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BONEFISH-OTOLITHS FROM THE ANVERSIAN (MIDDLE MIOCENE) OF ANTWERP *

BY

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ABSTRACT

31 species are listed from the Anversian in the neighbourhood of Antwerp (Belgium). Nine were previously known and one recorded species could not be found again.

The relative abundances of the species are discussed, especially with reference to *Trisopterus friedbergi* and small species.

The faunas from the 'Zanden van Antwerpen' (Sands of Antwerp) and the 'Zanden van Edegem' (Sands of Edegem), which make up the Anversian, are compared: the latter is older and the fauna preferred an environment close to the coast or shallow marine; the former, younger formation was formed in slightly deeper water further from the coast. The numerous otoliths of deep-sea fishes in the Sands of Antwerp must be allochthonous, although how these otoliths came to be there is still unknown.

One new species is described here, viz. *Trisopterus antwerpiensis*. This species is compared with the closely related *T. benedeni* biometrically.

The otoliths of the Sands of Antwerp confirm an age of uppermost Middle Miocene for this formation. Lowermost Middle Miocene for the Sands of Edegem is not contradicted by the otoliths found there.

INTRODUCTION

Leriche (1926) published a list of nine species of otoliths from the Anversian of Antwerp; one species, *Trisopterus benedeni*, could not be found in the material described here. The next publication did not appear until 1969, when two articles appeared describing a large quantity of new material (Gaemers, 1969a, 1969b). Good but temporary exposures, due to the construction of the E-3 motorway around Antwerp, made it possible to collect this material. The otoliths of the Sands of Edegem are from the projected E-3 route (test pit) along the right bank of the Scheldt River, Antwerp, Belgium. The specimens from the Sands of Antwerp are from the E-3 route Berchem-Borgerhout (Antwerp-East). A few specimens from the Sands of Antwerp were found in an excavation on the Ploegstraat; they are specifically mentioned in the descriptions. The descriptions of the material can be found in former publications (Gaemers, 1969a, 1969b); only the most important species are described again here. In this publication, more attention will be paid to discussion and critical remarks.

For the new species *Trisopterus antwerpiensis*, an attempt is made to use more objective criteria than was usual in the past in order to arrive at a more reliable species delimitation. Biometrical characteristics and year rings yield measurable (and therefore more objective) features for identification of the otoliths.

The sequence of the families listed and the nomenclature of families and species are mainly based on Weiler (1968). The reader is referred to Weiler (1942, p. 10) or Gaemers (1968) for terminology of the different otolith parts.

The following abbreviations are used:
L: length, H: height, T: thickness of the otolith.

Specimens stored at the Rijksmuseum van Geologie en Mineralogie (National Museum of Geology and Mineralogy) in Leiden will be marked 'coll. RGM' followed by the collection number of this museum.

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SURVEY OF THE FAUNA OF BONEFISHES

First of all it should be stressed that most samples, apart from the sparse material collected by myself, are not representative since they were collected and investigated mainly for their mollusc contents. Therefore otoliths may have been overlooked. The probability that smaller and less obvious species were overlooked is of course greater than for larger and more spectacular forms. This selection however is of little influence here, because samples collected by the author from the Sands of Antwerp, the Reinbekstufe of Dingden (W. Germany) and the Hemmoorstufe at Miste in the neighbourhood of Winterswijk (the Netherlands) were quite similar: very high percentages for the most frequently occurring species *Trisopterus friedbergi* and low percentages for small species. Very small specimens may be lost by sieving but large mistakes in the percentages are not to be expected, since whole samples (sediment included) from the Sands of Antwerp contained only a few very small otoliths (<2 mm). So far 21 species are known from the Sands of Edegem and 20 species from the Sands of Antwerp; only 10 species are present in both formations (see Table 1). One species, *Bauzaia*

TABLE I

LIST OF SPECIES

Name of species	1	2	3	4
1. (Clupeidarum) sp.	—	1	—	—
2. *Myctophum debile* (Koken, 1891)	—	5	—	×
3. *Diaphus* sp.	—	1	—	—
4. *Trisopterus friedbergi* (Chaine & Duvergier, 1928) nov. comb.	×	439	431	×
5. *Trisopterus luscus* (Linnaeus, 1758) subsp. *spectabilis* (Koken, 1891)	×	15	19	×
6. *Trisopterus antwerpiensis* nov. sp.	?	—	10	—
7. *Trisopterus* sp.	—	—	1	—
8. *Trisopterus benedeni* (Leriche, 1926) nov. comb.	?	—	—	—
9. *Merlangius cognatus* (Koken, 1891)	—	3	5	×
10. *Merlangius pseudaeglefinus* (Newton, 1891)	×	—	1	×
11. *Merluccius vulgaris* Fleming, 1828	×	5	—	×
12. *Urophycis simplex* (Koken, 1884) subsp. *elongatus* (Posthumus, 1923)	—	1	4	×
13. *Macrurus communis* (Prochazka, 1894)	—	88	5	×
14. *Macrurus debilis* (Posthumus, 1923)	—	45	—	×
15. (Macruridarum) *minisculus* (Schubert, 1906)	—	2	—	—
16. *Serranus* aff. *noetlingi* Koken, 1891	—	—	2	—
17. *Morone limburgensis* (Posthumus, 1923)	?	8	1	×
18. *Corvina speciosa* (Koken, 1884)	—	1	—	×
19. *Dentex gregarius* (Koken, 1891)	×	12	8	×
20. *Dentex nobilis* Koken, 1891 subsp. *miocenica* Weiler, 1942	×	4	—	×
21. *Dentex* sp.	—	1	—	—
22. *Pagrus* aff. *distinctus* (Koken, 1891)	—	3	—	×
23. *Trachinus acutus* Weiler, 1942	—	—	1	×
24. *Trachinus mutabilis* Koken, 1891	—	1	3	×
25. *Trachinus verus* Koken, 1891	—	—	1	—
26. *Bauzaia joachimica* (Koken, 1884)	—	—	1	×
27. *Gobius laevis* Weiler, 1942	—	—	14	×
28. *Trigla asperoides* Schubert, 1906	—	—	1	×
29. *Trigla rhombica* Schubert, 1906	—	1	13	×
30. *Peristedion acutum* Weiler, 1942	—	—	2	×
31. *Agonus primus* Koken, 1891	—	—	3	—
32. *Solea approximata* Koken, 1891	(×)	2	3	×
	Total	638	529	

