

**FISH OTOLITHS FROM THE BASSEVELDE SAND (LATE TONGRIAN) OF RUISBROEK,
BELGIUM, AND THE STRATIGRAPHY OF THE EARLY OLIGOCENE OF BELGIUM**

by

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An otolith fauna of 24 species was found in the upper part of the Bassevelde Sand. Seven new species and four new genera are described.

The Bassevelde Sand belongs to the *Palaeogadus ruisbroekensis* Range Zone (otolith zone 2) and correlates with the Late Tongrian Sands and Marls of Oude Biesen in NE Belgium. This facilitates other correlations between Early Oligocene deposits of NW and NE Belgium. A new correlation scheme is presented.

The otolith fauna reflects the mixed sand-clay sedimentation with a dominance of sand and shows most resemblances with the fauna of the Nucula Clay. The Bassevelde Sand was formed in an open marine shelf environment at a depth of some tens of metres, under the influence of not very strong tidal currents. The sedimentation rate was not high. Production of organic material was low, probably due to a reduced content of oxygen and/or nutrients. The strong Rupelian affinities of the otolith fauna suggest similar temperatures. The sharp fall in temperature must have taken place between deposition of the Grimmeringen and Bassevelde Sands.

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SAMENVATTING

Gedurende een aantal jaren is het Zand van Bassevelde ontsloten geweest in de zuidelijke bouwput voor de tunnel onder de Rupel en het direkt ten zuiden daarvan liggende Zeevaartkanaal. De tunnel vormt een belangrijke schakel in de rijksweg nr. 177, lopende van Antwerpen via Boom naar Brussel. De bouwput was gelegen aan de zuidzijde van het Zeevaartkanaal ter plaatse van de toekomstige toegang tot de tunnel, in de gemeente Ruisbroek. Het grootste gedeelte van het beschreven materiaal werd verzameld tijdens akties van en voor het Rijksmuseum van Geologie en Mineralogie te Leiden.

Het Zand van Bassevelde vormt de onderste afzetting van de Formatie van Zelzate (Jacobs, 1978a; zie tabel 1), en bestaat te Ruisbroek uit drie gedeelten: een onderste, voornamelijk zandig gedeelte waarin grote kalkzandsteenconcreties met mollusken voorkomen; een middelste, sterk kleiig gedeelte waarvan geen fossielen bekend zijn; en een bovenste, weer voornamelijk zandig gedeelte. Dit bovenste gedeelte is het langst en het best ontsloten geweest en vrijwel al het verzamelde materiaal is daaruit afkomstig.

Er werd in totaal materiaal uit minstens 3500 kg sediment verzameld, waarin een otolietenfauna van 24 soorten werd aangetroffen. Hieronder bevinden zich zeven nieuwe soorten: *Semeniolum rupelense*, *Palaeogadus ruisbroekensis*, "*Enchelyopus*" *dorsoplicatus*, *Ectomirhamphus hinsberghi*, *Acanthatrigma biangulata*, *Gymnammodytes arnoldmuelleri* en "*Lepidorhombus*" *compressus*. Er worden vier nieuwe genera beschreven: *Semeniolum*, *Otarionichthys*, *Ectomirhamphus* en *Acanthatrigma*.

Het Zand van Bassevelde behoort tot de *Palaeogadus ruisbroekensis* Range Zone (otolietzone 2, Gaemers, in druk) en kan gecorreleerd worden met de Zanden en Mergels van Oude Biessen in NE-België. Deze afzettingen zijn in het Laat-Tongrien gevormd. Dank zij deze correlatie kunnen ook andere vroeg-oligocene afzettingen van noordwest en noordoost België beter gecorreleerd worden (zie tabel 1).

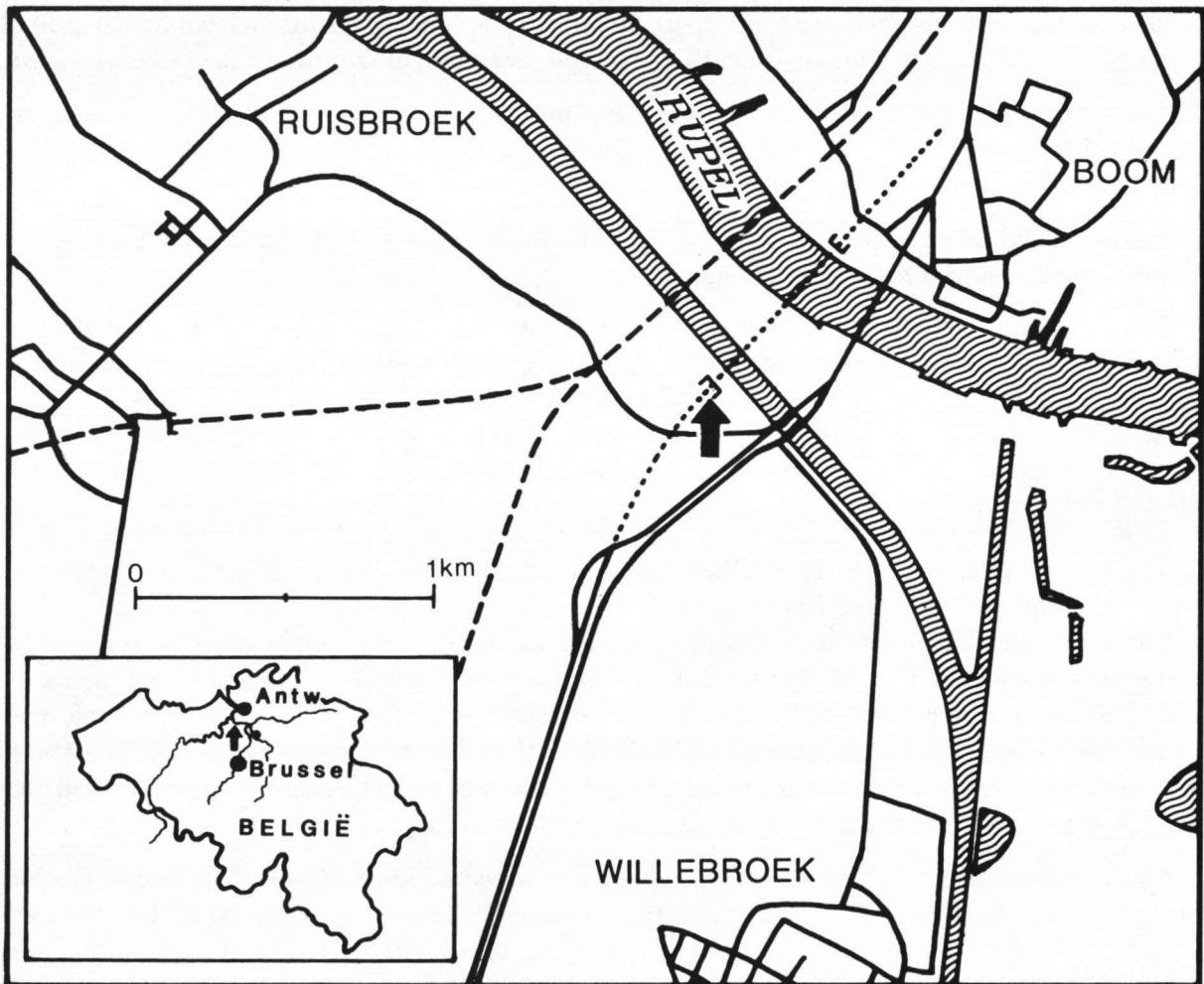
De beervisfauna weerspiegelt de bodemomstandigheden: een gemengde zandklei-sedimentatie waarbij het zand domineert. De drie meest algemene soorten leven boven zandbodems. Enkele minder algemene soorten prefereren zachte kleibodems. Er bestaat een grote overeenkomst tussen de otolietenfauna's van het Zand van Bassevelde en de Nuculaklei. Dit is grotendeels het resultaat van op elkaar gelijkende bodemomstandigheden van een gemengde zandklei-sedimentatie.

Het Zand van Bassevelde werd afgezet in een open marien shelf-milieu op een diepte van enkele tientallen meters, onder de invloed van sublittorale getijdestromingen. De sedimentatiesnelheid was niet erg groot. De produktie van organisch materiaal was laag, wat waarschijnlijk te wijten was aan een laag zuurstof- en/of voedselgehalte. De otolietenfauna vertoont sterke Rupelien-affiniteiten die wijzen op overeenkomstige watertemperaturen. De grote temperatuursverlaging in de oceanen die in het begin van het Oligoceen plaatsvond, kan dus tussen de afzetting van het Zand van Grimmeringen en die van het Zand van Bassevelde geplaatst worden.

INTRODUCTION

During a number of years an exposure in clayey sands of an Oligocene age existed 1.5 km E of the village of Ruisbroek, directly S of the municipality of Boom, province of Antwerpen, Belgium (map-

sheet 1:25.000 23/3-4 Boom-Mechelen). Lambert co-ordinates $x = 196.875$, $y = 148.875$. In the first years it was a deep elongate pit in which a tunnel element was built for a tunnel underneath the river Rupel and the "Zeevaartkanaal", a canal just S of the river Rupel. The tunnel replaces two bridges in the motor-way nr. 177 situated about 250 m to the E (fig. 1). The first fossil material was collected in the construction pit in May 1973 and May 1974 by Messrs A.W. Janssen, M. C. Cadée, V.W.M. van Hinsbergh and the author. At that time only the uppermost 1 to 1.5 metres of the Oligocene deposits were exposed. During some years the pit was inaccessible because it had been inundated. After transportation of the tunnel element the exposure was pumped dry again and the profile of the motor-way was excavated, so that about 4 metres of Oligocene deposits were visible near by the southern entrance of the Rupel tunnel. Again most sediment samples and fossils were collected from the uppermost 1 to 1.5 metres as the concentration of molluscs was higher than in the lower part of the section. Mr T.J. Bor collected a sample of 200 kg (weight of the moist sediment) on March 19, 1980. He washed the sediment carefully at home. Mr M. van den Bosch and RGM personnel washed a sample of about 1500 kg with a motor pump on a 0.5 mm mesh in the spring of 1980. On several occasions, in March and May 1980, and in April 1981 Mr A. W. Janssen collected mainly molluscs in the sediment



Text-fig. 1. Locality map of the temporary exposure at the southern entrance of the Rupel tunnel (indicated with an arrow).

which contained also otoliths. Finally the author, assisted by Mr C.P. Barnard (RGM), collected two samples, each of about 750 kg, for the RGM collection on the eastern slope near the entrance of the tunnel on April 8, 1981. These samples were taken resp. about 0.5-1 m and 1-1.5 m below the base of the Quaternary deposits. The samples were washed with a motor pump on a 0.5 mm mesh.

The mollusc fauna from the Bassevelde Sand will be described by Mr A.W. Janssen, the elasmobranch teeth by Mr M. van den Bosch.

ACKNOWLEDGEMENTS

Thanks are due to the contracting consortium building the Rupel tunnel for their continued permission to collect the samples.

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Recent otoliths, indispensable for comparison purposes were donated by Mr J. Bauza-Rullan (Palma de Mallorca, Spain), the late Mr J.E. Fitch (San Pedro, California), Dr D. Nolf (Brussel, Belgium) and Dr W. Schwarzahns (Hamburg, F.R.G.).

I am thankful to Messrs W.A.M. Devilé and B.F.M. Collet (both RGM), respectively for preparing the photographs and for drawing text-figure 1.

Finally I wish to thank the Niels Stensen Stichting in Amsterdam for the stipend granted to me; during the stipend period I could collect two large sediment samples yielding an important number of otoliths.

BIOSTRATIGRAPHY

The Oligocene deposits of the southern entrance of the Rupel tunnel belong to a new biozone, the *Palaeogadus ruisbroekensis* Range Zone (otolith zone 2; Gaemers, in press). The key species is a member of the *Palaeogadus emarginatus* lineage and probable represents the first stage of this lineage. Its descendant *P. emarginatus* Koken occurs in the Late Oligocene (Chattian) and some Middle Oligocene (Rupelian) otoliths are known which are also considered to belong to the same species (see Gaemers & van Hinsbergh, 1978. Müller, 1983, pl. 24, fig. 2, non fig. 1). The Middle and Late Oligocene otoliths of this lineage are larger, thinner and more strongly ornamented than *P. ruisbroekensis*, so that the latter species can be recognized easily.

Otolith zone 2 is preceded by the *Lagophycis praecognatus* Range Zone (otolith zone 1) which corresponds to the Latdorfian. Otoliths of this biozone are known from the type of this stage at Latdorf and from Westeregeln (German Democratic Republic; Koken, 1891), from the Brandhorst Schichten at the Doberg near Bünde (Federal Republic of Germany; Gaemers, in press), from Hückelhoven (FRG; Schwarzahns, 1977), from the Grimmertingen Sand at Grimmertingen (Belgium; Nolf, 1974; Gaemers, in press), and from the Early Oligocene of the South Limburg airport at Beek

(the Netherlands; unpublished). The otolith assemblage in the Latdorfian deposits always differs from that of otolith zone 2 in comprising a large number of members of Eocene lineages, notably Ophidiiformes. The occurrence during the Latdorfian of a new, still undescribed *Palaeogadus* species, a forerunner of *P. compactus* (present in otolith zones 2-5), also indicates that the Latdorfian is older than otolith zone 2.

The *Palaeogadus ruisbroekensis* Range Zone is succeeded by the *Parvicolliolus minutulus* Lineage Zone (otolith zone 3) corresponding to the base of the Rupelian deposits (Berg Sand, Nucula Clay and basal part of Boom Clay in Belgium; see Gaemers, in press). Otolith zone 3 is younger than the Oligocene deposits at Ruisbroek because *P. minutulus* appears at the beginning of the Rupelian and the *Palaeogadus emarginatus* lineage shows further development.

Thus it can be concluded that the Oligocene deposits at Ruisbroek are younger than any known Latdorfian and older than any known Rupelian deposit. Their age can be described as Late Tongrian, the Early Tongrian being the equivalent of the Latdorfian. The completely decalcified Neerrepen Sand in Belgian Limburg probably belongs to the Latdorfian together with the Grimmertingen Sand. In the borings at Beek airport namely a fossiliferous silty clay (probably the lateral equivalent of the Grimmertingen Sand) gradually passes into a fossiliferous fine sand (probably the equivalent of the Neerrepen Sand). Both clay and sand contain a Latdorfian otolith assemblage (unpublished data).

This would imply that the Oligocene deposits at Ruisbroek were deposited synchronously with the Atuatuca Formation (Henis Clay + Sands and Marls of Oude Biesen; Janssen, van Hinsbergh & Cadée, 1976) of the Tongeren area in NE Belgium. Additional support for this idea is given by the occurrence of *Ectomirhamphus hinsberghi* n. sp. at Ruisbroek and in the Sands and Marls of Oude Biesen near Tongeren. This species is unknown from other Tertiary deposits in the North Sea Basin.

The same conclusion was reached by van den Bosch (1982) who found agreement between the elasmobranch fauna with Dasyatidae of the Atuatuca Formation described by Bor (1980) and the fauna of Ruisbroek. On the other hand the elasmobranch fauna of the phosphorite bed at the base of the Boom Clay at Sint Niklaas and the type of the Berg Sand at Berg resemble one another so much that these deposits were formed at the same time. From this van den Bosch (1982) concluded that the Atuatuca Formation is older than the base of the Boom Clay at Sint Niklaas.

LITHOSTRATIGRAPHY

The Oligocene of the Rupel tunnel at Ruisbroek consists of clayey glauconitic sands which are strongly mottled and homogenized by bioturbation. Primary sedimentary structures have completely been wiped out. The sands are poorly sorted, mainly very fine to medium, with some coarse grains. It is characterized by a mollusc fauna containing the pectinid *Hilberia stettinensis* (von Koenen, 1868) (see Janssen, 1982). The aragonitic fossils have suffered more or less from dissolution. Further decay of calcareous fossils may have occurred by oxidation of indigenous pyrite in the sediment. The Oligocene deposits are overlain by about 13 m of Quaternary deposits, of which the lower 9 m consist of (sometimes gravelly) sands built up of cross-beddings and channels.

The Oligocene deposits belong to the Bassevelde Sand described by Gulinck (1969a, b). Before the construction of the Rupel tunnel the Bassevelde Sand was mainly known from borings and no representative collections of molluscs, elasmobranch teeth and fish otoliths were available. The

only fossils mentioned by Gulinck (1969a) are *Ostrea ventilabrum* (Goldfuss) and *Nummulites wemmelensis* de la Harp & van den Broek. Both must have been reworked from older sediments.

