

According to Seifert and subsequent authors *Dentalium badense* Hörnes is present during the entire Miocene, from the Vierlandian up to the Syltian, with the exception of Gramian. My studies have demonstrated that also in this case not a single species is involved, but a complex of several differing forms. Moreover, none of the species present in the North Sea Basin can be identified with genuine *badense* from the Vienna Basin Miocene (note 3).

The Vierlandian form is a descendant from the Late Oligocene *geminata*, which became extinct during the Vierlandian. The occurrence cited for the Hemmoorian is based—apart from misidentifications—mainly upon the record of Kautsky for the fauna of Hemmoor. Kautsky's material, however, was derived from glacial melting water deposits. It contained, besides true Hemmoorian elements, also Reinbekian species and even specimens from the Late Miocene mica clays. All the "badense" material from Hemmoor that I have been able to examine, was evidently derived from Late Miocene sediments. Also the citation of "badense" from the Reinbekian by Seifert is based on incorrectly identified material, in this case of "dollfusi" auct. non von Koenen. Anderson (1964: 194) mentioned an especially remarkable lot of "badense" in the Baumann collection from the locality Woltrup, near Osnabrück in Lower Saxony. This sample, however, certainly does not originate from that locality of unquestioned Reinbekian age, but from a Late Miocene locality (note 4). So, this large and characteristic species, thought to be *badense*, appears for the first time in the Langenfeldian, for which

it is an important index fossil. Gramian representatives seem to be known only from wells (Hinsch, 1977; 1979). From the Syltian at the Morsum Cliff (Island of Sylt) a rich population is known, which merits distinction from “*badense*” as a separate subspecies. A common Reinbekian species, always incorrectly identified as *D. dollfusi* von Koenen by Seifert, Anderson and subsequent authors (note 5) may be considered as the forerunner of the Late Miocene “*badense*”. An intermediate form occurs in the uppermost Reinbekian, resp. lowermost Langenfeldian deposits (Gühlitz in Mecklenburg; well Broekhuizenvorst, The Netherlands).

Some other, but only shortlived evolutionary lineages are represented in the Oligocene by the species/subspecies *Pseudantalis geinitzi* (von Koenen) - *sandbergeri* (Bosquet) in the Latdorfian and Rupelian, and *Episiphon sulcatulus* (von Koenen) — *ottoi* (Sharp & Pilsbry), also in the Latdorfian and Rupelian. But these species can hardly be used for stratigraphical purposes, since specific discrimination in these lineages is only possible with abundant and well-preserved material at hand.

The relationship between the smooth species *fissura* Lamarck and *vitreum* Gmelin, as supposed by Seifert, has no real basis: *Pseudantalis fissura* is an Eocene species not occurring in the North Sea Basin (but it might be the predecessor of the Latdorfian *geinitzi*). *Dentalium vitreum* was originally described from the Italian Pliocene, its true identity being somewhat doubtful to me (but see Caprotti, 1979: 238, who considers it as a synonym of *D. vulgare* Da Costa). The Miocene species of the North Sea Basin, usually identified as *vitreum*, is here indicated as *Antalis exlamarcki* n. subsp.

STRATIGRAPHICAL DISTRIBUTION OF OLIGOCENE SPECIES

Von Koenen (1892) described a number of species from the Early Oligocene (Latdorfian), among which the following more common and wide-spread forms characterize the Latdorf stage: *Fissidentalium acutum* (Hébert), *F. novaki* (von Koenen), “*Dentalium*” *dekagonum* von Koenen.

In the Middle Oligocene there is also a large number of species, partially restricted to special facies. *Fissidentalium novaki* n. subsp., *Antalis* n. sp. and *Pseudantalis sandbergeri* (Bosquet) are confined to the basal sandy facies and the Nucula Clay (in Belgium). Especially *Antalis* n. sp. and *P. sandbergeri*, however, have a large geographical distribution, not only including the North Sea Basin, but also the Mayence and Paris Basins. *Antalis kickxii* (Nyst) is an index species for the Rupelian clay facies. In the Nucula Clay as well as in the Rupel Clay also the species *Rhabdus parallelus* (Zinndorf) is found, whereas *Episiphon ottoi* (Sharp & Pilsbry) and *Siphonodentalium* (?) *microceras* (Zinndorf) seem to be restricted to the upper part of the Rupel Clay section. This needs confirmation by more material collected from short intervals of the Rupel Clay in Belgium and the Netherlands.