Significance of the columns

1. List of species according to Leriche (1926), Anversian.
2. Total number of specimens described in this publication, Sands of Antwerp, Anversian.
3. Total number of specimens described in this publication, Sands of Edegem, Anversian.
4. List of species, according to Weiler (1942); Reinbekstufe, Dingden, Niederrhein, Germany.

joachimica, presumably comes from older sediments (Middle Oligocene).

In both formations, the following species are the most important:

1. *Trisopterus friedbergi* (GADIDAE)
2. *Trisopterus luscus spectabilis* (GADIDAE)
3. *Dentex gregarius* (SPARIDAE)

All three have recent relatives, which are known from shelf seas. The recent species most closely allied to *T. friedbergi* is *T. esmarki* which lives in the northern part of the North Sea. The recent representative of *T. luscus spectabilis*, viz. *T. luscus*, especially prefers coastal waters but can also be found in *small* numbers out from the coast. The family of Sparidae is distributed further south almost exclusively in shelf seas. The conclusion can be drawn that the Sands of Edegem and the Sands of Antwerp were both deposited on the shelf of the North Sea at that time, most probably on the higher part of it.

The other 7 species common to both formations either were too rare or their total numbers differed too much to be used for conclusions of this kind.

The marked differences between the faunas of the Sands of Edegem and the Sands of Antwerp are certainly significant, in spite of the deformation of the total picture due to collecting techniques. The numerous specimens of Macruridae in the Sands of Antwerp are most striking. In number they are second after the Gadidae. In the Sands of Edegem, Macruridae are poorly represented as far as the number of species is concerned and particularly with respect to the number of specimens. On the other hand Gobiidae and Triglidae are not rare in the Sands of Edegem, while in the Sands of Antwerp, only one highly abraded specimen of *Trigla rhombica* was found. Myctophidae are only known from the Sands of Antwerp.

The Macruridae are presently found at depths between 175–5000 meters and the Myctophidae between 700–800 meters. The latter family has many representatives which come to the surface at night. The Sands of Antwerp, in which these families are found, are however shallow marine deposits presumably not very far from the coast. This is to be concluded from many benthonic fossils and sedimentary data. How these deep-sea fishes came into these shallow deposits, assuming that the fossil species had nearly the same way of life as the related living species, is a question difficult to answer. Perhaps at the time of the deposition of the Sands of Antwerp, there were currents from the deeper water toward the coast which forced the deep-living species into shallow waters. Or perhaps the edge of the shelf, and consequently also the oceanic waters, were too far away from Antwerp. A third possibility is that fishes or whales living in both deep and shallow water ate Macruridae and Myctophidae and left many of the otoliths practically unchanged in their excrements at the bottom of the shallow sea.

In the Sands of Edegem, families appear which prefer shallow, coastal waters, such as Gobiidae and Trachinidae. Triglidae are also found in deeper water. They live at present on the bottom of shelf seas (10–150 meters deep). The deep-sea species are only represented by a few specimens of one *Macrurus* species. One must assume that the Sands of Edegem were deposited closer (probably a few kilometers) to the shore than the Sands of Antwerp.

It is remarkable that *Trisopterus friedbergi* so completely dominates the thanatocoenosis. It usually makes up more than one half of the total number of specimens (45–90%).

It is not conceivable that the bonefish fauna contained such a high percentage of this single species at the time of deposition of the Sands of Edegem and the Sands of Antwerp because the Gadidae family (cod fishes) are fishes of prey, which live to an important degree on small fishes; in other words the Gadidae find themselves high on the food pyramid. One factor that may have affected the results is the short time interval between generations for many species of the Gadidae as compared with other fish families. There are more animals per unit of time when the generations of a species succeed each other rapidly (therefore more otoliths available for fossilization) than for a species with long generations. Another factor might be that smaller otoliths are less able to resist chemical breakdown (for example solution) and/or physical breakdown (for example abrasion by transport) perhaps due to their microstructure or merely their minute size. Finally there is yet another factor which is probably important but has not yet been sufficiently studied. What happens to the otoliths when fishes are eaten? The only thing known is that otoliths are well-preserved in the food remains of sea-gulls (Schäfer, 1966; Martini, 1966) and whales (Fitch & Brownell, 1968).

AGE OF ANVERSIAN BASED ON OTOLITH EVIDENCE

Most species from the Sands of Edegem and the Sands of Antwerp have a stratigraphical range including at least Middle Miocene.

In the Sands of Antwerp (Macruridarum) *miniscutus* is found, which has a known stratigraphical range of uppermost Middle Miocene to Upper Miocene.

In the Sands of Edegem *Agonus primus* is found, which to date was only known from the Middle Oligocene of Germany (Weiler, 1942); *Trachinus verus* is found from Upper Eocene up to and including lowermost Middle Miocene; *Trachinus acutus* was only known from the uppermost Middle Miocene of NW Germany (Weiler, 1942).

From these data it can be concluded that most probably the Sands of Antwerp are uppermost Middle Miocene in age. The Sands of Edegem might represent the lowermost Middle Miocene. Janssen & van der Mark (1968) arrive at the same conclusion as a result of their investigations of molluscs. Perhaps the Sands of Edegem are older (For the stratigraphy of Miocene of Belgium, see Table II).