The erosive contact between the Bassevelde Sand and the Quaternary Sands makes it uncertain how much sediment was eroded from the top of the Bassevelde Sand. In the type area of this deposit S of Zeeuwsch-Vlaanderen the total thickness amounts to ca 18 m (Jacobs, 1978). In this more westerly area the upper part of the Bassevelde Sand gradually passes into the Watervliet Clay, which is at least 6.7 m thick (Jacobs, 1978). According to Jacobs' pre-Quaternary subcrop map (1978, fig. 28) the Watervliet Clay wedges out about 15 km W of Antwerpen. It is not yet clear if the disappearance of the Watervliet Clay to the east is caused by erosion before the deposition of the Berg Sand or by transition into a more sandy development so that the deposition of the Bassevelde Sand in the Antwerpen-Mechelen area continued up to the deposition of the Berg Sand.

Judging from the cross-sections given by Gulinck (1965, 1969b) and extending the correlation lines of the top of the s3 bed (= Bassevelde Sand) in his diagrams, the Bassevelde Sand between Boom and Willebroek is about 11 m thick and can be divided into three sub-units: 1) a lower, more sandy part; 2) a middle, more clayey and silty part, and 3) an upper, more sandy part containing some fossils. This lithological succession agrees remarkably well with a reconnaissance boring on the proposed route of the tunnel (made for groundwater filter number 4). The data of this boring were kindly handed by the contracting consortium to Mr A.W. Janssen. The boring was made on 22 September 1972. Below the surface (ca 4.5 m above Ostende Datum Level) about 4 m of unconsolidated sand, probably supplied from elsewhere, occurred. Below this followed 9 m of fine to coarse sand (Quaternary) and next 10 m fine, clayey sands and fine-sandy clays (9-19 m below Ostende Datum Level) with the same tripartition as described above.

Combining Gulinck's data and the above-mentioned boring it may be concluded that only very little, probably about 1 metre of Bassevelde Sand is missing in the boring for filter number 4, and that the fossils collected at the southern entrance of the tunnel come from the upper sandy part of the Bassevelde Sand.

In the lower sandy part very large, round to elongate concretions of lime-sandstones up to a length of 2 m occur abundantly. They contain a similar mollusc fauna as the upper sandy part of the Bassevelde Sand (pers. comm. A.W. Janssen). The concretions caused the prolonged delay in the execution of the tunnel construction, for their presence was not discovered beforehand. Very similar concretions were found during the construction of a sluice at Sluiskil (Zeeuwsch-Vlaanderen, The Netherlands) at a depth of 24 m. Fragments of these concretions, again with more or less the same mollusc fauna, are kept in the collections of the Rijksmuseum van Geologie en Mineralogie in Leiden (pers. comm. A.W. Janssen).

LITHOSTRATIGRAPHIC CORRELATIONS

The otolith fauna from the Bassevelde Sand throws new light on the stratigraphic position of this lithological unit. This has also consequences for the underlying deposits which formerly could not be interpreted sufficiently.

Jacobs (1978) correlates the Bassevelde Sand with the Early Tongrian Grimmertingen Sand on the ground of the nannoplankton flora found in the lower part of the Bassevelde Sand at a depth of 124 m in boring Kallo. Martini (in Gulinck, Drooger & Martini, 1969) identified this nannoplankton

which agrees with that of the Grimmeringen Sand. This nannoflora however must have been reworked from older deposits, for the mollusc fauna of the lower part of the Bassevelde Sand does not differ substantially from that of the upper part, whereas both are distinctly different from the mollusc fauna of the Grimmeringen Sand. A further indication for reworking is that the nannoplankton sample was taken just above a sandstone containing nummulites which undoubtedly must have been reworked from upper Eocene beds (see cross-section in Gulinck, 1969b). This sandstone occurs nearly at the base of the Bassevelde Sand.

The correlation between the Bassevelde Sand and the Grimmeringen Sand proves to be incorrect because the otolith faunas of these sands differ markedly (see chapter Biostratigraphy). Gulinck's supposition of 1965 that the s3 sand (= Bassevelde Sand) belongs to the Late Tongrian thus is confirmed by the otoliths.

A greenish grey silt with lignitic traces underlies the Bassevelde Sand. It is sometimes perforated into an underlying very stiff green clay (Gulinck, 1965: bed a3). The lithology of the clay and the lignitic traces reminds strongly of the Henis Clay in NE Belgium. Jacobs (1978) has put the Onderdijke-Adegem Clay of NW Belgium on a par with the a3 bed. He described this clay as a greyish green to bluish grey stiff clay of at most about 10 m thickness with grey peaty sand on top of it often perforating into the clay. From Jacob's detailed description I conclude that the Onderdijke-Adegem Clay is a westerly equivalent of the Henis Clay.

Arrived at this point the only conclusion that is left is that the Bassevelde Sand and Watervliet Clay together correlate with the upper part of the Atuatuca Formation, i.e. Sands and Marls of Oude Biesen and the Kerkom Sand.

The fine glauconitic sand, locally somewhat clayey, named s2 by Gulinck (1965) can be correlated with the Neerrepen Sand. The equivalent of this deposit in NW Belgium is the Buisputten Sand, which is often more clayey than the Neerrepen Sand in NE Belgium and the s2 bed in the Boom-Mechelen area (Jacobs, 1978). According to Gulinck (1965) the s2 bed in the latter area should even be an exact replica of the Neerrepen Sand.

The greenish plastic clay and silty clay named a2 is supposed to be the lateral equivalent of the Grimmeringen Sand (Gulinck, 1965). The detailed description of Jacobs' Zomergem Clay agrees with Gulinck's a2 bed. The transition from sands to clays in westward direction is not so astonishing when keeping in mind the rapid northward change from sands to clays between Grimmeringen and South-Limburg airport at Beek (unpublished data).

The older members of the Meetjesland Formation introduced by Jacobs (1978) probably all belong to the Late Eocene.

With the above discussion I come to the correlation scheme as represented in table 1, with deep respect to Gulinck who had already the same interpretation for most of the lithologic units with much less paleontologic data.

PALAEOECOLOGY

The number of otoliths per kg dry sediment is never high in the Bassevelde Sand. The sample with the highest concentration of otoliths is that collected by Mr Bor. He weighted the sediment with the natural content of moist, so that the minimum number of otoliths per 10 kg amount to

Table 1. Proposed correlation scheme for Late Eocene to Middle Oligocene deposits of NW and NE Belgium.

Deposits marked with an asterisk were introduced as new members by Jacobs (1978), just as the Meetjesland and Zelzate Formations. The Atuatuca Formation was introduced by Janssen et al. (1976). The symbols are abbreviations for the members used on the geological maps of Belgium; symbols a1, s1, a2, s2, a3 and s3 were introduced by Gulinck (1956).

In the NE part of Belgium the Grimmertingen Sand immediately rests upon Paleocene deposits; Eocene deposits are completely missing in that area.

Lithostratigraphy for NW Belgium			Lithostratigraphy for NE and Central Belgium					Stages
Formations	Members	symbols	symbols	Members	symbols	Members		
Rupel Formation	Boom Clay	R2c	R2c	Boom Clay				Rupelian
			R2b	Nucula Clay				
	Berg Sand	R1	R1	Berg Sand				
Zelzate Formation	Watervliet Clay ☆		Tg2o	Sands and Marls of Oude Biesen	Tg2k	Kerkom Sand		Late Tongrian
	Bassevelde Sand	s3						
Meetjesland	Onderdijke-Adegem Clay ☆	a3	Tg2n	Henis Clay		Boutersem Sand		Late Tongrian
	Buisputten Sand ☆	s2	Tg1d	Neerrepn Sand		Hoogbutsel Horizon		
	Zomergem Clay ☆	a2	Tg1c	Grimmertingen Sand				
	Onderdale Sand ☆	s1	Asd	Asse Sand				Latdorfian
	Ursel Clay ☆	a1	Asc	Asse Clay				(Early Tongrian)
Formation	Asse Clay	Asb	Asb					Asschian
	Asse Glauconite Sand	Asa	Asa	'bande noire'				
	Wemmel Sand/Clay	We	We	Wemmel Sand				Wemmelian
Kallo Complex								

4.4. The real amount for dry sediment will have been around 5 otoliths per 10 kg. A sediment sample of 12 kg dry weight, collected by the author, contained 2 otoliths, what means 1.7 otoliths per 10 kg. This number probably is a more realistic figure and will approach the average for the Bassevelde Sand. Estimated weights of 750 kg for the lower and higher sample collected by the author namely gives numbers of 1.8 and 1.6 otoliths per 10 kg, respectively.

For the other samples no reliable numbers can be calculated because no weights were estimated or defined, and/or the collecting techniques were different. Mr Bor's sample probably was taken from a fossil concentrate; he found not only a large number of otoliths but also an extraordinarily high number of elasmobranch teeth.

Two species clearly dominate the otolith fauna: *Palaeogadus ruisbroekensis* and *Semeniolum rupelense* (table 2); they constitute more than half to three quarters of the total number of otoliths in the various samples. The frequencies of the two species vary considerably. The frequency percentages from the composite sample of Mr Janssen can not be used, because a large part of this sample was collected from sediment surrounding larger molluscs. The differences between the other percentages may reflect variations in the original faunal composition, but another possible explanation for the differences in percentages may be that subtle changes in the predator assemblage occurred. Nearly all otoliths in the Bassevelde Sand represent small fishes probably captured by larger predators. In this respect this otolith fauna does not differ from most other fossil otolith assemblages.

"*Trachinus*" aff. *biscissus* is a good third in number of specimens, followed by *Acanthatrigla biangulata*, *Ensigadus ensiformis* and *Gymnammodytes arnoldmuelleri*. The percentages of the other species are so small and variable that it is difficult to place them in order of importance.

The fish fauna nicely reflects bottom conditions with a mixed sand-clay sedimentation in which the sand dominates. Typical sand dwellers are the three most abundant species, viz. *Palaeogadus ruisbroekensis*, *Semeniolum rupelense* and "*Trachinus*" aff. *biscissus*. The latter two are the most abundant species occurring in the Berg Sand which contains no clay at all. The first species belongs to the *P. emarginatus* lineage from which the members also prefer a sandy bottom as can be concluded from the large number of otoliths in the sandy Late Oligocene deposits and their rarity in the Rupelian clays. Other typical sand dwellers are "*Gaidropsarus*" *stettiniensis* and *Citharus belgicus* which sometimes occur in large numbers in the Berg Sand (unpublished data, van Hinsbergh collection).

Typical representatives of soft clayey bottoms are *Argentina parvula* and *Palaeogadus compactus*, and presumably *Otarionichthys occultus* and *Ensigadus ensiformis* too. The first three species are common in the Rupelian clays.

A remarkably large number of species, not less than 13, occurs in the Bassevelde Sand as well in the Nucula Clay (table 3), as a result of the fact that both deposits are mixtures of sand and clay. Mixed deposits generally attract a larger number of fish (and other) species. Several species seem to be limited to such mixed environments because they are not known outside the Bassevelde Sand and Nucula clay: ?*Etrumeus* sp., "*Enchelyopus*" *dorsoplicatus*, *Acanthatrigla biangulata* and *Gymnammodytes arnoldmuelleri*. Also *Sparidarum* sp. may belong to this group, although it is sometimes found in the Rupelian clays.

The otolith fauna of the Bassevelde Sand shows some similarities with the fauna of the Boom Clay in Belgium and the Brinkheurne Member in the Netherlands; a still smaller number of species

Table 2. Distribution of otoliths in the Late Tongrian Bassevelde Sand at Ruisbroek.

The first eight columns give the number of specimens per collection: 1a = coll. RGM, leg. M. van den Bosch; 2a = coll. RGM, leg. A.W. Janssen; 3a = coll. RGM, leg. P.A.M. Gaemers, lower sample; 4a = coll. RGM, leg. P.A.M. Gaemers, higher sample; 5a = coll. T.J. Bor; 6a = coll. P.A.M. Gaemers; 7a = coll. V.W.M. van Hinsbergh, leg. M.C. Cadée; 8a = coll. V.W.M. van Hinsbergh.

The last five columns give percentages of the species. 1b, 3b, 4b and 5b give the percentages of columns 1a, 3a, 4a and 5a, respectively; column 9: total percentages of joint columns 1a, 3a, 4a and 5a.

	1a	2a	3a	4a	5a	6a	7a	8a	1b	3b	4b	5b	9
1. <i>"Pterothrissus" umbonatus</i>	2	1	-	-	-	-	-	-	2.1	-	-	-	0.4
2. <i>"Conger" aff. glaber</i>	-	-	1	1	-	-	-	-	-	0.7	0.8	-	0.4
3. ? <i>Etrumeus</i> sp.	-	-	1	-	3	-	-	-	-	0.7	-	3.4	0.9
4. <i>Argentina parvula</i>	-	-	-	-	-	1	-	-	-	-	-	-	-
5. <i>Saurida</i> sp.	-	-	-	1	-	-	-	-	-	-	0.8	-	0.2
6. <i>Ogcocephalidarum</i> sp.	1	-	-	-	-	-	-	-	1.0	-	-	-	0.2
7. <i>Semeniolium rupelense</i>	36	122	31	49	22	9	27	7	37.5	22.8	40.2	25.0	31.2
8. <i>Palaeogadus compactus</i>	-	-	2	-	2	-	1	-	-	1.5	-	2.3	0.9
9. <i>Palaeogadus ruisbroekensis</i>	34	25	63	43	24	-	3	1	35.4	46.3	35.3	27.3	37.1
10. <i>"Gaidropsarus" stettiniensis</i>	-	-	2	1	-	-	-	-	-	1.5	0.8	-	0.7
11. <i>"Enchelyopus" dorsoplicatus</i>	-	-	-	1	-	-	-	-	-	-	0.8	-	0.2
12. <i>Palaeoraniceps</i> sp.	1	2	2	2	1	-	-	-	1.0	1.5	1.6	1.1	1.4
13. <i>Ensigadus ensiformis</i>	5	2	6	3	3	-	-	-	5.2	4.4	2.5	3.4	3.9
14. <i>Otarionichthys occultus</i>	-	1	2	3	2	-	1	-	-	1.5	2.5	2.3	1.6
15. <i>Ectomirhamphus hinsberghi</i>	1	-	1	-	-	-	-	-	1.0	0.7	-	-	0.4
16. <i>"Pontinus" ellipticus</i>	2	1	-	1	-	-	-	-	2.1	-	0.8	-	0.7
17. <i>Acanthatrigla biangulata</i>	5	3	5	5	10	1	-	-	5.2	3.7	4.1	11.4	5.7
18. <i>"Pagellus" sp.</i>	2	-	1	-	-	-	-	-	2.1	0.7	-	-	0.7
19. <i>Sparidarum</i> sp.	-	-	4	1	1	-	-	-	-	3.0	0.8	1.0	1.4
20. <i>"Trachinus" aff. biscissus</i>	6	5	9	7	10	2	2	2	6.3	6.6	5.8	11.4	7.2
21. <i>Gymnamodytes arnoldmuelleri</i>	1	1	6	2	5	-	-	-	1.1	4.4	1.6	5.7	3.2
22. <i>Scombridarum</i> sp.	-	1	-	-	-	-	-	-	-	-	-	-	-
23. <i>Citharus belgicus</i>	-	-	-	2	5	-	-	-	-	-	1.6	5.7	1.6
24. <i>"Lepidorhombus" compressus</i>	-	-	-	-	-	-	-	1	-	-	-	-	-
Total numbers	96	164	136	122	88	13	34	11	100%	100%	100%	100%	100%

Columns 1a to 8a give the number of specimens per collection (1a = coll. RGM, leg. M. van den Bosch; 2a = coll. RGM, leg. A.W. Janssen; 3a = coll. RGM, leg. P.A.M. Gaemers, lower sample; 4a = coll. RGM, leg. P.A.M. Gaemers, higher sample; 5a = coll. T.J. Bor; 6a = coll. P.A.M. Gaemers; 7a = coll. V.W.M. van Hinsbergh, leg. M.C. Cadée; 8a = coll. V.W.M. van Hinsbergh).

Columns 1b, 3b, 4b and 5b give percentages of columns 1a, 3a, 4a and 5a, respectively.

Column 9 totals percentages of columns 1a, 3a, 4a and 5a.

Table 3. Distribution of Bassevelde Sand species in other Oligocene deposits of Belgium and the Netherlands.

x = species present; * = forerunner or successor species in the same lineage present; ? = it is not certain that the same species occurs, but in any case a related species is present.