The scaphopod fauna of the Late Oligocene is quite poor in species. Typical and common elements for the Chattian are *A. geminata* (Goldfuss), *A. pseudofissura* (R. Janssen) and *Fissidentalium polypleurum* (Seifert). The latter species reaches just beyond the Oligocene/Miocene boundary into the Vierlandian.

The stratigraphical distribution of the more important Oligocene species is shown in fig. 1.

CHATTIAN	Neochatt			A. geminata n. ssp.	
	Eochatt		F. polypleurum	A. geminata	
	Rupel Clay			E. ottoii	S. microceras
			A. kickxii	?	R. parallelus ?
RUPELLIAN	Nucula Clay	Meeressand		A. n. sp.	
	Berg Sands	Mayence Basin			
			F. novaki n. ssp.	P. sandbergeri	
	Ruisbroek Sand			A. n. sp.	
LATDORFIAN					
			D. dekadonum	F. novaki	E. sulcatulus
					P. geinitzi

Fig. 1. Stratigraphical distribution of Oligocene scaphopods.

STRATIGRAPHICAL DISTRIBUTION OF MIOCENE SPECIES

During the Vierlandian essentially only those species are present, which are descendants of Oligocene forerunners. During the Hemmoorian, however, a large number of new forms suddenly appears, without affinities to older North Sea Basin species. Several of them demonstrate close relationships with species from the Burdigalian in the Aquitaine Basin (SW France): *Pseudantalis aturensis* (Cossmann & Peyrot), *Antalis exlamarcki* n. subsp., “*Dentalium*” *dumasi* n. subsp., *Gadila benoisti houthalenensis* (Goddeeris), *Dischides subpolitus* (Cossmann & Peyrot). These species are restricted to the Hemmoorian. Furthermore some apparently endemic species are present in the North Sea Basin, *Antalis dollfusi* (von Koenen), and *Lentigodentalium* “*costatum*”/“*mutabile*” auct. *A. dollfusi* is confined to the lowermost Hemmoorian (Behrendorfian) of Belgium (Edegem Sands). The so-called “*dollfusi*” from the Reinbekian is not identical with the form of the Edegem Sands, but represents an as yet undescribed species. The species previously identified as *novemcostatum mutabile* or *costatum* has nothing to do with the true *mutabile* Hörnes from the Vienna Basin, or with *costatum* Sowerby from the English Pliocene. It is, on the contrary, yet another undescribed taxon (note 6), which is typical for the Hemmoorian and the Reinbekian. Two different forms can be distinguished, characterized by the constant number of ribs (8 resp. 10-11). The form with 10-11 ribs is present in the Early Hemmoorian and in the Reinbekian, whereas the other with only 8 ribs occurs in the later Hemmoorian (Winterswijk-Miste, resp. Houthalen).

Goddeeris (1978) (note 7) reported in a preliminary paper on the refined stratigraphical distribution of some species from the lower part of the Belgian Miocene sequence. The observed succession agrees with the results of my study based on material from classical outcrops and on the well Broekhuizenvorst in the Netherlands. It is possible, especially by means of well-defined species assemblages, to distinguish various horizons, respectively to arrange the classical localities into a relative sequence according to their age. The Edegem Sands are characterized by the true *A. dollfusi*, *D.* “*costatum*”/“*mutabile*” (10-11 ribs) and the first occurrence of *Dischides subpolitus*. The Miste Bed of the Aalten Member in the Netherlands and the Houthalen Sands in Belgium yield a rich assemblage, with *A. exlamarcki* n. subsp., *D. dumasi* n. subsp., *D.* “*costatum*”/“*mutabile*” (8 ribs), *Gadila benoisti houthalenensis*, *Dischides subpolitus* and other species (cf. A.W. Janssen, 1984). In the Antwerp Sands species like *A. exlamarcki* n. subsp. and *Dischides subpolitus* are absent, whereas *D.* “*costatum*”/“*mutabile*” (10-11 ribs) and *Gadila benoisti houthalenensis* persist. In addition *Gadila dingdenensis* occurs for the first time. In the Reinbekian the only remaining species are *Gadila dingdenensis* and *D.* “*costatum*”/“*mutabile*”, and one species, *D.* “*dollfusi*” auct., is introduced for the first time. Thus a considerable impoverishment takes place, which continues during the Langenfeldian. The large and conspicuous species “*badense*” auct. (= *floratum*) is the only characteristic species of this stage. Two further species, *Polyschides* sp. and *Pulsellum* sp. (both undescribed) are introduced during the Langenfeldian and range through the Gramian and the Syltian.