TABLE II

UPPER MIOCENE	Zanden van Loxbergen en Diest Zanden van Deurne	Deurnian
UPPERMOST MIDDLE MIOCENE LOWERMOST MIDDLE MIOCENE	Zanden van Antwerpen Zanden van Edegem	Anversian
LOWER MIOCENE	Zanden van Houthalen —	Houthalian (Burdigalian?) Aquitanian

Stratigraphical column of the Miocene of Belgium.

TABLE III

KEY TO THE SPECIES

1. Ventral rim not or indistinctly knobbed, or at the most one knob
  2. Maximum width of ostium greater than that of cauda
    3. Cauda markedly bent to ventral side, outside with big nipple: *Corvina speciosa*
    3. Cauda slightly bent to ventral side, outside without nipple
      4. L/H=±1; abrupt transition from ostium to cauda: *Dentex gregarius*
      4. L/H=1.5—2; abrupt transition from ostium to cauda; sulcus acusticus closer to dorsal than to ventral side: *Morone limburgensis*
      4. L/H>2; more gradual transition from ostium to cauda; sulcus acusticus closer to ventral than to dorsal side: *Agonus primus*
  2. Greatest width of ostium equal to or smaller than width of cauda
    5. Sulcus acusticus slightly S-shaped
      6. Caudal and dorsal rims distinctly knobbed: *Trachinus verus*
      6. Caudal rim not knobbed, dorsal rim at the most slightly knobbed; caudal rim usually blunt: *Trachinus biscissus*
      6. Caudal and dorsal rims not knobbed; in front and in back a distinct point: *Trachinus acutus*
    5. Sulcus acusticus straight or almost straight
      7. L/H=±1
        8. Ostium and cauda distinctly separated
          9. Sulcus acusticus closer to ventral than to dorsal side: *Diaphus* sp.
          9. Sulcus acusticus approximately in the middle: *Myctophum debile*
        8. Ostium and cauda not distinctly separated
          10. Ostium closed on rostral side: *Gobius laevis*
          10. Ostium open on rostral side: *Solea approximata*
      7. L/H>1.7
        11. Width of sulcus acusticus/height of sagitta=½: *Clupea* sp.
        11. Width of sulcus acusticus/height of sagitta=1/3: *Merlangius cognatus*
        11. Width of sulcus acusticus/height of sagitta<1/4
          12. Length of ostium/length of cauda <½; sulcus acusticus closer to ventral side: *Bauzaia joachimica*
          12. Length of ostium/length of cauda >1; sulcus acusticus closer to dorsal side
            13. Two or three dorsal knobs, centrally situated: *Trisopterus* sp.
            13. More than 8 knobs along the entire length: *Trisopterus friedbergi*
1. Ventral rim, seen on inner surface, distinctly knobbed, with clear 'sharp' grooves
  14. Maximum width of ostium greater than that of cauda
    15. Sulcus acusticus distinctly S-shaped: *Trigla rhombica*
    15. Sulcus acusticus almost straight; cauda not bent to ventral side: *Trisopterus luscus spectabilis*
    15. Cauda bent to ventral side
      16. Excisura ostii distinct, deeper than grooves between knobs
        17. Caudal side pointed; outline irregular oblique hexagonal: *Pagrus* aff. *distinctus*
        17. Caudal side rounded; outline roughly elliptic: *Serranus noetlingi*
      16. Excisura ostii indistinct, at most as deep as grooves between knobs
        18. Dorsal and ventral rims with many regular and distinct small knobs: *Dentex nobilis miocenica*
        18. Dorsal and ventral rim set with a few irregular knobs
          19. Caudal and postdorsal angles rounded; postdorsal rim makes an angle of more than 60 degrees with the median line: *Dentex* sp.
          19. Caudal and postdorsal angles pointed; postdorsal rim makes an angle of 45 degrees with the median line: *Dentex gregarius*
  14. Maximum width of ostium roughly the same as that of cauda
    20. Dorsal rim smooth or with less than 4 usually indistinct knobs
      21. Sulcus acusticus distinctly closer to dorsal than ventral side

22. Very many knobs along entire ventral rim: *Urophycis simplex elongatus*
22. One central knob at ventral rim: *Trisopterus* sp.
21. Sulcus acusticus about in the middle; L/H=1—1.2
23. Outline triangular; collum narrower than ostium and cauda: *Trigla asperoides*
23. Outline roughly rounded; collum indistinct *Myctophum debile*
21. Sulcus acusticus about in the middle; L/H>2
24. Length about 2 mm; ostium less than half of total length of sagitta: *Otolithus* (Macruridarum) *minisculus*
24. Length usually 6 to 12 mm; ostium more than half of total length of sagitta: *Merlangius cognatus*
20. Dorsal rim with 5 or more distinct knobs
25. L/H=1—1.6
26. Sulcus acusticus S-shaped; outline nearly diamond-shaped; ostium wider than cauda: *Trigla rhombica*
26. Sulcus acusticus almost straight; ostium as wide as cauda, but shorter; outline ovate with pointed caudal side: *Peristedion acutum*
26. Sulcus acusticus almost straight; ostium as long and as wide as cauda; collum narrow; caudal side rounded
27. L/H=±1: *Macrurus debilis*
27. L/H=1.4—1.6: *Macrurus communis*
25. L/H>2: Gadidae
28. Outline elliptic: *Merlangius pseudaeglefinus*
28. Outline ovate
29. Preventral angle about 130 degrees; distinct postdorsal angle that makes the outline somewhat triangular: *Merluccius vulgaris*
29. No preventral angle
30. Predorsal rim usually concave; L/T<3.5: *Trisopterus luscus spectabilis*
30. Predorsal rim never concave; L/T>4.5
31. Width of ostium/maximum height of sagitta about 1/4: *Trisopterus antwerpiensis*
31. Width of ostium/maximum height of sagitta about 1/7: *Trisopterus friedbergi*