1 = Grimmertingen Sand and Early Oligocene clay at Beek: based on Nolf (1974) and unpublished data;

2 = Sands and Marls of Oude Biesen: based on van Hinsbergh (1980);

3 = Berg Sand: based on Gaemers (1972), Nolf (1977), and unpublished material (van Hinsbergh and Gaemers collections);

4 = Nucula Clay: based on Nolf (1977), this paper, and unpublished material (RGM collections, leg. M. van den Bosch & A.W. Janssen);

5 = Boom Clay and Brinkheurne + Winterswijk Members: based on Nolf (1977), Gaemers & van Hinsbergh (1978) and Steurbaut & Herman (1978).

	1	2	3	4	5
1. <i>"Pterothrissus" umbonatus</i> (Koken, 1884)	x	x	x	x	x
2. <i>"Conger" aff. glaber</i> Brzobohatý, 1967	-	-	-	-	-
3. ? <i>Etrumeus</i> sp.	-	-	-	x	-
4. <i>Argentina parvula</i> (Koken, 1891)	-	-	-	x	x
5. <i>Saurida</i> sp.	-	-	-	-	-
6. <i>Ogcocephalidarum</i> sp.	-	-	-	-	-
7. <i>Semeniolum rupelense</i> n. sp.	*	-	x	x	x
8. <i>Palaeogadus compactus</i> Gaemers & van Hinsbergh, 1978	*	-	x	x	x
9. <i>Palaeogadus ruisbroekensis</i> n. sp.	-	-	-	-	*
10. <i>"Gaidropsarus" stettiniensis</i> (Richter, 1928)	-	-	x	-	-
11. <i>"Enchelyopus" dorsoplicatus</i> n. sp.	-	-	-	x	-
12. <i>Palaeoraniceps</i> sp.	?	-	?	?	?
13. <i>Ensigadus ensiformis</i> (Steurbaut & Herman, 1978)	x	-	-	-	x
14. <i>Otarionichthys occultus</i> (Koken, 1891)	-	-	x	-	x
15. <i>Ectomirhamphus hinsberghi</i> n. sp.	-	x	-	-	-
16. <i>"Pontinus" ellipticus</i> (Koken, 1884)	-	-	x	x	x
17. <i>Acanthatrigla biangulata</i> n. sp.	-	-	-	x	-
18. <i>"Pagellus" sp.</i>	-	-	-	x	x
19. <i>Sparidarum</i> sp.	-	x	-	x	x
20. <i>"Trachinus" aff. biscissus</i> Koken, 1884	*?	-	x	x	-
21. <i>Gymnamodytes arnoldmuelleri</i> n. sp.	-	-	-	x	-
22. <i>Scombridarum</i> sp.	-	-	-	-	-
23. <i>Citharus belgicus</i> (Gaemers, 1972)	*	-	x	x	-
24. <i>"Lepidorhombus" compressus</i> n. sp.	-	-	-	-	-

1 = Grimmertingen Sand and Early Oligocene clay at Beek
2 = Sands and Marls of Oude Biesen
3 = Berg Sand
4 = Nucula Clay
5 = Boom Clay (Belgium) and Brinkheurne + Winterswijk Member (The Netherlands)

is also known from the Berg Sand. The resemblance with the Grimmertingen Sand and the Latdorfian clay of Beek is much less, especially when the percentages of the species are taken into account.

All above-mentioned deposits were formed in marine conditions with normal salinities for sea water. This is in contrast with the more or less brackish circumstances and varying salinities which existed in the area where the Sands and Marls of Oude Biesen were deposited. Although these sands and marls must have been formed simultaneously with the Bassevelde Sand only three bony fish species occur in either deposit. *Ectomirhamphus hinsberghi* is the most important one of these because it has not been found in older or younger sediments in the North Sea Basin; it may be the key species for the Late Tongrian. The occurrence of *E. hinsberghi* in the "Unterer Meeressand" of the Mainz Basin indicates that it lived in Rupelian time there, but detailed biostratigraphic correlations with the North Sea Basin are not available as yet.

The composition of the Bassevelde Sand otolith fauna demonstrates an open marine shelf environment. The fauna is rich in species, especially when realizing the total number of otoliths. Wadden environments are never very rich in species. Therefore the conclusion of Jacobs & de Coninck (1978) that the Bassevelde Sand was formed in a wadden milieu is not correct. The strong bioturbation indicates deposition below wave base. The depth of the sea probably was some tens of metres considering the abundance of *Palaeogadus* otoliths. The wide variety of grain sizes points to the influence of tidal currents with varying current velocities. The velocities and sedimentation rates were generally not very high judging from the strong bioturbation and the presence of much glauconite.

The small concentration of otoliths and other fossils in a sea with a relatively slow accumulation of sediment signifies a small production of organic material probably caused by a relatively low content of oxygen and/or nutrients in the water.

The otolith fauna has many affinities with Rupelian faunas and shows only minor resemblance with Latdorfian ones. This suggests that Late Tongrian temperatures were similar to Rupelian ones. The strong world-wide cooling of the oceans at some time in the beginning of the Oligocene must have taken place between the deposition of the Grimmertingen and Bassevelde Sands. This large climatic alteration has caused important shifts of faunal provinces resulting in strongly different faunas in the North Sea Basin before and after this event. The Bassevelde Sand contains the first post-Eocene otolith fauna of the North Sea Basin dominated by cod fishes (Gadidae) with respect to the number of specimens. This is in strong contrast with the otolith fauna of the Grimmertingen Sand which is clearly dominated by ophidiiform fishes, thus corresponding with the Eocene faunas.

SYSTEMATIC PART

The generic names of several species are placed between quotation marks. This is done to indicate that they probably belong to still undescribed fossil genera. I have chosen this system because it is shorter and more convenient than that introduced by Nolf (1974). Moreover the plural genitive of family names is avoided in species names in this way what saves some important taxonomic difficulties and discussions. For otolith-based taxa of unknown generic and familial position the collective-group name *Otolithopsis* Huddleston, 1983 is recommended.

The following abbreviations are used: OL = otolith length, OH = otolith height, OT = otolith thickness. For incomplete otoliths dimensions are placed in parentheses.

Phylum PISCES
Classis ACTINOPTERYGII
Subclassis TELEOSTEI
Ordo ALBULIFORMES
Familia PTEROTHRISIDAE
Genus *Pterothrissus* Hilgendorf, 1877

“*Pterothrissus*” *umbonatus* (Koken, 1884)

Material. – 3 poorly preserved sagittas: 2 sagittas, leg. M. van den Bosch, RGM 177 216; 1 sagitta, leg. A.W. Janssen, RGM 177 217.

Discussion – These otoliths represent adult fishes. Two of them are strongly eroded, the other has a relatively well preserved dorsal rim which does not seem to deviate essentially from typical Middle Oligocene specimens.

Some important differences exist between the two recent *Pterothrissus* species and the fossil species in the ratio between lengths of ostium and cauda, and the shape of the dorsal rim. It is therefore highly probable that the fossil species belongs to an extinct genus, the forerunner lineage of at least one of the two living species.

Ordo ANGUILLIFORMES
Familia CONGRIDAE
Genus *Conger* Oken, 1817

“*Conger*” aff. *glaber* Brzobohatý, 1967
Plate 1, figs 4, 5

Material – 2 eroded sagittas: 1 sagitta, lower sample, leg. P.A.M. Gaemers, RGM 117 218; 1 sagitta, higher sample, leg. P.A.M. Gaemers, RGM 177 219.

(OL: 6.09 mm OH: 3.06 mm OT: 1.34 mm) (pl. 1, fig. 5)

Discussion – The most complete specimen shows many resemblances with the holotype of *C. glaber* (Brzobohatý, 1967, pl. 4, fig. 8), especially concerning the general outline. An important difference however is the length-height ratio. Brzobohatý’s Czechoslovak species is distinctly more slender than the Ruisbroek otolith. Also the specimen illustrated by Steurbaut (1981) from the Early Oligocene Yrieu Sand of SW France is more slender. The Ruisbroek specimens are larger than the ones from the other two localities. If allometric growth is considerable in *C. glaber*, they all might belong to the same species. The few specimens known now however do not yet allow a firm conclusion.

Differences in the shape of the dorsal rim between the otoliths of the recent *Conger conger* (Linnaeus) and *C. glaber* make it very likely that the fossil species belongs to another, probably extinct, genus.

Ordo CLUPEIFORMES
Familia CLUPEIDAE
Genus *Etrumeus* Bleeker, 1853

?*Etrumeus* sp.
Plate 1, figs 1-3

Material – 4 fragments of sagittas: 2 sagittas, coll. T.J. Bor; 1 sagitta, leg. T.J. Bor, RGM 177 220; 1 sagitta, lower sample, leg. P.A.M. Gaemers, RGM 117 221.

Description – The rostral part of all specimens is broken hampering the identification of the otoliths. The posterior rim is rather variable and is more or less rounded. A mid-dorsal angle is present in at least three of the specimens. The posterior part of the ventral rim is rather strongly rounded indicating the presence of a discontinuity with the anterior part of this rim. The ventral rim is set with several small knobs.

Discussion – Recent otoliths of the genus *Etrumeus* possess a distinct discontinuity on the ventral rim consisting of a clear, deep incision at about half the length of the rim. This incision divides the ventral rim in a rounded posterior part and a straight anterior part. It is very likely that the Ruisbroek specimens had such a construction of the ventral rim, the more so as many well-preserved, complete specimens occur in the Middle Oligocene Nucula Clay of Belgian Limburg (undescribed material in the RGM collections) which agree in all respects.

The species *Clupeidarum atuatucae* van Hinsbergh, 1980 is another, possibly rather related, species also showing the mid-ventral incision, but having a more straight posterior rim and a dorsal rim without mid-dorsal angle.

Studying the many Recent clupeid otoliths in John Fitch's collection, those present in my own collection, and illustrations of Recent species in literature (see especially Nolf & Lapierre, 1979 and Steurbaut, 1981), indicate that no other Recent genus is known with a clear mid-ventral incision. The Clupeidae are however a large family and otoliths of many genera are still unknown.

Ordo SALMONIFORMES
Familia ARGENTINIDAE
Genus *Argentina* Linnaeus, 1758

Argentina parvula (Koken, 1891)

Material – 1 sagitta, coll. P.A.M. Gaemers.

Discussion – Shape and size of this otolith agree well with those of *A. parvula* from the Brinkheurne and Winterswijk Members of Winterswijk (Gaemers & van Hinsbergh, 1978) and the Boom Clay of Belgium. There are however differences, especially in size, with the early Eochattian specimens from Söllingen (from which Koken's types originate) and younger Chattian specimens which are considerably larger.

Ordo AULOPIFORMES
Familia SYNODIDAE
Genus *Saurida* Valenciennes, 1849

Saurida sp.
Plate 1, fig. 6

Material - 1 damaged, but uneroded sagitta, higher sample, leg. P.A.M. Gaemers, RGM 177 222.
OL: 1.15 m OH: 0.59 mm OT: 0.18 mm OL/OH: 1.95 OL/OT: 6.39.

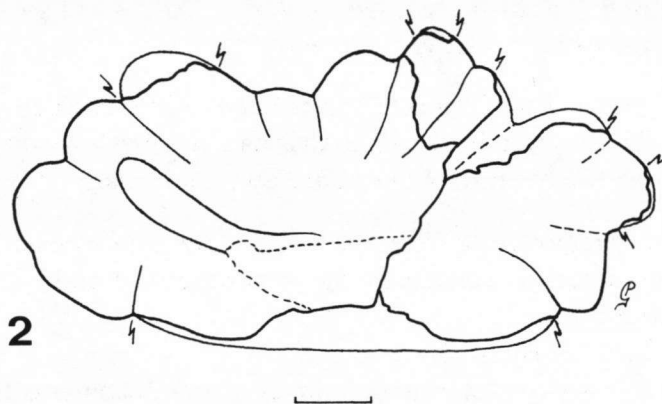
Discussion - The lower rostral part is broken, but it is still possible to get a good impression of this otolith because the more important dorsal part of the rostrum is intact. A specific identification is impossible, though probably the otolith represents a juvenile specimen of an unknown species. Moreover, equally old otoliths of the genus are still unknown.

Ordo LOPHIIFORMES
Familia OGCOEPHALIDAE

Ogcocephalidarum sp.
Text-fig. 2

Material - 1 strongly eroded, broken sagitta, leg. M. van den Bosch, RGM 177 223.

Description - Although many parts of this otolith are heavily damaged, several important characteristics are still visible. A small number of large, wide and well-developed knobs occurs along the dorsal rim and along the anterior and posterior rims. The height of the knobs is very variable giving



Text-fig. 2. Inner surface of left sagitta of *Ogcocephalidarum* sp.; 10 x.

the dorsal rim an irregular appearance. The shape and size of these knobs is characteristic for lophiiform otoliths. A part of the sulcus is still preserved. It is a substantial part of the cauda which is long, rather narrow, and with distinct boundaries, both ventrally and dorsally. Above the central part of the sulcus a conspicuous high and wide crista superior is present. The boundary between this crista and the area is sharp. The area is large and deep.

Discussion - The cauda of this otolith points to an ogocephalid species rather than a lophiid one. In Lophiidae otoliths the sulcus has a vague dorsal boundary. For comparison with a recent ogocephalid otolith one is referred to Nolf (1981) who illustrated the western Atlantic *Dibranchius atlanticus* Peters, 1875. Steurbaut (1981) and Nolf & Steurbaut (1983) gave illustrations of the Miocene *Ogcocephalidarum unicus* (Bassoli, 1906).

The otolith described here may be identical to the species *Lophius dolloi* Leriche, 1910, based on jaw fragments with teeth from the Rupelian of Belgium and recently also found in the Rupelian of the German Democratic Republic (Müller, 1983).

Ordo GADIFORMES
Familia GADIDAE
Subfamilia GADINAE
Genus *Semeniolum* n. gen.

Type species – *Semeniolum rupelense* n. sp.

Diagnosis – A genus of the subfamily Gadinae with small and thick to very thick otoliths. Rounded anterior rim. Inner surface strongly convex lengthwise. Sulcus wide. Collum narrow, obliquely triangular (most typical shape) or dumb-bell shaped, nearly always deeper than colliculi. A short pseudocolliculum may be present (usually combined with a dumb-bell shaped collum), especially in juvenile specimens. With an obliquely triangular collum the colliculi approach one another very closely or even fuse just below crista superior. Outer surface usually slightly to moderately convex, in the largest specimens sometimes strongly convex. Outer surface extends beyond dorsal and ventral rims of inner surface. Small number of knobs, usually well-developed in the centre and on central part of ventral and dorsal rims. Knobs low to strongly swollen, depending on ontogenetic stage and on species. Ventral and dorsal rims thick to very thick and blunt. Dorsal rim often slightly thinner than ventral rim. Thickest part of otoliths situated inframedially or medially.

Derivatio nominis – *Semen* (Latin) = seed, *semeniolum* = like a small seed (the otoliths resemble plant seeds, mainly because of their relative thickness).

Distribution – Early Oligocene-Late Oligocene: *Semeniolum* n. sp. 1: Younger Eochattian (Chattian A). *Semeniolum* n. sp. 2: Younger Eochattian (Chattian A). *Semeniolum rupelense* n. sp.: Late Tongrian-Early Eochattian (Chattian A). *Semeniolum* sp.: Latdorfian.

Discussion – There are four important differences between *Semeniolum* and *Trisopterus*:

- the shape of the sulcus, especially concerning the collum, colliculi and pseudocolliculum;
- the shape of the anterior rim;
- the knob pattern on the outer surface;
- the *Semeniolum* lineages are the forerunner lineages of the *Trisopterus* lineages; both groups of lineages coexist in the Eochattian.

Semeniolum n. sp. 1 and 2 will be described in a forthcoming paper. A few specimens of a *Semeniolum* sp. are available from the Grimmeringen Sand in Belgian Limburg (Latdorfian), but their state of preservation does not allow the introduction of a new species.

There are two lineages. *Semeniolum* n. sp. 1 belongs to a lineage of which no other species are known at the moment. The species is characterized by the presence of a short, distinct pseudocolliculum and a well-developed sculpture in all ontogenetic stages. Its sulcus is rather deep, the knobs are swollen, and the cristae are well-marked in adult otoliths. Smaller specimens have a rounded postdorsal angle.

All other species belong to a second lineage. A pseudocolliculum is only present in a varying number of juvenile and half-grown otoliths; it is mostly shorter, more irregular and less sculptured than in the first lineage. The sulcus is always shallow. The sculpture is rather poor and the knobs are not high, especially not in adult otoliths. Cristae are not or only weakly developed. There is no postdorsal angle.

Semeniolum rupelense n. sp.