A common and conspicuous element in Miocene faunas is the species *Pseudantalis aturensis* (Cossmann & Peyrot), with a smooth and polished tube. This species was previously misidentified as *D. entalis* Linné, which is a Recent species. *P. aturensis* occurs from the Hemmoorian until the Langenfeldian and has therefore no special value for stratigraphical purposes.

The results on the stratigraphical distribution of the Miocene species are summarized in fig. 2.

			F. floratum n. sp.			
	Torton. Messin.					
	Serravallian	LANGENFELDE	F. floratum	Polyschides n. sp.	Pulsellum n. sp.	
			?			
	Langhian	REINBEK	(10-11)	F. n. sp.	G. dingdenensis	
		Antwerpen	P. aturensis			
		Miste	L. n. sp. (8)	A. exlamarcki n. sp.	G. benoisti houthalenensis	D. dumasi n. sp.
	Burdigalian	HEM MOOR				
		Houthalen		D. subpolitus		
		Edegem	A. dollfusi (10-11)			
	Aqitan.	VIERLAND	A. n. sp.	?		
		NEOCHATT	A. geminata n. sp.	F. polypleurum		

Fig. 2. Stratigraphical distribution of Miocene scaphopods.

SOME GENERAL CONSIDERATIONS

The scaphopod faunas of the Oligo-Miocene in the North Sea Basin developed from the comparatively rich assemblage of the Early Oligocene. The lineages of several species continue through Middle and Late Oligocene times. At the beginning of the Rupelian a conspicuous innovation of the fauna occurs, whereas an impoverishment of the fauna is observed during the Chattian and the Vierlandian, in which hardly any genuine new elements are introduced. It is only in the Hemmoorian that again a lot of new species show up. These new forms give a special character to the Hemmoorian fauna, demonstrating a connection between the North Sea Basin and the Aquitaine Basin in SW France. During the Reinbekian there is again a process of species reduction, continuing until the Late Miocene. The Late Miocene (Langenfeldian to Syltian) is characterized by a quite independent fauna rather poor in species. Only one of these has its roots in the Reinbekian. There are no relationships with the fauna of the northern Pliocene. The previously supposed connections with the Miocene of the Paratethys (Vienna Basin), as inferred by some species identifications, cannot be substantiated on the basis of Scaphopoda.

NOTES

1. *Fissidentalium novaki* (von Koenen). Populations from the Middle Oligocene can be distinguished subspecifically from typical Early Oligocene *novaki* by details of the sculpture. The form from the Berg Sands has been identified up to now as *acutum*. The real *Fissidentalium acutum* (Hébert), however, is restricted to the Latdorfian and clearly distinguishable from *novaki* by details of the sculpture.
2. *Antalis* n. sp. This is the species present in the Meeressand in the Mayence Basin, identified as *kickxii* by Sandberger and later authors. It can be distinguished from *kickxii* by a differing sculpture and the presence of an apical notch.
3. The true *Fissidentalium badense* (Hörnnes) from the Vienna Basin has a very different type of sculpture, especially in the juvenile stage, and lacks the distinct secondary striation between the primary ribs. To the North Sea Basin species the name *floratum* Zimmermann can be applied.
4. Sediment extracted from the scaphopods in this sample yielded, apart from a characteristic fragment of *Carinastarte*, a typical Langenfeldian foraminiferal assemblage, kindly identified by Dr C.H. von Daniels, to whom I am grateful for his cooperation.
5. The Reinbekian species exhibits a striking similarity, especially in some details of the sculpture, with the Late Miocene *floratum*. It can be distinguished by its much smaller dimensions and the presence of an apical slit. Its sculpture is completely different from that of the true *dollfusi* from the Edegem Sands.
6. This form is characterized by its sculpture, consisting of either 8 or 10-11 sharp-edged primary ribs and regularly developing secondary riblets. It cannot be connected with the real *mutabile* from the Vienna Basin Miocene or with *costatum* Sowerby from the British Pliocene. Very striking is the occurrence, in different horizons of the Hemmoorian, of two forms with a constantly differing number of ribs (8 or 10-11). As further differentiating characteristics are not present, and in the absence of an obvious evolutionary trend, these two forms are not considered to represent subspecies.
7. Goddeeris (1978) unfortunately used some nomina nuda, the identity of which can only indirectly be inferred from his notes on occurrence and frequency. So it seems that his *D. antverpiense*, with the two forms *octo*-resp. *decemstriatum*, equals my *Lentigodentalium* n. sp. ("*costatum*"/'*mutabile*' auct.). *D. decagonum* might be *dumasi* n. subsp. and *D. houthalenensis* perhaps is *extamarcki* n. subsp.