SYSTEMATIC DESCRIPTIONS

Phylum PISCES
Superclassis TELEOSTOMI (OSTEICHTYES)
Classis ACTINOPTERYGII
Subclassis TELEOSTEI
Ordo CLUPEIDA
Familia CLUPEIDAE Bonaparte, 1831

(Clupeidarum) sp.
(Pl. I, Fig. 1a, b, Pl. IV, Fig. 1a, b)

Description. – Very fragile, small otolith. Outline oval; rims smooth and very sharp, without knobbing; rostrum lost in our specimen (sharply pointed in Clupeidae). Inner surface flat; sulcus acusticus very wide and fairly deep with an asymmetrical cross-section; area distinct. Outer surface slightly convex, smooth. Some growth lines knobbed in younger stages. L: 1.2 mm (incomplete), H: 1.1 mm, T: 0.2 mm.

Material. – 1 sagitta, Sands of Antwerp, Coll. Gaemers.

Remarks. – The specimen is incomplete; front including rostrum and part of ostium is broken off. Further identification is therefore impossible without other well-preserved material.

Ordo SCOPELIFORMES
Familia MYCTOPHIDAE Gill, 1892
Genus MYCTOPHUM Rafinesque, 1810

Myctophum debile (Koken, 1891)
(Pl. I, Fig. 2a, b, Pl. IV, Fig. 3a, b)

Otolithus (Berycidarum) *austriacus* Koken, 1891, p. 122, fig. 14.

Material. – 3 sagittas, Sands of Antwerp, Coll. RGM, st. 155171, 155172. 2 sagittas, Sands of Antwerp, Coll. Gaemers.
L: 1.9 mm, H: 1.6 mm, T: 0.25 mm.

Distribution. – Lower Oligocene – Upper Miocene.

Discussion. – This species is highly variable. The delimitation of the species within the family Myctophidae is indistinct. The range of variation for recent species has not yet been sufficiently studied. The status of *M. debile* and *M. pulchrum* is questionable because intermediate forms occur which closely resemble these species. The specimens formerly ascribed to *M. austriacum* may be regarded as belonging to a subspecies of *M. debile*.

Remarks. – Gaemers (1969a) (Pl. I, Fig. 2a, b) identified an otolith as *M. debile*, but because of the presence of a pronounced postdorsal angle and a different sulcus acusticus, this otolith must be ascribed to the genus *Diaphus*. Less well-preserved specimens have lost their crenate ventral rim by erosion.

Genus DIAPHUS Eigenmann, 1891

Diaphus sp.
(Pl. I, Fig. 3a, b; Pl. IV, Fig. 2a, b)

Description. – Otolith small, fairly strong. Outline rounded, irregularly pentagonal; excisura ostii distinct; rostrum somewhat better developed than antirostrum; postdorsal angle conspicuous; postventral angle present, but less distinct than postdorsal angle; rims smooth and sharp. Inner surface flat; sulcus acusticus composed of clearly separated ostium and cauda, both being wide and shallow; sulcus acusticus

closer to ventral side than to dorsal side; cauda longer than ostium; area big and shallow; ventral furrow distinct and close to ventral rim. Outer surface convex; big caudal knob present; ostial furrow distinct. Rest of outer surface smooth.
L: 1.8 mm, H: 1.1 mm, T: 0.25 mm.

Material. – One sagitta, well-preserved, Sands of Antwerp, Coll. Gaemers.

Discussion. – The conspicuous high postdorsal angle is a characteristic feature for identification of the genus *Diaphus* (personal communication Prof. Dr. W. Weiler).

Remarks. – Former identification of this specimen: *Myctophum debile* (Gaemers, 1969a, p. 7, Pl. I, Fig. 2a, b).

Ordo GADIFORMES
Familia GADIDAE Rafinesque, 1810
Genus TRISOPTERUS

Remarks. – The recent species *Trisopterus esmarki* (Nilsson) (formerly named *Gadus esmarki*) has an otolith which resembles that of *T. friedbergi* (Pl. V, Fig. 1a, b; Pl. I, Fig. 5a, b, 6a, b, Pl. V, Fig. 2a, b, Pl. VI, Fig. 3a, b). The differences are not great. In *T. esmarki* there is a distinct predorsal angle. The sulcus acusticus lies somewhat closer to the dorsal rim and the postdorsal part is a little more pronounced and somewhat less rounded than in *T. friedbergi.* Schmidt (1968) gives a short description with pictures of *T. esmarki* found in the northern North Sea (p. 16, Pl. 3, Fig. 31). In our collection there are some otoliths of this recent species so that a direct comparison with *T. friedbergi* was possible. Probably *T. friedbergi* is an ancestor of *T. esmarki.* The resemblances are so great that we can assume that both species belong to the same genus. Therefore the genus *Gadus* is replaced by *Trisopterus* for *T. friedbergi* and all directly related animals, viz. *T. luscus, T. antwerpiensis, T. benedeni, T. sp.*

Trisopterus friedbergi (Chaine & Duvergier, 1928) nov. comb.
(Pl. I, Fig. 5a, b, 6a, b; Pl. V, Fig. 2a, b; Pl. VI, Fig. 3a, b)

Material. – A total of 870 sagittas.
253 sagittas, Sands of Antwerp, Coll. RGM, st. 155175. 58 sagittas, Sands of Antwerp, Coll. Gaemers. 128 sagittas, Sands of Antwerp, Coll. Gaemers, leg. Cadée, Ploegstraat. 350 sagittas, Sands of Edegem, Coll. RGM, st. 155176, 155177. 81 sagittas, Sands of Edegem, Coll. Gaemers, leg. Cadée.
L: 10.7 mm, H: 4.2 mm, T: 1.8 mm.
L: 6.7 mm, H: 2.7 mm, T: 1.1 mm.
The condition of preservation is usually good to very good, some specimens are eroded.