Plate 1, figs 7-13

- 1884 *Otolithus* (*Gadidarum*) *elegans* Koken, p. 542 (partim), pl. 11, fig. 2, 4 (non fig. 3).
1891 *Otolithus* (*Gadus*) *elegans* (Koken, 1884) – Koken, p. 93 (partim, non pl. 4, fig. 1, 2; non pl. 5, fig. 6).
1910 *Gadus elegans* (Koken, 1884) – Leriche, p. 349, fig. 150a.
1928 *Otolithus* (*Gadidarum*) *elegans* Koken, 1884 – Richter, p. 140.
1942 *Gadus elegans* (Koken, 1884) – Weiler, p. 74 (partim), pl. 5, fig. 7 (non pl. 5, fig. 5, 6, 9).
1964 *Gadus elegans* (Koken, 1884) – Martini, p. 53 (partim), fig. 1 (2), 3 (3) [non fig. 2 (4)].
1965 *Gadus elegans* (Koken, 1884) – Zilch, p. 457.
1968 *Gadus elegans* (Koken, 1884) – Martini, p. 65, pl. 1, fig. 4; pl. 2, fig. 2.
1972 *Trisopterus elegans* (Koken, 1884) – Gaemers, p. 75, pl. 2, fig. 1, 2.
1974 *Trisopterus elegans* (Koken, 1884) – Schwarzahans, p. 98, fig. 70.
1977 *Trisopterus elegans* (Koken, 1884) – Nolf, p. 28 (partim), pl. 6, fig. 6-8, 10-13 (non fig. 9).
1978 *Trisopterus elegans* (Koken, 1884) – Steurbaut & Herman, tab. 2, 3, 5, 6.
1978 *Trisopterus elegans* (Koken, 1884) – Müller (partim), p. 120, pl. 3, fig. 4; pl. 4, fig. 3; pl. 7, fig. 1, 5, 7 (non pl. 3, fig. 2; pl. 7, fig. 2).
1978 *Colliolus* cf. *sculptus* (Koken, 1891) – Müller, p. 121, pl. 4, fig. 2; pl. 7, fig. 3.
1981 *Trisopterus elegans* (Koken, 1884) – Gaemers, p. 119, pl. 3, fig. 4.
1983 *Trisopterus elegans* (Koken, 1884) – Müller, p. 66, pl. 24, fig. 8; pl. 25, fig. 1, 2.

Holotype – Plate 1, fig. 7, leg. M. van den Bosch, RGM 117 224.

Paratypes – See section Material for Ruisbroek specimens; further paratypes:

Berg Sand, Keistraat, Berg, Kleine Spouwen, Belgium: 3030 sagittas, leg. M. van den Bosch & A.W. Janssen, RGM 175 459-175 461; 276 sagittas, coll. M.C. Cadée; 112 sagittas, coll. P.A.M. Gaemers; 24 sagittas, leg. A.C. Janse, coll. P.A.M. Gaemers. Nucula Clay, lowermost 1.5 m, Keistraat, Berg, Kleine Spouwen, Belgium: 33 sagittas, leg. M. van den Bosch & A.W. Janssen, 1981, RGM 177324. Nucula Clay, lowermost 1.5 m, Bosselaarstraat, Kleine Spouwen, Belgium: 86 sagittas, leg. A.W. Janssen, 1972-1973, RGM 177 319-177 323. Nucula Clay, 0.3-1.8 m above base, Mommen sand-pit, Vliermaal, Belgium: 152 sagittas, leg. A.W. Janssen, 1978, RGM 177 315-177 318. Early Rupelian Sand, Siadłó Górne, Poland: 5 sagittas, leg. A.W. Janssen, 1979, RGM 176 621, 176 622.

Locus typicus – Southern entrance of Rupel tunnel, as described in the introduction.

Stratum typicum – Oligocene, Late Tongrian, Bassevelde Sand, 6-6.5 m below Ostende Datum Level.

Derivatio nominis – Named after the river Rupel.

Diagnosis – A *Semeniolum* species with relatively long-drawn otoliths which are clearly higher than thick. Adult otoliths are much thicker than juvenile ones. Juvenile otoliths mostly possess a short, somewhat irregular and not very strongly developed pseudocolliculum, which is always absent in adult otoliths. Small number of low knobs which are most developed in the central part of the otoliths.

Material – 303 sagittas: 36 sagittas, leg. M. van den Bosch, RGM 177 224-177 228; 122 sagittas, leg. A.W. Janssen, RGM 177 229-177 235; 31 sagittas, lower sample, leg. P.A.M. Gaemers, RGM 177 236; 49 sagittas, higher sample, leg. P.A.M. Gaemers, RGM 177 237-177 239; 9 sagittas, coll.

P.A.M. Gaemers; 21 sagittas, coll. T.J. Bor; 1 sagitta, leg. T.J. Bor, RGM 177 240; 27 sagittas, leg. M.C. Cadée, coll. V.W.M. van Hinsbergh; 7 sagittas, coll. V.W.M. van Hinsbergh.

OL: 4.3 mm	OH: 1.87 mm	OT: 1.50 mm	OL/OH: 2.30	OL/OT: 2.87 (holotype)
OL: 3.83 mm	OH: 1.83 mm	OT: 1.36 mm	OL/OH: 2.09	OL/OT: 2.82 (pl. 1, fig. 8)
OL: 2.22 mm	OH: 1.14 mm	OT: 0.67 mm	OL/OH: 1.95	OL/OT: 3.31 (pl. 1, fig. 9)
(OL: 4.18 mm)	OH: 2.14 mm	OT: 1.59 mm	(pl. 1, fig. 10)	
OL: 3.26 mm	OH: 1.52 mm	OT: 1.06 mm	OL/OH: 2.14	OL/OT: 3.08 (pl. 1, fig. 13)
OL: 2.60 mm	OH: 1.14 mm	OT: 0.70 mm	OL/OH: 2.28	OL/OT: 3.71 (pl. 1 fig. 12)
OL: 1.87 mm	OH: 0.90 mm	OT: 0.46 mm	OL/OH: 2.08	OL/OT: 4.06 (pl. 1, fig. 11)

Description - Small, compact and thick otoliths. Outline oblongly pear-shaped with a rounded rostral rim and a pointed posterior end. Rims usually with a few low knobs, sometimes entirely and rather strongly knobbed. Highest part of the otolith far to the front. No dorsal angles, at best a few undulations along dorsal rim. Ventral rim very thick, dorsal rim thick. Both rims blunt. In juvenile specimens both rims may be equally thick.

Inner surface strongly convex lengthwise, nearly flat heightwise. Sulcus slightly suprmedial; especially in larger specimens shaped as in *Trisopterus*: wide and shallow, with a short, obliquely triangular collum. Cristae not or only weakly developed. Area large and shallow. Ventral furrow distinct, rather far from ventral rim, especially on the anterior part. A few vague and short furrows end at the ventral furrow.

Outer surface flat to convex lengthwise, convex heightwise. In juvenile otoliths a medial ridge may be present, in adult ones the vertical cross-section is usually a more or less regular curve, especially when knobs are weakly developed. One or a few furrows cross the whole height in the central part of the otolith. The deepest furrows and strongest knobs occur in the central part. Sometimes one or a few large knobs are situated medially but they do not form a clear medial row. Knobbing is often irregular.

Variability - Length/height and length/thickness ratios are highly variable in equal-sized specimens, but allometric growth is rather strong also. Length tends to increase more than height, but less than thickness during growth. Juvenile specimens from the Nucula Clay are remarkably thin compared with those from the Berg and Bassevelde Sands. Thus the length/thickness ratio shows stronger allometry in the Nucula Clay otoliths. Moreover in juvenile Nucula Clay specimens a pseudocolliculum is present more often than those from older deposits. Finally the maximum size of the Nucula Clay otoliths is less than that of specimens from the Berg and Bassevelde Sands.

Discussion - Koken (1884, 1891) described the species *Gadus elegans* from several Middle and Late Oligocene deposits. The type material from Söllingen is still accessible and is kept in the collections of the Museum für Naturkunde an der Humboldt-Universität, East Berlin (registration number Ot. 48). I had the opportunity to study these otoliths and to make photographs of the best preserved specimens. At first I considered this material conspecific, in accordance with Koken. When I re-examined the photographs several years later I suspected that more than one species might be represented in Koken's material. Thus I became strongly interested in the Söllingen otolith fauna. Dr R. Janssen (Senckenberg Museum, Frankfurt am Main, FRG) who had rediscovered the long forgotten railway cut exposure lent me otolith material from this classic locality, which affirmed my supposition: at least three species are present instead of one. Later Mr A.W. Janssen and myself collected large samples at Söllingen, which yielded an extensive otolith collection, suitable for a redescription of the fauna. Söllingen is the type-locality for several species described by Koken.

The Söllingen fauna proved to be of a Late Oligocene, not Middle Oligocene age as thought by Koken. Dr R. Janssen was the first to recognize this when studying the molluscs of this locality. The otoliths confirmed that the Söllingen material is younger than the Rupelian type section in Belgium. It turned out to be the oldest Late Oligocene fauna, and it is the only exposure known to me containing otoliths of this age.

The "*Gadus elegans*" material of Söllingen can be divided into two *Trisopterus* species and probably one *Semeniolum* species. I restricted the name *elegans* to the highest and thickest *Trisopterus* otoliths, a well-preserved syntype is designated here as the lectotype. It agrees with the original description of the knob pattern of *elegans*: "Die Sculptur besteht normal aus relativ grossen, besonders im vorderen Theile des Otolithen zu rundlichen Tuberkeln entwickelten Rippen, welche in eine erhöhte Mittelreihe und zwei Seitenreihen, deren dorsal gelegene stets mehr oder weniger concav ist, geordnet sind" (Koken, 1884, p. 542). Photographs of the lectotype are given here on pl. 3, fig. 10. An otolith, of which only the outer surface was illustrated (Koken, 1884, pl. 11, fig. 3) must belong to this species and may even represent the same specimen (the drawing probably is somewhat distorted, as is also the case in other otolith drawings published by Koken).

The *Trisopterus* otoliths of Söllingen are the oldest known representatives of the genus. *T. elegans* is a direct forerunner of the recent *T. luscus*. The *Semeniolum* lineages became extinct, probably at the end of the Eochattian.

Subfamilia MERLUCCIINAE

Genus *Palaeogadus* von Rath, 1859

Palaeogadus compactus Gaemers & van Hinsbergh, 1978

Plate 3, fig. 1; text-fig. 3

1978 *Palaeogadus emarginatus* (Koken, 1884) – Müller, p. 122, pl. 5, fig. 3; pl. 8, fig. 6.

1983 *Palaeogadus emarginatus* (Koken, 1884) – Müller, p. 65, pl. 24, fig. 1, non fig. 2.

Material – 2 eroded sagittas, lower sample, leg. P.A.M. Gaemers, RGM 177 241-177 242; 2 broken sagittas, coll. T.J. Bor; 1 well-preserved juvenile sagitta, leg. M.C. Cadée, coll. V.W.M. van Hinsbergh.

Discussion – Three juvenile and two adult otoliths were found. They can be separated easily from the other *Palaeogadus* species because they are distinctly higher and more thickset. Outline and shape of the sulcus (especially the very wide cauda) agree with the type material from the Rupelian. The only difference seems to be that the two larger Ruisbroek specimens are somewhat more thickset than equal-sized otoliths from the Rupelian. This may indicate that the maximum size of the Ruisbroek otoliths was less than that of Rupelian ones. More and better preserved specimens are necessary however to prove this. Fragments of otoliths of this species can be recognized by the relatively flat outer surface which has a central umbo developed as a normal knob. Ornamentation of the outer surface is more distinct and stronger developed than in *P. ruisbroekensis*.

Palaeogadus ruisbroekensis n. sp.

Plate 2, figs 1-7

Holotype – Plate 2, fig. 1, lower sample, leg. P.A.M. Gaemers, RGM 177 249.

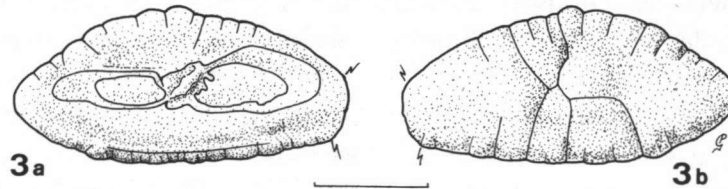
Paratypes – See section Material.

Locus typicus - Southern entrance of Rupel tunnel, as described in the introduction.

Stratum typicum - Oligocene, Late Tongrian, Bassevelde Sand.

Derivatio nominis - Named after the Ruisbroek municipality.

Diagnosis - A small *Palaeogadus* species with thick, slender otoliths with a sharp rostrum. Otoliths only slightly bent lengthwise. A conspicuous, large and usually massive knob (umbo) on the outer surface where otolith has its greatest height. An often markedly developed depression is present directly behind umbo.



Text-fig. 3. Inner (a) and outer (b) surface of right sagitta of *Palaeogadus compactus* Gaemers & van Hinsbergh, 1978 (coll. van Hinsbergh); 15 x.

Material - 193 sagittas: 34 sagittas, leg. M. van den Bosch, RGM 177 243; 25 sagittas, leg. A.W. Janssen, RGM 177 244-177 248; 63 sagittas, lower sample, leg. P.A.M. Gaemers, RGM 177 249-177 251; 43 sagittas, higher sample, leg. P.A.M. Gaemers, RGM 177 252; 2 sagittas, leg. T.J. Bor, coll. RGM 177 253-177 254; 22 sagittas, coll. T.J. Bor; 3 sagittas, leg. M.C. Cadée; coll. V.W.M. van Hinsbergh; 1 sagitta, coll. V.W.M. van Hinsbergh.

OL: 6.16 mm	OH: 2.18 mm	OT: 1.08 mm	OL/OH: 2.83	OL/OT: 5.70 (holotype)
OL: 4.61 mm	OH: 1.63 mm	OT: 0.79 mm	OL/OH: 2.83	OL/OT: 5.84 (pl. 2, fig. 6)
OL: 4.03 mm	OH: 1.40 mm	OT: 0.74 mm	OL/OH: 2.88	OL/OT: 5.45 (pl. 2, fig. 4)
OL: 4.02 mm	OH: 1.40 mm	OT: 0.73 mm	OL/OH: 2.87	OL/OT: 5.51 (pl. 2, fig. 5)
OL: 2.76 mm	OH: 1.14 mm	OT: 0.50 mm	OL/OH: 2.42	OL/OT: 5.52 (pl. 2, fig. 3)

Description - Small to medium-sized otoliths with a slender outline. Shape of outline is a low, oblique triangle. Rostrum protruding and sharply pointed. Caudal end also protruding but less sharp. Ventral rim smooth and sharp, nearly straight in the middle and regularly bent near rostrum and caudal end; sometimes an incision exists in the central part of this rim. Dorsal rim rounded and set with a variable number of knobs. Large, rounded predorsal angle. Largest and protruding knobs near predorsal angle. Juvenile otoliths have only a few low, large, rounded and unequal knobs. Young adult otoliths have largest number of more equal knobs along the whole dorsal rim; they are higher and rounded. Older adult otoliths again have less and more irregular knobs; rounded and pointed knobs occur in this growth stage. Dorsal rim concave in front of predorsal angle, slightly convex behind it.

Inner surface slightly but always distinctly convex lengthwise. Sulcus long and wide. Cauda longer and wider than ostium. Colliculi not occupying the entire ostium and cauda; towards the rims they disappear. Collum very long and narrow with a rounded indentation dorsally and an angular indentation ventrally. Pseudocolliculum pillow-shaped with a long, somewhat irregular furrow along its ventral border. Crista superior sharp and high, especially along ostium and collum. Crista inferior lower and rounder, but still well-developed along ostium and cauda. Distinct and

rather large area up to the dorsal rim, but not along entire cauda. Deepest part of area situated above ostium. Ventral furrow very close to ventral rim or absent.

Outer surface concave lengthwise behind the umbo, slightly concave to flat lengthwise before the umbo. A large and usually high and massive umbo is present below the predorsal angle. Directly behind the umbo a large, often deep and sharply bounded depression exists. In many otoliths a clear, irregular vertical furrow divides the otolith in two nearly equal parts. Other furrows and ridges most developed near predorsal angle. Otherwise only short furrows at the rims, or furrows absent.

Variability - Variability is principally restricted to the ornamentation: the number and size of the knobs and furrows and their (ir)regularities. The predorsal angle may be more or less pronounced.

Discussion - *P. ruisbroekensis* is the oldest known and also the smallest member of the *P. emarginatus* lineage. This can be concluded from the large number of otoliths available and from the development of the ornamentation during growth. The irregular, rather coarse and somewhat smoothed sculpture of the holotype indicates for instance that this specimen belonged to a full-grown fish. The maximum size of the otoliths of this species must therefore be close to that of the holotype.