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REFERENCES

- Anderson, H.-J., 1964. Die miocäne Reinbek-Stufe in Nord- und Westdeutschland und ihre Mollusken-Fauna. — Fortschr. Geol. Rheinld. u. Westf., 14: 31-368, 18 figs, pls 1-52.
- Caprotti, E., 1979. Scafopodi neogenici e recenti del bacino Mediterraneo. Iconografia ed epitome. — Boll. malac., 15 (9/10): 213-288, pls 1-15.
- Goddeeris, B., 1977. *Cadulus* (*Gadila*) *dingdenensis* sp. nov. and *Cadulus* (*Gadila*) *benoisti* houthalenensis subsp. nov. from the Neogene of the North Sea Basin. — Bull. Soc. belge Géol., 85 (4): 155-162, 4 figs.
- Goddeeris, B., 1978. The biozonation of the Miocene of Belgium with Scaphopoda. — I.G.C.P. project 124. The NW European Tertiary Basin; report 2: 68-72.
- Hinsch, W., 1977. Die Faziesverteilung und Mesofauna im Miozän des Unterelbe-Gebietes. — Geol. Jb., (A) 40: 115-153, 3 figs, 5 tabs.
- Hinsch, W., 1979. Biostratigraphie des jüngeren Tertiärs im Raum der Salinarstrukturen Sülfeld und Nusse (Schleswig-Holstein). — Geol. Jb., (C) 21: 5-43, 2 figs, 1 pl.
- Janssen, A.W., 1984. Mollusken uit het Mioceen van Winterswijk-Miste. Een inventarisatie met beschrijvingen en afbeeldingen van alle aangetroffen soorten. Amsterdam (KNNV, NGV, RGM), 451 pp, 5 figs, 4 tabs, atlas with 82 pls.
- Janssen, R., 1978. Die Mollusken des Oberoligozäns (Chattium) im Nordseebecken, 1. Scaphopoda, Archaeogastropoda, Mesogastropoda. — Arch. Moll., 109 (1/3): 137-227, 1 fig., pls 9-14.
- Kautsky, F., 1925. Das Miocän von Hemmoor und Basbeck-Osten. — Abhandl. preuss. geol. L.-Anst., (NF) 97: 1-225, pls 1-12.
- Koenen, A. von, 1882. Die Gastropoda holostomata und tectibranchiata, Cephalopoda und Pteropoda des norddeutschen Miocän. — N. Jb. Min., Geol., Paläont., Beil.-Bd 2: 223-367, pls 5-7.
- Koenen, A. von, 1892. Das norddeutsche Unter-Oligocän und seine Mollusken-Fauna, 4. — Abhandl. geol. Spezialkarte Preussen Thüring. Staat., 10 (4): 819-1004, pls 53-62.
- Nyst, P.H., 1845. Description des coquilles et des polypiers fossiles des terrains tertiaires de la Belgique. — Mém. cour. Sav. étr. Acad. r. Sci. Bell.-Lett. Bruxelles, 17: 1-688, pls 1-15.
- Rooijen, P. van, J. Klostermann, J.W.C. Doppert, C.K. Rescher, J.W. Verbeek, B.C. Sliggers & P. Glasbergen, 1984. Stratigraphy and tectonics in the Peel-Venlo area as indicated by Tertiary sediments in the Broekhuizenborst and Geldern T1 boreholes. — Meded. Rijks Geol. Dienst, 38 (1): 1-27, pls 1-3, 4 encls.
- Sandberger, F., 1858-1863. Die Conchylien des Mainzer Tertiärbeckens. Wiesbaden (Kreidel's Verlag), V + 458 pp, atlas with 35 pls.
- Seifert, F., 1959. Die Scaphopoden des jüngeren Tertiärs (Oligozän-Pliozän) in Nordwestdeutschland. — Meyniana, 8: 22-36, 7 figs, pls 1-2.
- Speyer, O., 1870. Die Conchylien der Casseler Tertiär-Bildungen. — Palaeontogr., 19: 159-202, pls 18-21.