Distribution. – Lower Miocene – Upper Pliocene.

Remarks. – By far the most common species (45–90% of the total number of specimens). Rather variable in outline.

Trisopterus luscus (Linnaeus, 1758) subsp. spectabilis (Koken, 1891)
(Pl. I, Fig. 7a, b; Pl. VI, Fig. 4a, b, 5)

Material. – 14 sagittas, Sands of Edegem, Coll. RGM, st. 155178, 155179. 5 sagittas, Sands of Edegem, Coll. Gaemers, leg. Cadée. 12 sagittas, Sands of Antwerp, Coll. RGM, st. 155180, 155181. 3 sagittas, Sands of Antwerp, Coll. Gaemers, leg. Cadée (1 specimen from Ploegstraat).
L: 8.7 mm, H: 3.6 mm, T: 2.7 mm.
L: 6.5 mm, H: 3.0 mm, T: 1.9 mm.
Condition of preservation: specimens from the Sands of Edegem usually very good; specimens from the Sands of Antwerp very good to bad.

Distribution. – Middle Miocene.

Discussion. – Rather variable otoliths. *Gadus luscus* is at present included in the genus *Trisopterus* (Schmidt, 1968). See also discussion under *Trisopterus.*
For *T. luscus spectabilis,* the rostral part of the dorsal rim is concave; it is slightly convex in *T. luscus.*

Trisopterus antwerpiensis nov. spec.
(Pl. I, Fig. 8a, b; Pl. V, Fig. 3a, b)

Type. – Holotype: Pl. V, Fig. 3a, b, Coll. RGM, st. 155173.

Locus typicus. – Test pit for E-3 tunnel, right bank of Scheldt River, Antwerp, Belgium.

Stratum typicum. – Miocene, Sands of Edegem.

Derivatio nominis. – Named after Antwerp, where the species was first found.

Diagnosis. – A big *Trisopterus* species with very pronounced knobs and furrows. Postdorsal angle situated at the caudal end. Caudal part of ostium bends distinctly to ventral side. Sulcus acusticus wide. Cauda short. The most rostral part of dorsal rim is nearly straight and the longest.

Description. – Otoliths robust and strong. Outline narrowly pear-shaped with an occasionally blunt rostral point; postdorsal angle situated at the caudal end. Usually inconspicuous; dorsal rim sharp and knobbed; rostral part of dorsal rim the longest and usually entirely straight, sometimes slightly bent; ventral rim blunt, highly knobbed.
Inner surface convex, slightly curved along the long axis; sulcus acusticus wide and deep, approximately halfway between dorsal and ventral rims or slightly closer to ventral rim; caudal part of the long ostium distinctly bent toward ventral side; cauda short;

collum (connection between cauda and ostium) slightly shorter than cauda; furrow under the collum very distinct and deep; postcaudal depression conspicuous, small furrows traverse the crista superior which gives a knobbed impression; these furrows also traverse the sulcus acusticus; area big; ventral furrow very distinct, traversed to some extent by minute ventral furrows.

Outer surface convex; entire surface highly sculptured; peripheral knobs in obvious pattern nearly perpendicular to the rims; central knobs clustered.
L: 11.8 mm, 5.2 mm, T: 2.4 mm.

Material. – 8 sagittas, Sands of Edegem, Coll. RGM, st. 155173, 155174 (3 young specimens and 5 adult specimens which are either very well-preserved or considerably eroded). 1 sagitta, Sands of Edegem, Coll. Gaemers, leg. Janssen (well-preserved).

Distribution. – Lowermost Middle Miocene: Antwerp (Sands of Edegem).

Discussion. – Variation in width is not very great. *Trisopterus antwerpiensis* shows striking similarities with *T. benedeni.* The most important differences are the following: In *T. antwerpiensis* the ostium is obviously bent, the rostral part of the dorsal rim is usually entirely straight and the postdorsal angle is situated far to the rear. In *T. benedeni* the ostium is barely bent, the rostral part of the dorsal rim is almost always distinctly bent and the postdorsal angle lies much further foreward. For this species the degree of variation is much greater, particularly for the outline. In Figs. 1a and 1b length-height and length-thickness ratios are plotted, regular curves or lines result and if the two species are taken together, the curve of one species is continuous with and complementary to the curve of the other. From this, one might conclude that the two species should be lumped together. Other data however do not permit this. From these biometrical data we may only conclude that both species are closely related.

From the number of year rings on a damaged specimen of *T. benedeni* (Sands of Kattendijk) (height: 3.7 mm, calculated length: 7.8 mm) which is one of the largest specimens of this species, it can be concluded that this specimen has reached an age of 7 years. The number of year rings observed on a damaged specimen of *T. antwerpiensis* (height: 4.7 mm, calculated length: 10–12 mm) was also 7. The equally old adult specimens of these two species differ markedly in size; therefore the smallest specimens of *T. antwerpien-*