The types of *P. emarginatus* are from the early Eochattian of Söllingen and not of Middle Oligocene age as stated by Koken (1891) and still accepted by Gaemers & van Hinsbergh (1978). The otoliths of this species differ from *P. ruisbroekensis* by being much larger, thinner and usually higher; the umbo is mostly less massive; the rostrum is less protruding.

Subfamilia GAIDROPSARINAE

Genus *Gaidropsarus* Rafinesque, 1810

"*Gaidropsarus*" *stettiniensis* (Richter, 1928)

Plate 2, fig. 11

1972 *Onos bergensis* Gaemers, 1972, p. 76 (partim), pl. 1, fig. 4 (non pl. 2, fig. 4, 5).

Material - 3 sagittas: 2 fragments of sagittas, lower sample, leg. P.A.M. Gaemers, RGM 177 255; 1 broken sagitta, higher sample, leg. P.A.M. Gaemers, RGM 177 256.

(OL: 4.65 mm OH: 2.21 mm OT: 0.85 mm)

Discussion - Although only defective specimens were collected, it is possible to identify the least badly preserved otolith by comparison with still unpublished material from the Berg Sand in the van Hinsbergh collection. He collected a large number of gaidropsarinid otoliths from a shell bed in the Berg Sand which proved to belong to two species, viz. "*Gaidropsarus*" *bergensis* (Gaemers, 1972) and "*G.*" *stettiniensis*. The number of specimens available in 1972 and the rather poor state of preservation of some specimens made it impossible for me to recognize more than one species. The drawing of the outer surface in Gaemers (1972, pl. 1, fig. 4) is identified as "*G.*" *stettiniensis* now. The holotype of *stettiniensis* is a large otolith, strongly bent lengthwise, with a very shallow sulcus (see description of Richter, 1928). The largest Ruisbroek specimen is smaller, but distinctly bent lengthwise, with its inner surface clearly convex and the outer surface concave. No other gaidid in the Ruisbroek fauna shows this latter feature, thus enabling the recognition of the two badly preserved fragments. The central part of their sulcus is still present. The colliculi fill the

sulcus to the level of the inner surface. The collum is short and narrow. A considerable part of the outline is visible agreeing with that of the *stettiniensis* holotype.

The outline and the strong lengthwise bending demonstrate that this species is closely related with the Recent genus *Gaidropsarus*. An essential difference is the filling of the sulcus: the Recent genus has a clearly incised sulcus. It can be concluded that "G." *stettiniensis* belongs to a still undescribed, extinct genus.

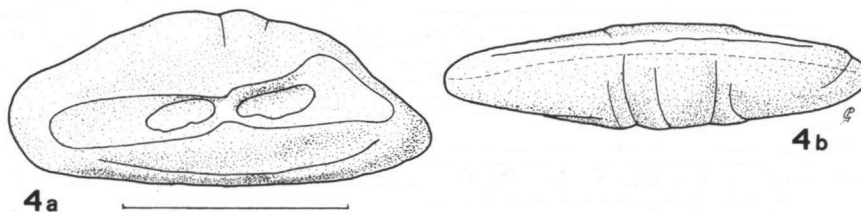
Genus *Enchelyopus* Schneider, 1801

"*Enchelyopus*" *dorsoplicatus* n. sp.

Plate 4, fig. 17; text-fig. 4

Holotype - Plate 1, fig. 14; text-fig. 4, higher sample, leg. P.A.M. Gaemers, RGM 177 257.

Paratypes - Nucula Clay, Nachtegaalstraat, Kleine Spouwen, Belgium: 1 sagitta, leg. A.W. Janssen, RGM 177 325; Nucula Clay, lowermost 1.5 m, Bosselaarstraat, Kleine Spouwen, Belgium: 1 sagitta, leg. A.W. Janssen 1972-1973, RGM 177 326; Nucula Clay, 0.3-1.8 m above base, sand-pit Mommen, Vliermaal, Belgium: 2 sagittas, leg. A.W. Janssen 1978, RGM 177 327.



Text-fig. 4. Holotype (left sagitta) of "*Enchelyopus*" *dorsoplicatus* n. sp.; (a) inner surface; (b) ventral view; 30 x.

Locus typicus - Southern entrance of Rupel tunnel, as described in the introduction.

Stratum typicum - Oligocene, Late Tongrian, Bassevelde Sand.

Derivatio nominis - *Dorsum* (Latin) = back; *plicatus* = folded. Named after the characteristic, deep middorsal furrow present in all specimens.

Diagnosis - A small gaidropsarinid species showing many resemblances with *Enchelyopus*. Otoliths relatively slender and thick, flat lengthwise. Dorsal rim with a few low, wide knobs, middorsal angle strongly rounded. A few furrows and knobs on dorsal part of outer surface; middorsal furrow always deepest.

Material - Bassevelde Sand: 1 sagitta; Nucula Clay: 4 sagittas (see sections Holotype and Paratypes).

OL: 1.87 mm OH: 0.75 mm OT: 0.47 mm OL/OH: 2.49 OL/OT: 3.98 (holotype)

OL: 2.01 mm OH: 0.85 mm OT: 0.41 mm OL/OH: 2.36 OL/OT: 4.90 (Nucula Clay)

OL: 1.81 mm OH: 0.76 mm OT: 0.42 mm OL/OH: 2.38 OL/OT: 4.31 (Nucula Clay)

Description - Small, thick otoliths with a relatively slender outline, not bent lengthwise. Shape of outline a low, nearly symmetrical triangle. Rostrum pointed to rounded. Posterior end rounded. Ventral rim smooth and rather blunt; boundary between inner and outer surface along this rim

strongly shifted towards inner surface. Dorsal rim regularly rounded and ornamented with a few low, wide knobs, so that only a very rounded middorsal angle is present.

Inner surface slightly convex lengthwise. Sulcus straight, slightly oblique: ostium medial and cauda slightly inframedial. Ostium widens towards rostrum and opens above it. Cauda widens towards posterior end but less than ostium. Cauda ends rather far from posterior end. Ostial and caudal colliculum equally short, oval in shape, and close to collum. Ostium and cauda clearly separated by a short and narrow collum having the shape of a rather low ridge. Cristae higher and sharper along ostium than along cauda. Area only present above ostium and collum. Ventral furrow close to ventral rim, especially in the middle.

Outer surface slightly convex lengthwise. Ventral part thicker than dorsal part. A few, mostly short and rather shallow furrows and low rounded knobs, especially on the dorsal part. Most obvious and deepest furrow precisely ending in the centre of the middorsal angle. One or two furrows may traverse the entire height.

Variability - The rostrum is mostly sharper than the posterior end, or vice versa. The height of the knobs is variable, but the ornamentation is never strongly developed. The Nucula Clay specimens are thinner and somewhat higher than the Ruisbroek specimen, probably reflecting some evolutionary change.

Discussion - These otoliths resemble Recent *Enchelyopus cimbrius* (Linnaeus, 1758) more than other Recent gaidropsarinids, concerning the general outline, the shape of the sulcus, and the ornamentation along the dorsal rim and on the outer surface. Other present-day species resembling the fossil specimens are *Onogadus argentatus* (Reinhardt, 1837) and *O. ensis* (Reinhardt, 1837); they are completely flat, just like the fossil otoliths, but differ in the shape of the sulcus and outline. Larger otoliths of *E. cimbrius* are always clearly bent lengthwise, but small otoliths are not or only slightly bent.

An important difference between the fossil and above-mentioned Recent otoliths is the shape of the dorsal rim. The latter ones possess a much stronger and more pointed middorsal angle, and are higher and shorter in outline. From this it can be concluded that the fossil species probably belongs to an extinct genus which may be the forerunner lineage of *Enchelyopus*. For the description of a new genus it is desirable however that more otoliths from a larger stratigraphic range are available.

Subfamilia RANICIPINAE

Genus *Palaeoraniceps* Gaemers, 1976

Palaeoraniceps sp.

Plate 2, fig. 8

Material - 8 fragments of sagittas: 1 sagitta, leg. M. van den Bosch, RGM 177 258; 2 sagittas, leg. A.W. Janssen, RGM 177 259-177 260; 2 sagittas, lower sample, leg. P.A.M. Gaemers, RGM 177 261; 2 sagittas, higher sample, leg. P.A.M. Gaemers, RGM 177 262; 1 sagitta, coll. T.J. Bor.

Discussion - As only fragments were found, of which the inner surface always is broken off, it is impossible to identify the species. The most complete fragment is illustrated. The central part of the otolith has largely been dissolved. The junctions of adjacent fans of radiating aragonite needles appear to be the most resistant elements, as they are the only remaining central parts; these junctions

coincide with the furrows on the outer surface. This pattern of dissolution is a general phenomenon among otoliths. The inner surface is apparently less resistant than the outer surface which easily can be explained by the (practically complete) lack of furrows on the inner surface.

Subfamilia PHYCINAE

Genus *Ensigadus* Gaemers, 1978

Ensigadus ensiformis (Steurbaut & Herman, 1978)

Plate 2, fig. 9, 10; plate 4, fig. 7

1978 "genus Gadidarum" *ensiformis* Steurbaut & Herman, p. 307, pl. 3, fig. 18, 19.

1978 *Ensigadus ensiformis* (Steurbaut & Herman, 1978) - Gaemers, p. 157, pl. 1, fig. 8.

Material - 19 sagittas: 5 sagittas, leg. M. van den Bosch, RGM 177 263; 2 sagittas, leg. A.W. Janssen, RGM 177 264-177 265; 6 sagittas, lower sample, leg. P.A.M. Gaemers, RGM 177 266-177 267; 3 sagittas, higher sample, leg. P.A.M. Gaemers, RGM 177 268; 1 sagitta, leg. T.J. Bor, coll. RGM 177 269; 2 sagittas, coll. T.J. Bor.

(OL: 3.74 mm) OH: 1.65 mm OT: 0.91 mm (pl. 2, fig. 9)

(OL: 2.58 mm) OH: 1.04 mm OT: 0.63 mm (pl. 2, fig. 10)

(OL: 2.40 mm) OH: 1.06 mm OT: 0.63 mm (pl. 4, fig. 7)

Discussion - Most otoliths, especially medium sized and larger specimens are damaged, missing parts of the rims, or are fragments. Only a few juvenile specimens are almost complete. Nevertheless it is possible to observe that the otoliths are highly variable in shape, especially in the following characteristics: length/height ratio, middorsal angle (present or absent), rostral part, and ornamentation on outer surface.

The general shape and the construction of the sulcus strongly resemble Recent and fossil phycinids. Therefore the species is included in this subfamily. The very sharp ventral rim and some details of the sulcus on the other hand give it a special position within this group.

In juvenile otoliths ostium and cauda can be distinguished much better than in adult otoliths, because the colliculi are not fused (although they are close together) and the ostium is somewhat wider along its ventral rim. In adult otoliths the colliculi are partly fused, and ostium and cauda are equally wide.

Familia BYTHITIDAE

Subfamilia BROSMOPHYCINAE

Tribus DINEMATICHTHYINI

Genus *Otarionichthys* n. gen.

Type species - *Otolithus* (Ophidiidarum) *occultus* Koken, 1891.

Diagnosis - A genus of the subfamily Brosmophycinae with rather large otoliths not bent lengthwise. Outline trapezoidal and nearly or completely symmetrical. Distinct rounded pre- and post-dorsal angles. Large, wide, but low knobs especially developed on the dorsal half are usually present. Rather long sulcus consisting of a large and wide ostium and a short, narrow cauda. One colliculum filling the whole sulcus. Inframedial sulcus parallel to the length axis. A low but clear ridge running

from the rostrum to the crista superior connects sulcus with outline. Ventral and dorsal rims about equally thick and sharp.

Derivatio nominis - ὠταριον (Greek) = diminutive of ear; ἰχθυς (Greek) = fish. Named after the small ear-like cauda, of which the colliculum is connected at the dorsal half of the sulcus with the ostial colliculum.

Range - Oligocene: Late Tongrian-Rupelian (otolith zones 2-5). Only the type species is known up to now.

Discussion - The trapezoid shape of the otoliths is characteristic for the subfamily Brosmophycinae as can be concluded from the illustrated species in the monographs on ophidiiform otoliths by Nolf (1980) and Schwarzhans (1981). The fossil genus seems to be closely related to *Gunterichthys longipenis* Dawson, 1966, living in the Gulf of Mexico. The sulcus of that species is essentially the same being only somewhat shorter and wider (especially the ostium is wider) in the Recent species (the best drawing of the sulcus can be found in Schwarzhans, fig. 149a). Nolf (pl. 14, fig. 5b) clearly describes and illustrates the ridge between ostium and rostrum of *G. longipenis*; this ridge has exactly the same position as in the fossil genus. The otoliths of *Gunterichthys* are slightly bent lengthwise, whereas they are completely flat in *O. occultus*. Furthermore *Gunterichthys* is not sculptured. Another difference seems to be that *Gunterichthys* is less symmetrical than the fossil form. Other brosmophycinid otoliths illustrated by Nolf and Schwarzhans are much less related to the fossil genus because they differ markedly in the construction of the sulcus, especially concerning the cauda.

Otarionichthys occultus (Koken, 1891)

Plate 3, figs 3-5

1978 Brotulidarum *occultus* (Koken, 1891) - Gaemers & van Hinsbergh, p. 18, pl. 7, figs 1, 3, 4, 8 (with further synonymy).

1980 "genus Bythitidarum" *occultus* (Koken, 1891) - Nolf, p. 127, pl. 19, fig. 15.

1981 *Oligopus occultus* (Koken, 1891) - Schwarzhans, p. 113.

Material - 9 sagittas: 1 sagitta, leg. A.W. Janssen, RGM 177 270; 2 sagittas, lower sample, leg. P.A.M. Gaemers, RGM 177 271-177 272; 3 sagittas, higher sample, leg. P.A.M. Gaemers, RGM 177 273-177 274; 2 sagittas, coll. T.J. Bor; 1 sagitta, leg. M.C. Cadée, coll. V.W.M. van Hinsbergh.

OL: 4.55 mm OH: 2.25 mm OT: 0.99 mm OL/OH: 2.02 OL/OT: 4.60 (pl. 3, fig. 3)
(OL: 3.68 mm) OH: 1.99 mm OT: 0.91 mm (pl. 3, fig. 4)
(OL: 3.65 mm) OH: 1.95 mm OT: 0.89 mm (pl. 3, fig. 5)

Discussion - There are no distinct differences in length/height or length/thickness ratios or other characteristics between the Rupelian specimens from the Boom Clay, and the Brinkheurne Member, and the Ruisbroek specimens.

Ordo BELONIFORMES

Familia HEMIRAMPHIDAE

Genus *Ectomirhamphus* n. gen.

Type species – *Ectomirhamphus hinsberghi* n. sp.

Diagnosis – A genus of the family Hemiramphidae with small, short otoliths which are slightly bent lengthwise. Outline rounded triangular with a large, rather blunt rostrum, a somewhat smaller antirostrum, and a sharp but not very deep excisura. Ostium bipartite: one part opens at the excisura and is separated by a narrow from the second part which is situated more towards ventral rim. This second part can be distinguished from the cauda (into which it passes) by a somewhat larger gentle ventral bulge and a smaller dorsal bulge.

Derivatio nominis – ἐκτομή (Greek) = excisura (Latin) = excision; ῥάμφος (Greek) = hooked beak of birds. Named after the distinct excisura of the otoliths.

Range – Oligocene: Late Tongrian (Belgium)-Rupelian (Mainz Basin).

Discussion – Recent otoliths of the following hemiramphid species are in my collection for comparison: *Arrhamphus sclerolepis* Günther, *Dermogenys pusillus* van Hasselt, *Hemiramphus far* (Forskål), *Hyporhamphus ihi*, *H. unifasciatus* (Ranzani) and *Oxyporhamphus micropterus* (Valenciennes).

Apart from *D. pusillus* these otoliths lack an excisura, but the outline of the otoliths of *D. pusillus* differs strongly from that of the fossil species. All Recent representatives have an undivided ostium, or at the most a very short first part of the ostium opening above the rostrum. An excisura is absent or dubious. The outline and the sulcus of *H. unifasciatus* resemble the fossil genus the most, but the differences are still too considerable to include the fossil species in the same genus.

***Ectomirhamphus hinsberghi* n. sp.**

Plate 4, figs 11, 12; text-fig. 5

1980 Genus aff. Hemiramphidarum sp. van Hinsbergh, p. 208, pl. 1, fig. 10, 11.

Holotype – Plate 4, fig. 11; text-fig. 5, lower sample, leg. P.A.M. Gaemers, RGM 177 275.