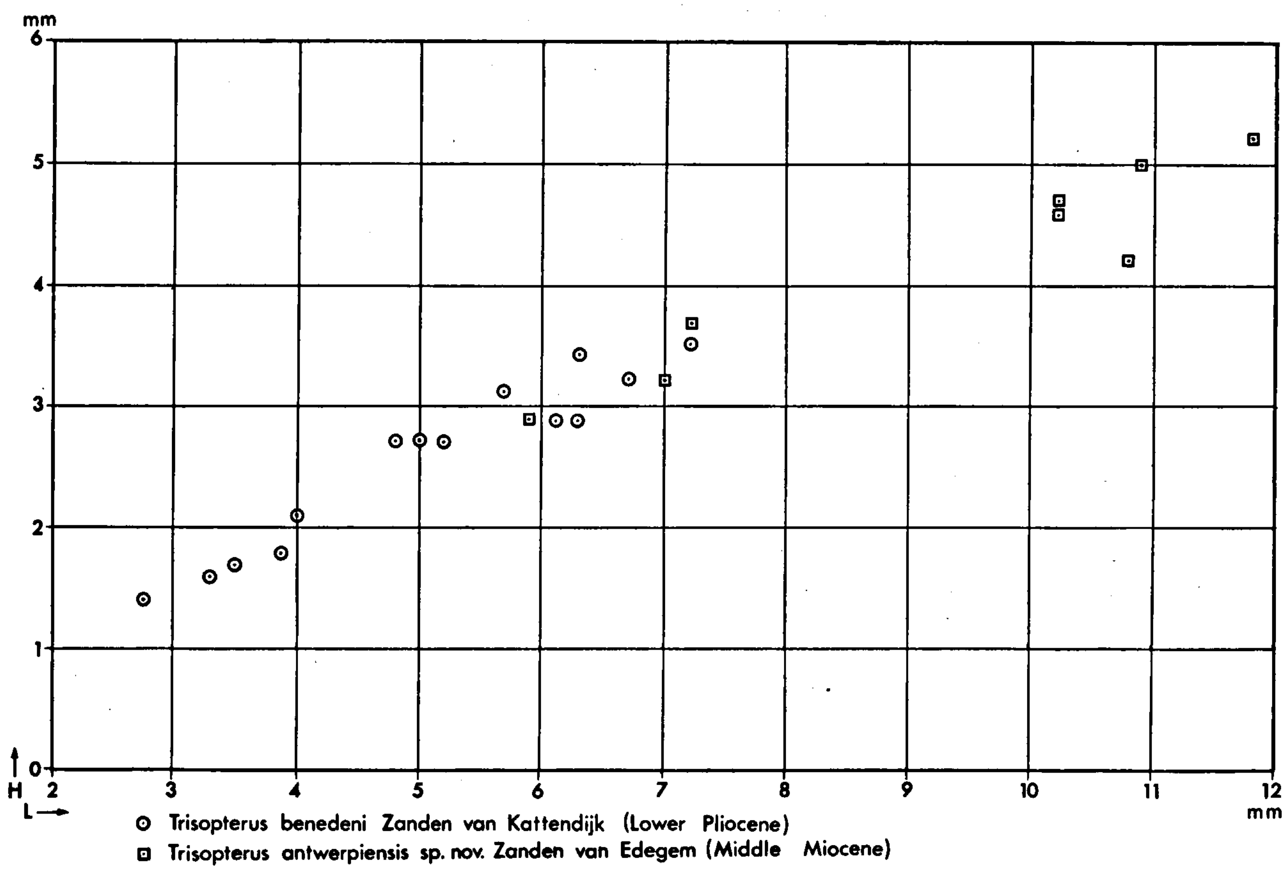

Fig. 1a.

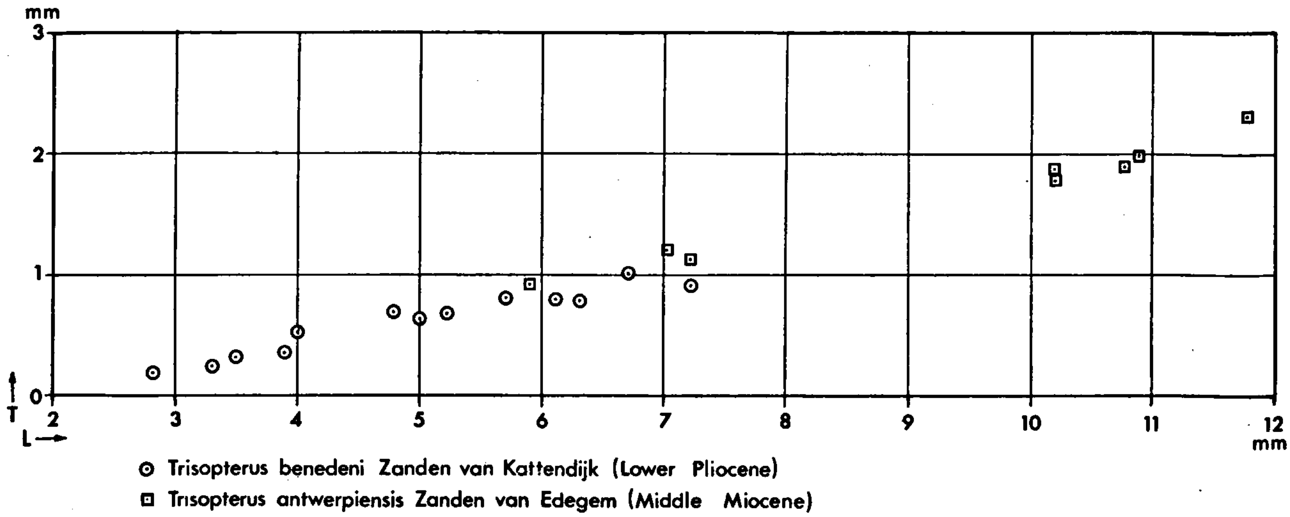

Fig. 1b.

sis will be younger than specimens of *T. benedeni* with the same size. We can eliminate the possibility that the specimens of *T. benedeni* are dwarf forms due to unfavourable conditions, because there is no evidence of extreme marine circumstances in the Sands of Kattendijk; nor does possible transport play a selective role since 12 mm specimens of other species occur. It may be assumed that *T. antwerpiensis* is a direct ancestor of the smaller *T. benedeni*.

Remarks. – Former identification: *Merlangius spatulatus* (Koken, 1891); Gaemers, 1969a, p. 9, Pl. I, Fig. 9a, b.

Trisopterus sp.
(Pl. I, Fig. 4a, b; Pl. IV, Fig. 7a, b)

Description. – Otolith small and strong. Outline oval and elongated; knobbed in the middle of dorsal and ventral rims, remainder smooth; rims blunt. Inner surface convex; sulcus acusticus closer to dorsal than ventral rim, and barely depressed; small furrows on dorsal part up to crista superior; knobs on ventral part up to ventral furrow. Outer surface convex; thickly knobbed only in its middle part.
L: 2.5 mm, H: 1.1 mm, T: 0.3 mm.

Material. – 1 damaged sagitta from the Sands of Edegem, Coll. RGM, st. 155182.

Discussion. – Owing to the great resemblance to *T. friedbergi* this specimen is included in the genus *Trisopterus*.

Remarks. – In Gaemers (1969a), this otolith is referred to as *Gadus elegans* (= *T. elegans*). Because this specimen is damaged and there is no additional material for this species, only a genus identification can be justified.

Trisopterus benedeni (Leriche, 1926) nov. comb.

Remarks. – This species was not found in the material from the Middle Miocene of Antwerp. However, several otolith specimens were found which closely resemble the otoliths of this species. The specimens labeled by Leriche as *Gadus benedeni* are from the Deurnian. According to Leriche (1926), *Gadus benedeni* is found in the Anversian, Deurnian (= Diestian) and Kattendijkian (= Lower Scaldisian). Most likely Leriche worked with material from the Anversian which was mixed up with younger material. Janssen & van der Mark (1969) also mention a case in which molluscs were investigated from impure collections.

Genus MERLANGIUS Oken, 1817.

Merlangius cognatus (Koken, 1891)
(Pl. I, Fig. 9a, b; Pl. II, Fig. 3a, b; Pl. V, Fig. 5a, b; Pl. VI, Fig. 1a, b)

Material. – 5 sagittas of adult specimens, Sands of Edegem, coll. RGM, st. 155183, 155184. 3 juvenile sagittas, Sands of Antwerp, Coll. RGM, st. 155185, 155186.
L: 12.3 mm, H: 4.5 mm, T: 2.6 mm (largest specimen). Condition of specimens: adult specimens eroded; juvenile specimens all without rostral part (broken off).

Distribution. – Upper Oligocene - lowermost Upper Miocene.

Merlangius pseudaeglefinus (Newton, 1891)
(Pl. I, Fig. 13a, b; Pl. V, Fig. 6a, b)

Material. – 1 well-preserved sagitta, Sands of Edegem, Coll. Gaemers, leg. Cadée.
L: 8.0 mm, H: 3.1 mm, T: 0.9 mm.

Distribution. – Upper Eocene – Pliocene.

Genus MERLUCCIUS Rafinesque, 1810

Merluccius vulgaris Fleming, 1828
(Pl. II, Fig. 1a, b; Pl. V, Fig. 4a, b)

Material. – 5 sagittas, Sands of Antwerp, Coll. RGM, st. 155187, 155188. All specimens eroded; all but one broken; 3 specimens not full-grown.
L: 14.2 mm, H: 5.6 mm, T: 1.2 mm.

Distribution. – Oligocene – Lower Pleistocene.

Remarks. – Specimen shown is slightly eroded, so that the delicate small furrows on the inner side, which are usually continuous up to the sulcus, have partly disappeared.

Genus UROPHYCIS Gill, 1863

Urophycis simplex (Koken, 1884) subsp. *elongatus* (Posthumus, 1923)
(Pl. I, Fig. 11a, b; Pl. VI, Fig. 2a, b)

Material. – 3 sagittas, Sands of Edegem, Coll. RGM, st. 155189, 155190. 1 juvenile sagitta, Sands of Edegem, Coll. Gaemers, leg. Cadée. 1 young sagitta, Sands of Antwerp, coll. RGM, st. 155191.
L: 5.8 mm, H: 1.8 mm, T: 1.3 mm.

Distribution. – Middle Miocene.

Remarks. – In Gaemers (1969a, 1969b), the otoliths in question were identified as *Urophycis simplex* but according to Weiler (1968) this is only true for the Upper Eocene and Middle Oligocene forms described by Koken (1884). All of the Miocene specimens can be placed under the subspecies *U. simplex elongatus.*

Ordo MACRURIFORMES
Familia MACRURIDAE Bonaparte, 1838
Genus MACRURUS Bloch, 1737

Macrurus communis (Prochazka, 1894)
(Pl. I, fig. 12a, b; Pl. IV, Fig. 4a, b)

Otolithus (Macrurus) ellipticus Schubert, 1905, p. 622, Pl. XVI, Figs. 31–33.

Material. – 4 sagittas, Sands of Edegem, Coll. RGM, st. 155192, 155193. 1 sagitta, Sands of Edegem, Coll. Gaemers, leg. Cadée. 67 sagittas, Sands of Antwerp, Coll. RGM, st. 155194. 14 sagittas, Sands of Antwerp, Coll. Gaemers. 7 sagittas, Sands of Antwerp, Coll. Gaemers, leg. Cadée.
L: 3.7 mm, H: 2.1 mm, T: 0.4 mm (largest specimen Sands of Edegem).
L: 2.8 mm, H: 2.2 mm, T: 0.3 mm (adult specimen Sands of Antwerp).
Most specimens are eroded.

Distribution. – Lower Oligocene – Lower Pleistocene.