Paratypes – From the type locality: 1 sagitta, leg. M. van den Bosch, RGM 177 276. Sands and Marls of Oude Biesen, Atuatuca Formation, Late Tongrian, Francart clay-pit, section at the southern wall, Tongeren, Belgium, leg. A.W. Janssen, October 1977: 6 more or less eroded sagittas, 1.82-1.88 m below surface, RGM 176 514, 176 515; 2 more or less eroded sagittas, 1.55-1.60 m below surface, RGM 176 516; 3 eroded sagittas, 1.49-1.55 m below surface, RGM 176 517; 1 eroded sagitta, 1.23-1.49 m below surface, RGM 176 518. Unterer Meeressand, Rupelian, Zeilstück sand-pit, Weinheim, Mainz Basin, F.R.G., coll. D. Grüll, museum Alzey: 4 sagittas, sample 1; 14 sagittas, sample 2.

Locus typicus – Southern entrance of Rupel tunnel, as described in the introduction.

Stratum typicum – Oligocene, Late Tongrian, Bassevelde Sand.

Derivatio nominis – Named after Dr V.W.M. van Hinsbergh (Leiden) who was the first author describing otoliths of this species.

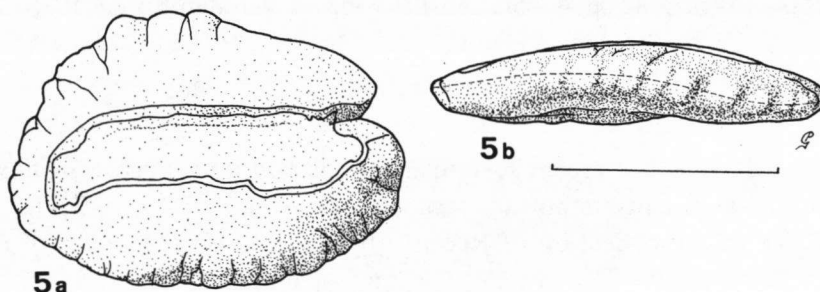
Diagnosis – A small hemiramphid species with small, short otoliths. Sulcus shallow and rather wide. Dorsal rim ornamented with a few round knobs, mainly concentrated on or near rounded postdorsal angle. Dorsal rim concave between antirostrum and postdorsal angle.

Material - (See sections Holotype and Paratypes). Bassevelde Sand: 2 sagittas; Sands and Marls of Oude Biesen: 12 sagittas; Rupelian, Mainz Basin: 18 sagittas.

OL: 1.76 mm OH: 1.23 mm OT: 0.36 mm OL/OH: 1.43 OL/OT: 4.89 (holotype)

OL: 1.62 mm OH: 1.14 mm OT: 0.35 mm OL/OH: 1.42 OL/OT: 4.63 (pl. 4, fig. 12)

Description - Small, high and rather thick otoliths which are slightly bent lengthwise. Outline rounded triangular, with a large, rather blunt rostrum, a somewhat smaller antirostrum and a sharp but not very deep excisura. Dorsal rim ornamented with a few round knobs, mainly concentrated and most developed on or near rounded postdorsal angle. Dorsal rim between antirostrum and postdorsal angle concave, between postdorsal angle and posterior end slightly convex or straight. Ventral rim regularly bent, ornamentation of small, very weakly developed knobs may be present.



Text-fig. 5. Holotype (left sagitta) of *Ectomirhamphus hinsberghi* n. sp.; (a) inner surface; (b) ventral view; 30 x.

Inner surface clearly convex. Medial sulcus shallow and rather wide to wide. Ostium bipartite: one part opens at the excisura and is often deeper than the rest of the sulcus; it is separated by a narrow from the second part which is situated more towards ventral rim. This second part can be distinguished from the cauda by a somewhat larger ventral bulge and a smaller dorsal bulge. Anterior part of cauda slightly directed towards dorsal rim, posterior part clearly bent towards ventral rim. Only one colliculum. Cristae low and rounded. No area, no ventral furrow.

Outer surface slightly concave, often accentuated by a central depression. Long, sharp and deep excisural furrow. Other radial furrows vague and short.

Variability - In juvenile specimens the excisura is less sharp but it still divides rostrum and antirostrum. The otolith illustrated by van Hinsbergh (1980, pl. 1, fig. 10) has an extremely narrow sulcus, an indistinct excisura and a small rostrum; this specimen does not seem to have been attacked by erosion very much, and therefore it must be considered an aberrant specimen. The other specimens from the Atuatuca Formation of Tongeren resemble the Ruisbroek specimens much closer, although they are often more strongly eroded.

Remark - One of the otoliths in the sample of RGM 176 515 identified by van Hinsbergh (1980) as Genus aff. *Hemiramphidarum* sp. is a strongly eroded sparid otolith which can not be identified in more detail.

Ordo SCORPAENIFORMES
Familia SCORPAENIDAE
Genus *Pontinus* Poey, 1860

"Pontinus" *ellipticus* (Koken, 1884)

Plate 3, fig. 2

- 1884 *Otolithus (Triglae) ellipticus* Koken, p. 555 (partim), pl. 12, fig. 9 (non fig. 10).
 1891 *Otolithus (Triglae) ellipticus* Koken, 1884 - Koken, p. 130, fig. 21.
 1942 *Peristedion ellipticus* (Koken, 1884) - Weiler, p. 63 (partim), pl. 4, fig. 11-13, ?15 (non pl. 12, fig. 9).
 1967 *Peristedion ellipticum* (Koken, 1884) - Brzobohatý, p. 145, pl. 4, fig. 6, 7.
 1977 "genus aff. *Lepidotrigla*" *elliptica* (Koken, 1884) - Nolf, p. 41 (partim), pl. 12, fig. 9 (non fig. 10, 11).
 1978 "genus aff. *Lepidotrigla*" *elliptica* (Koken, 1884) - Steurbaut & Herman, p. 315, 316, tab. 5, 6.
 1978 *Scorpaeniformorum ellipticus* (Koken, 1884) - Gaemers & van Hinsbergh, p. 38, pl. 15, fig. 1-7.
 1981 "genus aff. *Lepidotrigla*" *cadenati* Steurbaut, p. 63, pl. 17, fig. 7-13.

Material - 4 sagittas: 2 sagittas (one of which eroded), leg. M. van den Bosch, RGM 177 277-177 278; 1 eroded sagitta, leg. A.W. Janssen, RGM 177 279; 1 strongly eroded sagitta, higher sample, leg. P.A.M. Gaemers, RGM 177 280.

(OL: 3.35 mm OH: 1.96 mm OT: 0.61 mm).

Discussion - The otoliths of the recent Hawaiian species *Pontinus macrocephalus* (Sauvage, 1882) resemble "*P.*" *ellipticus* in many important respects (see Nolf, 1976, pl. 12, fig. 4, and Steurbaut, 1981, pl. 16, fig. 8). In my collection of Recent otoliths are also specimens of *P. macrocephalus*, kindly sent to me by the late John Fitch. The only striking differences are the thickness of the otoliths and the somewhat less deep and wide posterior part of the cauda. No other Recent scorpaeniform otoliths are known to me with such a strong resemblance as *Pontinus*. The triglid *Lepidotrigla* (as well as other real triglids) have essentially triangular otoliths and therefore do not match to the more oval otoliths of "*P.*" *ellipticus*.

It is quite possible that "*P.*" *ellipticus* belongs to an extinct genus, but more fossil and recent material is necessary to prove this. The Early Oligocene species "*L.*" *cadenati* does not differ from "*P.*" *ellipticus* in length/height ratio or other important characteristics and is therefore considered a junior synonym of the latter species.

The Miocene otoliths described by Nolf (1977) as "genus aff. *Lepidotrigla*" *elliptica* are shorter and higher, they certainly belong to another species.

Steurbaut (1981) described the new species *Pontinus robustus* from the Early Oligocene of SW France, but judging from his illustrations this species has a cottid sulcus and not a scorpaenid one.

The Middle Oligocene species "*Pontinus*" *foreyi* Nolf, 1977 shows more resemblances with Recent *Pontinus* species, but a close relationship is still questionable because this fossil species has a longer ostium and a shorter cauda.

Familia TRIGLIDAE

Genus *Acanthatrigla* n. gen.

Type species - *Acanthatrigla biangulata* n. sp.

Diagnosis - A genus of the family Triglidae with otoliths having a strongly developed posterior part with two distinct angles. Higher angle makes posterior part protruding.

Derivatio nominis - ἄκανθα (Greek) = spine, point; named after the two pointed posterior angles.

Discussion – No Recent triglid genus is known to exist which has otoliths with this type of strongly developed, protruding posterior part. Some Recent otoliths of the genus *Lepidotrigla* have a rather similar posterior part, but the higher angle is always less massive and less protruding; see for instance otoliths of *Lepidotrigla cadmani* Regan, 1915 in Nolf (1977, pl. 12, fig. 6-8) and Steurbaut (1981, pl. 16, fig. 15).

Probably *Trigla* sp. Steurbaut (1981, p. 62, pl. 16, fig. 16, non fig. 17) from the Burdigalian (Early Miocene) of the shell beds of Pont Pourquey, Saucats, SW France, belongs to the new genus. Also *Trigla ellipticus* (non Koken!) described by Bauzá-Rullán (1966) from the Pliocene of Spain may belong to the new genus.

***Acanthotrigla biangulata* n. sp.**

Plate 3, figs 6-9; pl. 4, fig. 15

Holotype – Plate 3, fig. 9, leg. A.W. Janssen, RGM 177 281.

Paratypes – From the type-locality: 2 sagittas, leg. A.W. Janssen, RGM 177 282-177 283; 5 sagittas, leg. M. van den Bosch, RGM 177 284-177 287; 5 sagittas, lower sample, leg. P.A.M. Gaemers, RGM 177 288; 5 sagittas, higher sample, leg. P.A.M. Gaemers, RGM 177 289; 10 sagittas, coll. T.J. Bor; 1 sagitta, coll. P.A.M. Gaemers. Nucula Clay, Belgium: 2 sagittas, lowermost 1.5 m, Berg, Keistraat, Kleine Spouwen, leg. M. van den Bosch & A.W. Janssen, 1971, RGM 177 328-177 329; 3 sagittas, lowermost 1.5 m, slope Bosselaarstraat, Kleine Spouwen, leg. A.W. Janssen 1972-1973, RGM 177 330; 17 sagittas, 0.3-1.8 m above base, Mommen sand-pit, Vliermaal, leg. A.W. Janssen 1978, RGM 177 331-177 336.

Locus typicus – Southern entrance of Rupel tunnel, as described in the introduction.

Stratum typicum – Oligocene, Late Tongrian, Bassevelde Sand.

Derivatio nominis – *Biangulata* (Latin) = with two angles; named after the two posterior angles.

Diagnosis – A triglid species with rather small otoliths. Sulcus relatively short. Excisura wide and shallow, rostrum large and sharply pointed, antirostrum small and rounded.

Material – Bassevelde Sand: 29 sagittas; Nucula Clay: 22 sagittas; see sections Holotype and Paratypes.

OL: 2.68 mm	OH: 1.83 mm	OT: 0.50 mm	OL/OH: 1.46	OL/OT: 5.36 (holotype)
OL: 2.36 mm	OH: 1.46 mm	OT: 0.49 mm	OL/OH: 1.62	OL/OT: 4.82 (pl. 3, fig. 7)
OL: 2.11 mm	OH: 1.54 mm	OT: 0.50 mm	OL/OH: 1.37	OL/OT: 4.22 (pl. 3, fig. 8)
OL: 1.88 mm	OH: 1.14 mm	OT: 0.50 mm	OL/OH: 1.65	OL/OT: 3.76 (pl. 4, fig. 15)
OL: 1.77 mm	OH: 1.27 mm	OT: 0.49 mm	OL/OH: 1.39	OL/OT: 3.61 (pl. 3, fig. 6)

Description – Small, high otoliths which are flat (juveniles) to clearly bent (adults) lengthwise. Outline basically triangular with a large, sharply pointed rostrum, a small rounded antirostrum, and a wide and shallow excisura. Dorsal rim with a rounded to very rounded middorsal angle and a few large but weakly developed undulations. Posterior part with two distinct, rather pointed angles; higher angle massive, making the posterior part clearly protruding. Ventral rim slightly and regularly bent.

Inner surface convex lengthwise. Sulcus medial or slightly supramedial and relatively short. Crista superior sharp and high, crista inferior low and rounded. Area large, deep and distinct. Ventral furrow strongly developed; posteriorly farther from ventral rim than in the anterior part.

Outer surface convex (juveniles) to concave (adults) lengthwise, nearly smooth, with often a weakly developed umbo and a few short and vague radiating furrows at the dorsal rim.

Variation - Length/height ratio highly variable. The two posterior angles also highly variable in size and shape. The higher angle is usually larger and more massive than the lower one, but may also be equal-sized or even smaller.

Ontogeny - An extraordinary allometric growth is present in the length/thickness ratios: the smaller specimens are relatively very thick and the larger ones relatively thin.

Ordo PERCIFORMES
Familia SPARIDAE
Genus *Pagellus* Valenciennes, 1830

“*Pagellus*” sp.
Plate 4, fig. 1

1978 *Centropristis* cf. *integer* Schubert, 1906 - Müller, p. 124, pl. 4, fig. 4; pl. 7, fig. 8.
1978 *Sparidarum* sp. 2, Gaemers & van Hinsbergh, p. 32, pl. 11, fig. 6.

Material - 3 sagittas: 1 somewhat eroded specimen and 1 fragment, leg. M. van den Bosch, RGM 177 290-177 291; 1 fragment of sagitta, lower sample, leg. P.A.M. Gaemers, RGM 177 292.
(OL: 3.67 mm) OH: 2.30 mm (OT: 0.50 m) (pl. 4, fig. 1)

Description - The most completely preserved otolith has a slender outline; a part of the large rostrum is missing. Otolith clearly bent lengthwise. Excisura deep and sharp, antirostrum large and somewhat eroded. A strongly developed postdorsal angle and a weakly developed predorsal angle are present. Dorsal rim straight between these angles, and also between postdorsal angle and posterior end; ornamented with a few low, wide undulations and knobs.

Inner surface convex lengthwise. Sulcus medial. Ostium (if completely preserved) and cauda about equally long. Area large, restricted to the part above the sulcus.

Outer surface slightly concave with a central depression. Radial furrows and knobs on whole surface but most developed on dorsal part. Ornamentation rather widely spaced.

Discussion - Outline and sulcus resemble most those in Recent *Pagellus* species, but it can not be excluded that the fossil otolith belongs to an extinct lineage.

Genus unknown

Sparidarum sp.
Plate 4, fig. 2

1978 *Serranus noetlingi* Koken, 1891 - Müller, p. 124, pl. 3, fig. 5; pl. 8, fig. 5.
1978 *Sparidarum* sp. 1, Gaemers & van Hinsbergh, p. 31, pl. 11, fig. 7.

Material - 6 sagittas: 1 somewhat broken sagitta, leg. T.J. Bor, RGM 177 293; 4 eroded and broken sagittas, lower sample, leg. P.A.M. Gaemers, RGM 177 294; 1 broken sagitta, higher sample, leg. P.A.M. Gaemers, RGM 177 295.

Discussion - This species differs from "*Pagellus*" sp. by its stronger developed ornamentation occurring along all rims. The number of knobs and furrows is larger and consequently the knobs are smaller. The dorsal rim is more or less regularly rounded. Postdorsal angle weakly developed. No predorsal angle. The preservation of the material is not good enough for a more detailed identification.

Familia TRACHINIDAE

Genus *Trachinus* Linnaeus, 1758

"*Trachinus*" aff. *biscissus* Koken, 1884

Plate 4, fig. 3-6

1972 *Trachinus mutabilis* Koken, 1891 - Gaemers, p. 78, pl. 2, fig. 8, 9.

1972 *Trachinus verus* Koken, 1891 - Gaemers, p. 79, pl. 3, fig. 1, 2.

1972 *Trachinus* aff. *verus* Koken, 1891 - Gaemers, p. 79, pl. 3, fig. 3.

1977 *Trachinus biscissus* Koken, 1884 - Nolf, p. 57 (partim), pl. 16, fig. 15, 16.

Material - 43 sagittas: 6 sagittas, leg. M. van den Bosch, RGM 177 296-177 297; 5 sagittas, leg. A.W. Janssen, RGM 177 298-177 299; 9 sagittas, lower sample, leg. P.A.M. Gaemers, RGM 177 300-177 301; 7 sagittas, higher sample, leg. P.A.M. Gaemers, RGM 177 302-177 303; 10 sagittas, coll. T.J. Bor; 2 sagittas, coll. P.A.M. Gaemers; 2 sagittas, leg. M.C. Cadée, coll. V.W.M. van Hinsbergh; 2 sagittas, coll. V.W.M. van Hinsbergh.

(OL: 3.84 mm) OH: 1.79 mm OT: 0.89 mm (pl. 4, fig. 4)

(OL: 3.43 mm) OH: 1.86 mm OT: 0.91 mm (pl. 4, fig. 3)

OL: 3.35 mm OH: 1.57 mm OT: 0.84 mm OL/OH: 2.13 OL/OT: 3.99 (pl. 4, fig. 5)

OL: 2.04 mm OH: 0.98 mm OT: 0.57 mm OL/OH: 2.08 OL/OT: 3.58 (pl. 4, fig. 6)

Discussion - The otoliths of this species are highly variable in their length/height and length/thickness ratios. This led me to the conclusion (Gaemers, 1972) that two species occur in the Berg Sand. All transitional forms occur in the Berg Sand population however, as well as in that of the Bassevelde Sand. Therefore unification to one species seems to be justified.

Trachinus biscissus and *T. verus* originally were described by Koken from Late Oligocene deposits of Söllingen and Kassel, F.R.G. These otoliths show many similarities with the older Oligocene specimens, but there are also differences, especially in their ontogenetic development. It is therefore rather probable that the Early and Middle Oligocene specimens belong to a new species. Furthermore it is highly conceivable that these otoliths are members of an extinct lineage, the fore-runner lineage of several modern trachinid species.

Familia AMMODYTIDAE

Genus *Gymnamodytes* Duncker & Mohr, 1935

Gymnamodytes arnoldmuelleri n. sp.

Plate 4, figs 8-10

1978 Inc. sed. sp. 2, Müller, p. 126, pl. 6, fig. 1; pl. 9, fig. 5.

1983 Euteleosteorum sp. 2, Müller, p. 71, pl. 25, fig. 9.

Holotype – Plate 4, fig. 8, leg. T.J. Bor, RGM 177 304.

Paratypes – From the type-locality: 1 sagitta, leg. M. van den Bosch, RGM 177 305; 1 sagitta, leg. A.W. Janssen, RGM 177 306; 6 sagittas, lower sample, leg. P.A.M. Gaemers, RGM 177 307-177 308; 2 sagittas, higher sample, leg. P.A.M. Gaemers, RGM 177 309; 2 sagittas, leg. T.J. Bor, RGM 177 310-177 311; 2 sagittas, coll. T.J. Bor. Nucula Clay, Belgium: 1 sagitta, lowermost 1.5 m, Berg, Keistraat, Kleine Spouwen, leg. M. van den Bosch & A.W. Janssen, 1971, RGM 177 337; 3 sagittas, lowermost 1.5 m, slope Bosselaarstraat, Kleine Spouwen, leg. A.W. Janssen 1972-1973, RGM 177 338-177 340; 4 sagittas, 0.3-1.8 m above base, sand-pit Mommen, Vliermaal, leg. A.W. Janssen 1978, RGM 177 341-177 343. Schluffiger brauner Sand, Rupelian, Leipzig area, G.D.R.: 1 sagitta, coll. A. Müller.

Locus typicus – Southern entrance of Rupel tunnel, as described in the introduction.

Stratum typicum – Oligocene, Late Tongrian, Bassevelde Sand.

Derivatio nominis – Named after Mr Arnold Müller, geologist and paleontologist specialized in the Rupelian of the German Democratic Republic, who gave the first description of this new species.

Diagnosis – A small *Gymnammodytes* species with otoliths which have a highly variable outline. Ostium and cauda are mostly (almost) equally long, sometimes the ostium is shorter. A few clear furrows on the central part of the outer surface; one or two furrows cross the entire height.

Material – Bassevelde Sand: 15 sagittas; Nucula Clay: 8 sagittas; see sections Holotype and Paratypes.

(OL: 1.54 mm)	OH: 0.79 mm	OT: 0.38 mm	OL/OH: ca 1.95	OL/OT: ca. 4.05 (holotype)
OL: 1.39 mm	OH: 0.67 mm	OT: 0.31 mm	OL/OH: 2.07	OL/OT: 4.48 (pl. 4, fig. 10)
OL: 1.31 mm	OH: 0.68 mm	OT: 0.33 mm	OL/OH: 1.93	OL/OT: 3.97 (pl. 4, fig. 9)

Description – Small, more or less oval to elliptical, flat otoliths. Outline highly variable. Rostrum small, mostly blunt, sometimes pointed. Excisura and antirostrum smaller than rostrum, sometimes even absent. Antirostrum rounded. Weakly developed knobs or undulations along the rims. Posterior part truncated with sharp angles with dorsal and ventral rims, regularly rounded, or asymmetrically pointed. Dorsal rim straight to rounded, ventral rim rounded.

Inner surface convex lengthwise. Sulcus supramedial. Ostium and cauda mostly equally long or nearly so, sometimes ostium clearly shorter. Ostium much deeper than cauda, because the cauda contains a colliculum that is absent in the ostium. Cristae distinct and rounded along whole sulcus. Area shallow and small. Ventral furrow variable and irregular but never very long and never completely developed.

Outer surface more or less convex to flat lengthwise, often somewhat irregular by a deep furrow. Some clear furrows, especially on the central part. One or two furrows cross entire height. A few large but generally not very high knobs. Ornamentation variable and always irregular.

Variation – The outline, and the length/height and length/thickness ratios are very variable. The different shapes of the outline remind of those in Recent *G. cicerehus* (Rafinesque, 1810).

Discussion – The strong resemblance with otoliths of Ammodytidae was already noted by Müller (1983). Otoliths of the Ammodytidae family easily can be distinguished from those of the Trachinidae family by the absence of the ostial colliculum.

The small size of the otoliths and the variability of the outline of the fossil species show a close relationship with the Recent species *G. cicereus*. The most important differences exist in the shape of the sulcus and in the ornamentation of the outer surface. The Recent species has a sulcus with an ostium clearly longer than the cauda, and a nearly smooth outer surface. The large otoliths of *G. cicereus* (larger than all available otoliths of *G. arnoldmuelleri*) have a well-developed rostrum, excisura and antirostrum.

Familia SCOMBRIDAE

Scombridarum sp.

Plate 4, fig. 16

1978 *Scombridarum* sp., Müller, p. 125, pl. 1, fig. 3; pl. 9, fig. 3.

1983 *Scombridarum* sp., Müller, p. 69, pl. 26, fig. 2a, b.

Material - 1 broken sagitta, leg. A.W. Janssen, RGM 177 312.

Discussion - A small part of the rostrum and a larger part of the antirostrum is missing of this otherwise well-preserved otolith.

Recent otoliths of the following mackerels and tunnies could be compared: *Scomber scombrus* Linnaeus, 1758, *Pneumatophorus japonicus* (Houttuyn, 1782), *Sarda chiliensis* Girard, and *Thunnus thynnus* (Linnaeus, 1758). The otoliths of the tunnies *Sarda* and *Thunnus* have a markedly different sulcus, as well as the tunny otoliths illustrated by Fitch & Craig (1964). They are therefore not closely related to the fossil otolith. The sulcuses of *Scomber* and *Pneumatophorus* show much better agreement, thus the fossil otolith probably belongs to a mackerel. The sulcus of *Scomber* essentially has the same construction; it is however deeper and wider, and has a relatively longer ostium. In the fossil otolith ostium and cauda must have been about equally long, in *Scomber scombrus* the cauda is distinctly longer than the ostium.

In *Pneumatophorus* a similar sulcus is present. It is narrow as in the fossil form but deeper, and its caudal end is more strongly curved towards the ventral rim. The postdorsal projection occurring in many specimens is missing however in the fossil otolith. The straight and steeply running posterior rim agrees with that of the Ruisbroek specimen.

The Ruisbroek otolith shows mixed characteristics of Recent *Scomber* and *Pneumatophorus*, thus it is likely that this otolith represents an extinct genus. The species *Scombridarum bisculptatus* Schwarzhan, 1974 has a much longer and deeper cauda than the Ruisbroek otolith and must belong to another lineage.

Ordo PLEURONECTIFORMES

Familia BOTHIDAE

Genus *Citharus* Röse, 1793

Citharus belgicus (Gaemers, 1972)

Plate 4, figs. 13, 14

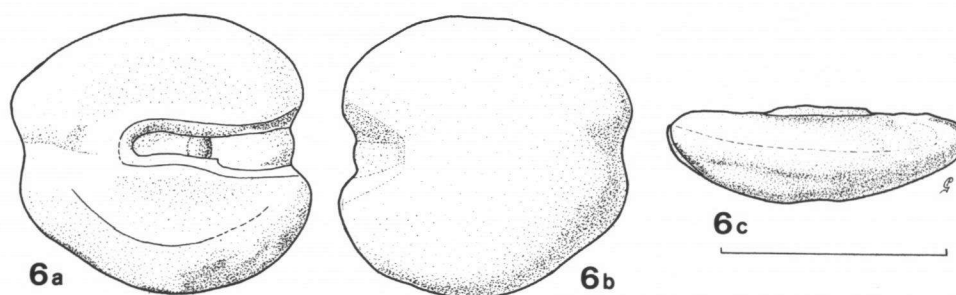
1972 *Eucitharus belgicus* Gaemers, p. 80, pl. 1, fig. 2, pl. 3, fig. 5, 6.

1977 *Citharus belgicus* (Gaemers, 1972) - Nolf, p. 60, non pl. 17, fig. 17, 18.

1983 *Citharus belgicus* (Gaemers, 1972) - Müller, p. 70.

Material - 7 sagittas, higher sample, leg. P.A.M. Gaemers, RGM 177 313; 5 sagittas, coll. T.J. Bor.

Discussion - All otoliths found are small and belong to juvenile fishes. Although the otoliths are not very well-preserved their outline is mostly still reliable and resembles that of small otoliths of *C. belgicus* from the Berg Sand of Borgloon (van Hinsbergh collection). Unpublished otoliths belonging to *Citharus*, from the Early Oligocene from borings at the South-Limburg airport at Beek, the Netherlands, are somewhat different. Specimens of the same size as the Ruisbroek specimens are on an average more thickset and have a posterior angle which is situated much closer to the dorsal rim. The otoliths from Ruisbroek are generally more slender and have their posterior angle about half-way between dorsal and ventral rims. The differences with *C. belgicus* show that the Early Oligocene *Citharus* belongs to another, still undescribed species.



Text-fig. 6. Holotype (left sagitta) of "*Lepidorhombus*" *compressus* n. sp.; (a) inner surface, (b) outer surface (c) ventral view; 30 x.

Genus *Lepidorhombus* Günther, 1862

"*Lepidorhombus*" *compressus* n. sp.

Text-fig. 6

Holotype - Text-fig. 6, leg. V.W.M. van Hinsbergh, RGM 177 314.

Locus typicus - Southern entrance of Rupel tunnel, as described in the introduction.

Stratum typicum - Oligocene, Late Tongrian, Bassevelde Sand.

Derivatio nominis - *Compressus* (Latin) = thick-set; named after the short, thick-set form of the otolith.

Diagnosis - Very short, compact, *Lepidorhombus*-like otoliths with a wide excisura, and an almost equally large and rounded rostrum and antirostrum.

Material - The holotype is the only available specimen.

OL: 1.29 mm OH: 1.25 mm OT: 0.43 mm OL/OH: 1.03 OL/OT: 3.00.

Description - A small, nearly circular left otolith, not bent lengthwise. Rostrum and antirostrum slightly damaged, but their shape and size are well recognizable; they are equally large and rounded. Excisura wide and deep; its inner width is exactly as wide as the ostium. Ventral and dorsal rims

regularly rounded and almost completely smooth. Posterior rim with two distinct angles and a shallow depression in between. The ventral angle is more rounded and massive.

Inner surface flat lengthwise and slightly heightwise. Sulcus medial. Ostium somewhat longer than cauda and equally deep. Ostium equally wide all over its length, about 1.5 times wider than cauda. Collum as wide as cauda and partly filled with a round knob. Cauda slightly bent towards ventral rim. Cristae rounded and indistinct. Area damaged: some growth layers are partially absent. Ventral furrow indistinct and situated far from ventral rim.

Outer surface convex. Thickset parts nearly in the centre, the anterior ventral part and the posterior dorsal part. A large, distinct v-shaped depression at the excisura. No furrows or knobs.

Discussion – This species shows most resemblance with the Late Miocene *Lepidorhombus kloekenhoffi* Gaemers & Schwarzhans, 1982 and the Recent *L. boscii* (Risso, 1810). Left otoliths of the latter two species are however more slender and have a much stronger developed rostrum. It is probable that the new species belongs to an extinct genus (presumably the forerunner lineage of the one to which *L. kloekenhoffi* and *L. boscii* belong) because the sulcus differs in some important respects. The two Recent species have a much shorter cauda in comparison with the length of the ostium, and the ostium widens towards the rim.

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PLATE 1

- Fig. 1a-b ?*Etrumeus* sp.
Bassevelde Sand, Ruisbroek, coll. RGM 177 220, leg. T.J. Bor; 20 x.
- Fig. 2a-b ?*Etrumeus* sp.
Bassevelde Sand, Ruisbroek, coll. T.J. Bor; 20 x.
- Fig. 3 ?*Etrumeus* sp.
Bassevelde Sand, Ruisbroek, lower sample, coll. RGM 177 221, leg. P.A.M. Gaemers; 20 x.
- Fig. 4 "*Conger*" aff. *glaber* Brzobohatý, 1967.
Bassevelde Sand, Ruisbroek, lower sample, coll. RGM 177 218, leg. P.A.M. Gaemers; 10 x.
- Fig. 5a-c "*Conger*" aff. *glaber* Brzobohatý, 1967.
Bassevelde Sand, Ruisbroek, higher sample, coll. RGM 177 219, leg. P.A.M. Gaemers; 10 x
- Fig. 6 *Saurida* sp.
Bassevelde Sand, Ruisbroek, higher sample, coll. RGM 177 222, leg. P.A.M. Gaemers; 20 x
- Fig. 7a-d *Semeniolium rupelense* n. sp. Holotype.
Bassevelde Sand, Ruisbroek, coll. RGM 177 224, leg. M. van den Bosch; 15 x.
- Fig. 8a-b *Semeniolium rupelense* n. sp. Paratype.
Bassevelde Sand, Ruisbroek, coll. RGM 177 229, leg. A.W. Janssen; 15 x.
- Fig. 9a-b *Semeniolium rupelense* n. sp. Paratype.
Bassevelde Sand, Ruisbroek, coll. RGM 177 240, leg. T.J. Bor; 15 x.
- Fig. 10a-b *Semeniolium rupelense* n. sp. Paratype.
Bassevelde Sand, Ruisbroek, coll. RGM 177 225, leg. M. van den Bosch; 15 x.
- Fig. 11a-c *Semeniolium rupelense* n. sp. Paratype.
Nucula Clay, Mommen sand-pit, Vliermaal, coll. RGM 177 315, leg. A.W. Janssen; 15 x.
- Fig. 12 *Semeniolium rupelense* n. sp. Paratype.
Nucula Clay, Mommen sand-pit, Vliermaal, coll. RGM 177 316, leg. A.W. Janssen; 15 x.
- Fig. 13a-d *Semeniolium rupelense* n. sp. Paratype.
Nucula Clay, Mommen sand-pit, Vliermaal, coll. RGM 177 317, leg. A.W. Janssen; 15 x.

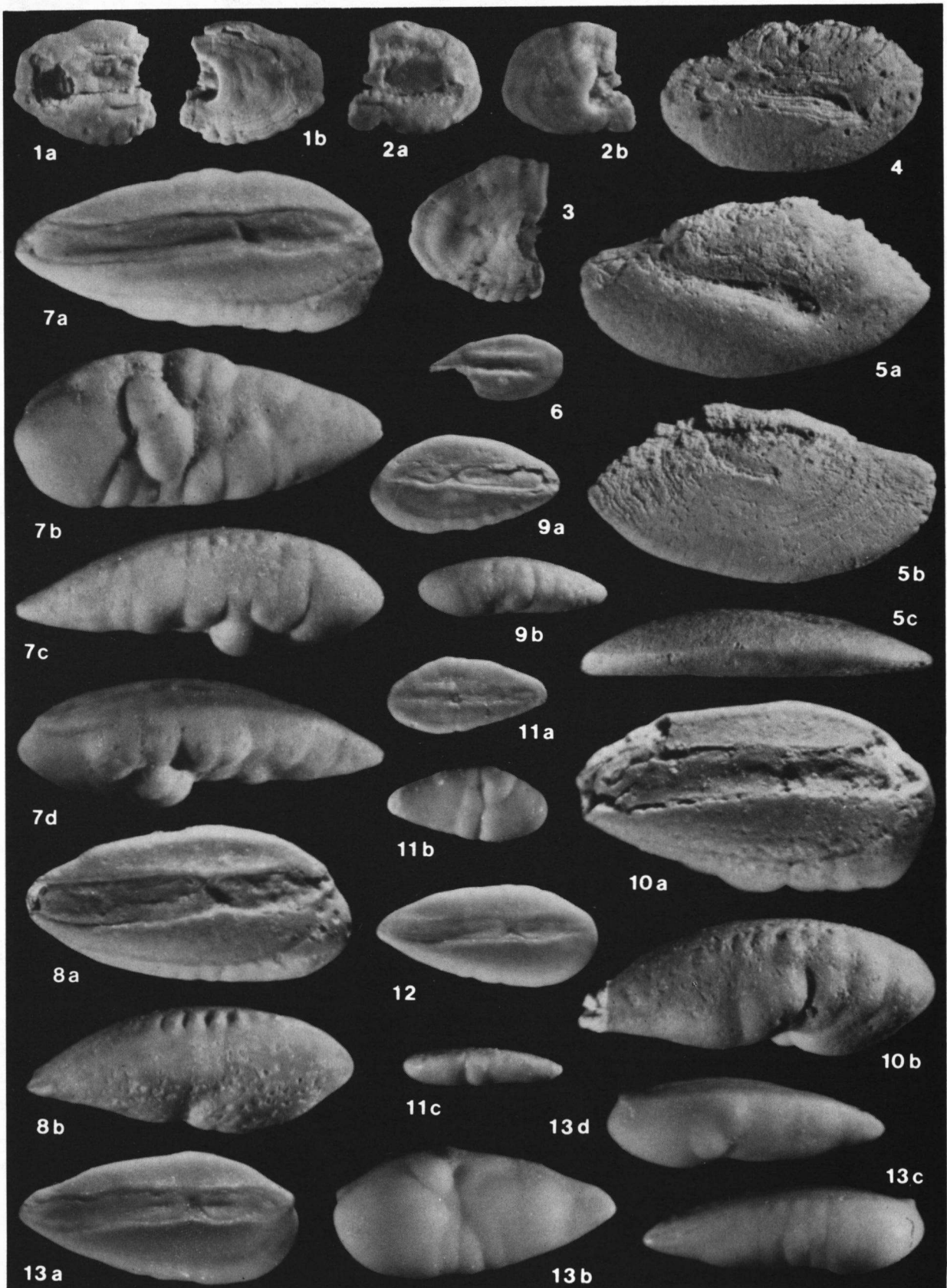


PLATE 2

All specimens figured from the Late Tongrian Bassevelde Sand of the southern entrance of the Rupel tunnel at Ruisbroek.

- Fig. 1a-d *Palaeogadus ruisbroekensis* n. sp. Holotype.
Lower sample, coll. RGM 177 249, leg. P.A.M. Gaemers; 10 x.
- Fig. 2a-d *Palaeogadus ruisbroekensis* n. sp. Paratype.
Coll. RGM 177 244, leg. A.W. Janssen; 10 x.
- Fig. 3a-c *Palaeogadus ruisbroekensis* n. sp. Paratype.
Coll. RGM 177 253, leg. T.J. Bor; 10 x.
- Fig. 4a-b *Palaeogadus ruisbroekensis* n. sp. Paratype.
Coll. RGM 177 245, leg. A.W. Janssen; 10 x.
- Fig. 5a-b *Palaeogadus ruisbroekensis* n. sp. Paratype.
Lower sample, coll. RGM 177 250, leg. P.A.M. Gaemers; 10 x.
- Fig. 6a-c *Palaeogadus ruisbroekensis* n. sp. Paratype.
Coll. RGM 177 246, leg. A.W. Janssen; 10 x.
- Fig. 7a-d *Palaeogadus ruisbroekensis* n. sp. Paratype.
Coll. RGM 177 254, leg. T.J. Bor; 10 x.
- Fig. 8a-b *Palaeoraniceps* sp.
Coll. RGM 177 259, leg. A.W. Janssen; 10 x.
- Fig. 9a-c *Ensigadus ensiformis* (Steurbaut & Herman, 1978).
Coll. RGM 177 269, leg. T.J. Bor; 15 x.
- Fig. 10a-b *Ensigadus ensiformis* (Steurbaut & Herman, 1978).
Lower sample, coll. RGM 177 266, leg. P.A.M. Gaemers; 15 x.
- Fig. 11a-c "*Gaidropsarus*" *stettiniensis* (Richter, 1928).
Higher sample, coll. RGM 177 256, leg. P.A.M. Gaemers; 10 x.

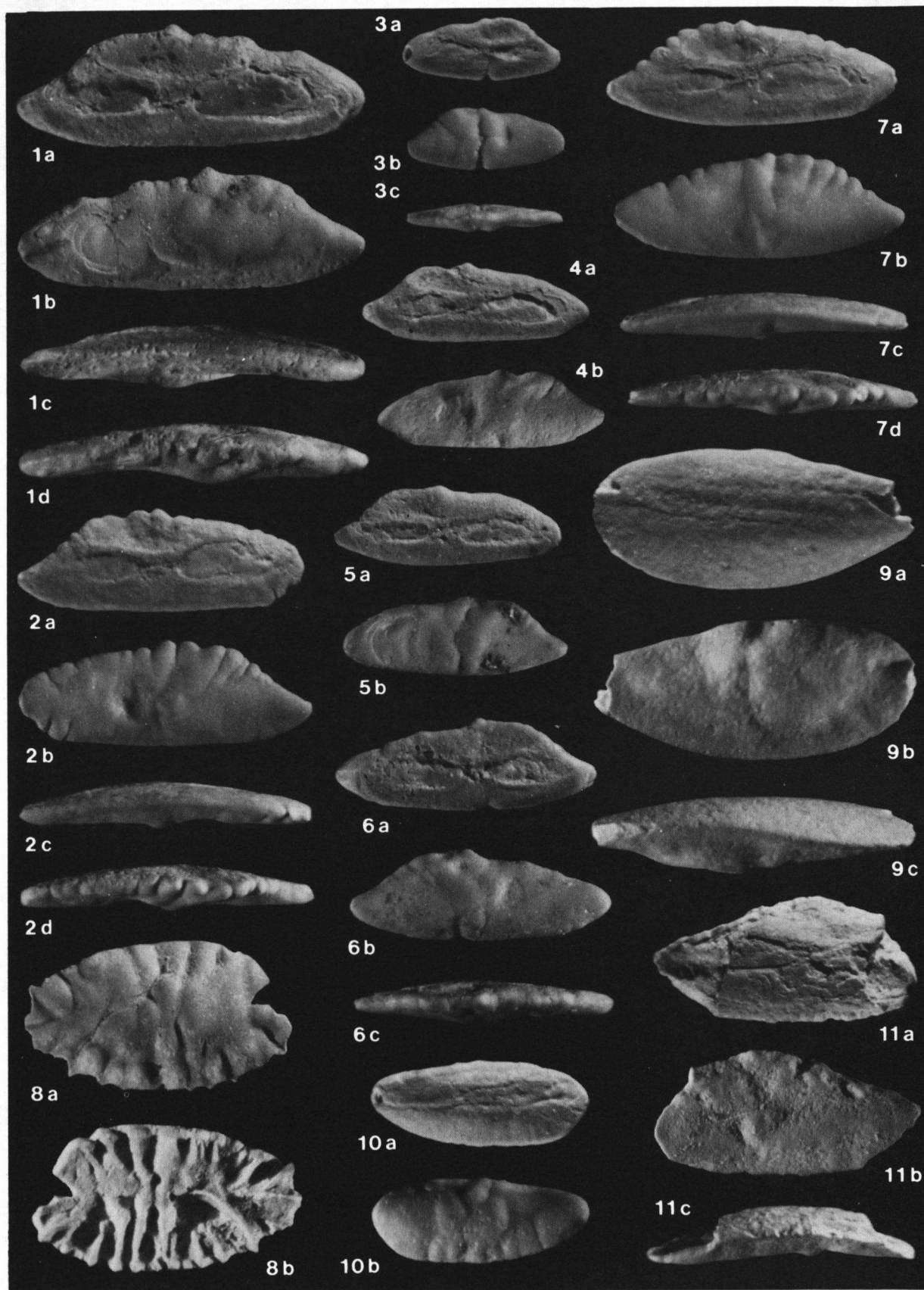


PLATE 3

All specimens figured (except fig. 10) from the Late Tongrian Bassevelde Sand of the southern entrance of the Rupel tunnel at Ruisbroek.

- Fig. 1a-c *Palaeogadus compactus* Gaemers & van Hinsbergh, 1978.
Lower sample, coll. RGM 177 241, leg. P.A.M. Gaemers; 10 x.
- Fig. 2a-b "*Pontinus*" *ellipticus* (Koken, 1884).
Coll. RGM 177 277, leg. M. van den Bosch; 15 x.
- Fig. 3a-c *Otarionichthys occultus* (Koken, 1891).
Higher sample, coll. RGM 177 273, leg. P.A.M. Gaemers; 15 x.
- Fig. 4 *Otarionichthys occultus* (Koken, 1891).
Lower sample, coll. RGM 177 271, leg. P.A.M. Gaemers; 15 x.
- Fig. 5a-c *Otarionichthys occultus* (Koken, 1891).
Coll. T.J. Bor; 15 x.
- Fig. 6 *Acanthatrigla biangulata* n. sp. Paratype.
Coll. RGM 177 284, leg. M. van den Bosch; 15 x.
- Fig. 7a-b *Acanthatrigla biangulata* n. sp. Paratype.
Coll. RGM 177 282, leg. A.W. Janssen; 15 x.
- Fig. 8a-b *Acanthatrigla biangulata* n. sp. Paratype.
Coll. RGM 177 285, leg. M. van den Bosch; 15 x.
- Fig. 9a-c *Acanthatrigla biangulata* n. sp. Holotype.
Coll. RGM 177 281, leg. A.W. Janssen; 15 x.
- Fig. 10a-b *Trisopterus elegans* (Koken, 1884). Lectotype.
Söllingen, F.R.G., early Eochattian, coll. P.M.H.U., reg. nr. Ot. 48; 10 x.

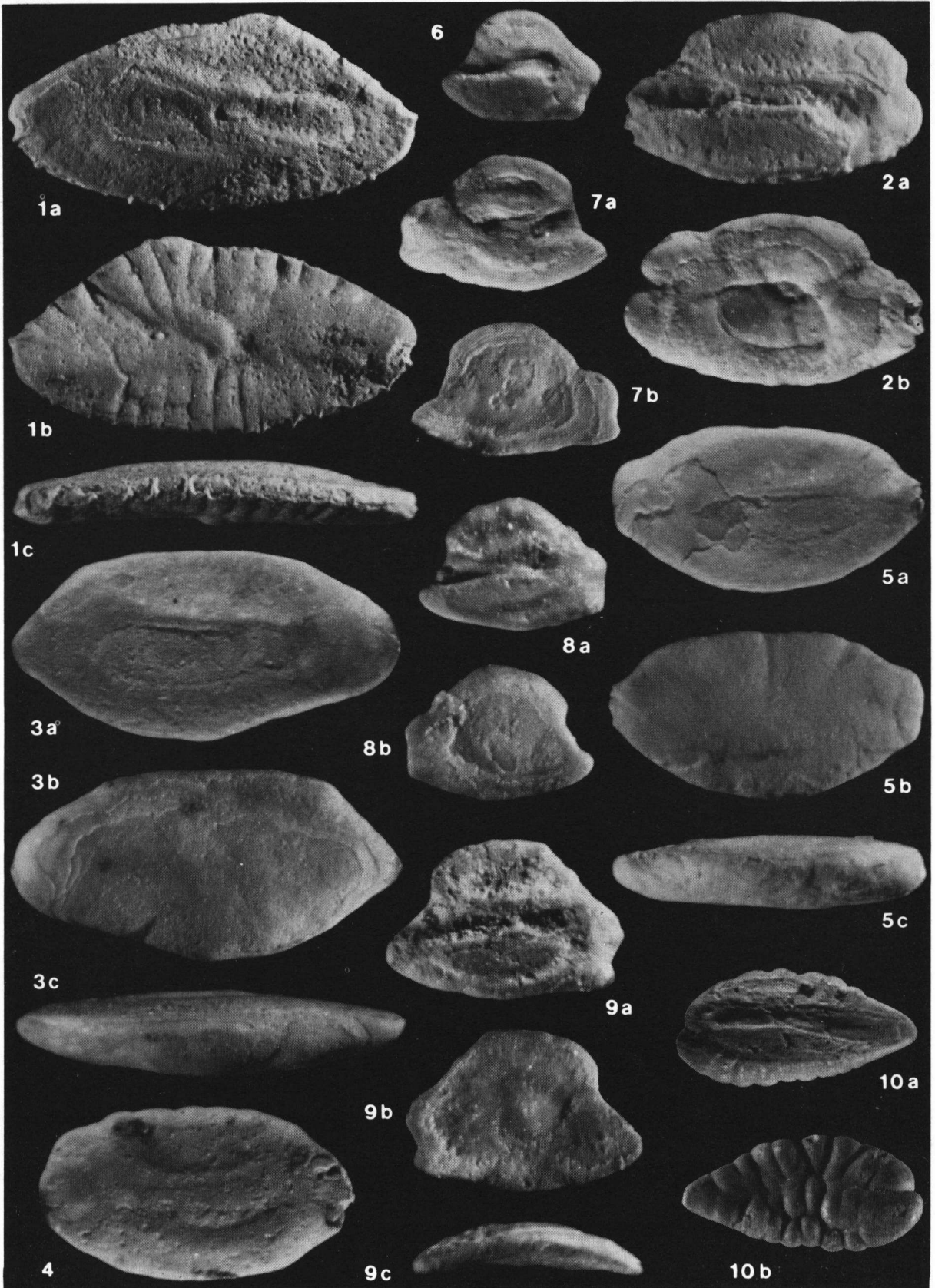


PLATE 4

All specimens figured from the Late Tongrian Bassevelde Sand of the southern entrance of the Rupel tunnel at Ruisbroek.

- Fig. 1a-b "*Pagellus*" sp.
Coll. RGM 177 290, leg. M. van den Bosch; 15 x.
- Fig. 2a-b *Sparidarum* sp.
Coll. RGM 177 293, leg. T.J. Bor; 15 x.
- Fig. 3a-b "*Trachinus*" aff. *biscissus* Koken, 1884.
Higher sample, coll. RGM 177 302, leg. P.A.M. Gaemers; 15 x.
- Fig. 4a-b "*Trachinus*" aff. *biscissus* Koken, 1884.
Coll. RGM 177 298, leg. A.W. Janssen; 15 x.
- Fig. 5a-c "*Trachinus*" aff. *biscissus* Koken, 1884.
Lower sample, coll. RGM 177 300, leg. P.A.M. Gaemers; 15 x.
- Fig. 6 "*Trachinus*" aff. *biscissus* Koken, 1884.
Coll. RGM 177 296, leg. M. van den Bosch; 15 x.
- Fig. 7a-b *Ensigadus ensiformis* (Steurbaut & Herman, 1978).
Coll. RGM 177 264, leg. A.W. Janssen; 15 x.
- Fig. 8a-b *Gymnammodytes arnoldmuelleri* n. sp. Holotype.
Coll. RGM 177 304, leg. T.J. Bor; 20 x.
- Fig. 9a-b *Gymnammodytes arnoldmuelleri* n. sp. Paratype.
Lower sample, coll. RGM 177 307, leg. P.A.M. Gaemers; 20 x.
- Fig. 10 *Gymnammodytes arnoldmuelleri* n. sp. Paratype.
Coll. RGM 177 310, leg. T.J. Bor; 20 x.
- Fig. 11a-b *Ectomirhamphus hinsberghi* n. sp. Holotype.
Lower sample, coll. RGM 177 275, leg. P.A.M. Gaemers; 15 x.
- Fig. 12a-b *Ectomirhamphus hinsberghi* n. sp. Paratype.
Coll. RGM 177 276, leg. M. van den Bosch; 15 x.
- Figs 13-14 *Citharus belgicus* (Gaemers, 1972).
Coll. T.J. Bor; 20 x.
- Fig. 15 *Acanthatrigla biangulata* n. sp. Paratype.
Coll. RGM 177 286, leg. M. van den Bosch; 15 x.
- Fig. 16a-b *Scombridarum* sp.
Coll. RGM 177 312, leg. A.W. Janssen; 15 x.
- Fig. 17a-b "*Enchelyopus*" *dorsoplicatus* n. sp. Holotype.
Higher sample, coll. RGM 177 257, leg. P.A.M. Gaemers; 15 x.