Discussion. – *M. communis* is highly variable and therefore often difficult to distinguish from *M. debilis.* Posthumus (1923) thought that this could be solved by defining many species (no less than eight), some in fact being based on eroded specimens. How this group of otoliths can be divided more satisfactorily is not yet clear. A statistical investigation is probably the answer, as well as a study of the range of variation in recent related species. For the present the two abovementioned species are used since they represent approximately the end-members of this group of closely related otoliths.

Macrurus debilis Posthumus, 1923
(Pl. I, Fig. 10a, b; Pl. IV, Fig. 6a, b)

Material. – 28 sagittas, Sands of Antwerp, coll. RGM, st. 155195, 155196. 9 sagittas, Sands of Antwerp, Coll. Gaemers. 8 sagittas, Sands of Antwerp, Coll. Gaemers, leg. Cadée.
L: 2.2 mm, H: 1.5 mm. T: 0.3 mm.
Many specimens are somewhat eroded.

Distribution. – Oligocene – Upper Miocene.

Discussion. – Highly variable species; see discussion under *Macrurus communis.*

(Macruridarum) *minisculus* (Schubert, 1906)
(Pl. II, Fig. 4a, b; Pl. IV, Fig. 5a, b)

Material. – 2 sagittas, Sands of Antwerp, Coll. RGM, st. 155197, 155198. One specimen greatly damaged, the other slightly.
L: 1.8 mm, H: 0.9 mm, T: 0.2 mm.

Distribution. – Upper Miocene.

Ordo PERCIFORMES
Familia SERRANIDAE Richardson, 1817
Genus SERRANUS Cuvier, 1817

Serranus aff. *noetlingi* Koken, 1891
(Pl. II, Fig. 2a, b; Pl. IX, Fig. 4a, b)

Description. – Otoliths flat, fragile and rather small. Outline oval, with distinct excisura ostii; dorsal and ventral rims both markedly and sharply incised; postdorsal angle most pronounced. Inner surface convex; sulcus acusticus deeply incised; cauda long, rather narrow, bent toward ventral side; ostium short, wider than cauda; ventral furrow not very clear; small furrows at dorsal rim sometimes up to sulcus acusticus. Outer surface concave, with center as deepest lying point; small, fairly irregular furrows and knobs radiate from center.

Material. – 2 sagittas, Sands of Edegem, Coll. RGM, st. 155199, 155200, both damaged at the rostrum.
L: 3.0 mm, H: 1.8 mm, T: 0.2 mm.

Distribution. – Middle Oligocene – Upper Miocene. Specimen shown agrees well with drawings of this species from Weiler (1942). The other specimen is somewhat higher in relation to the length, and perhaps belongs to another *Serranus* species.

Genus MORONE Mitchell, 1814

Morone limburgensis (Posthumus, 1923)
(Pl. II, Fig. 5, 6; Pl. VII, Fig. 4a, b)

Material. – 1 eroded sagitta, Sands of Edegem, Coll. RGM, st. 155201. 1 eroded sagitta, Sands of Antwerp, Coll. Gaemers. 5 sagittas, steeped in lye, Sands of Antwerp, Coll. Gaemers, leg. Cadée, Ploegstraat. 3 sagittas, Sands of Antwerp, Coll. RGM, st. 155202 (2 specimens highly eroded).
L: 6.1 mm, H: 4.1 mm, T: 0.6 mm (Sands of Edegem).
L: 12.2 mm, H: 6.6 mm, T: 2.5 mm (largest specimen Sands of Antwerp).

Distribution. – Middle Oligocene – Lowermost Middle Miocene.

Discussion. – This species has a very great range of variation. The biggest specimens (from the lowermost bed of Ploegstraat, Antwerp) are proportionally much thicker than the smaller ones. This is caused by an allometrical growth, by which the thickness increases faster than the length and the height. Because of the large increase in thickness, the outer surface becomes convex instead of concave as found in young specimens.

Familia SCIAENIDAE Cuvier, 1829
Genus CORVINA Cuvier, 1829

Corvina speciosa (Koken, 1884)
(Pl. II, Fig. 7a, b; Pl. VIII, Fig. 1a, b)

Material. – 1 sagitta, Sands of Antwerp, Coll. RGM, st. 155203 (somewhat eroded).
L: 7.1 mm, H: 4.9 mm, T: 2.0 mm.

Distribution. – Upper Oligocene – Pliocene.

Familia SPARIDAE Bonaparte, 1831
Genus DENTEX Cuvier, 1815

Dentex gregarius (Koken, 1891)
(Pl. II, Fig. 8a, b; Pl. III, Fig. 3a, b; Pl. VII, Fig. 2a,b)

Material. – 8 sagittas, Sands of Edegem, Coll. RGM, st. 155204, 155205 (7 specimens juveniles). 6 sagittas, Sands of Antwerp, Coll. Gaemers, leg. Cadée, Ploegstraat. 5 sagittas, Sands of Antwerp, Coll. RGM, st. 155206 (juveniles). 1 sagitta, Sands of Antwerp, Coll. Gaemers (juvenile). Nearly all eroded.
L: 14.5 mm, H: 9.6 mm, T: 3.0 mm (largest specimen Sands of Antwerp).
L: 11.4 mm, H: 9.0 mm, T: 3.1 mm (largest specimen Sands of Edegem).

Distribution. – Palaeocene – Pliocene.

Discussion. – It is quite possible that many species are identified as *Dentex gregarius* at present. Many species of the family Sparidae resemble each other closely, also with respect to their otoliths. This might explain the large variation within the now defined *D. gregarius*.

Dentex nobilis Koken, 1891 subsp. *miocenica* Weiler, 1942
(Pl. III, Fig. 1a, b; Pl. VII, Fig. 1a, b)

Material. – 1 sagitta, Sands of Antwerp, Coll. Gaemers. 3 sagittas (2 juveniles), Sands of Antwerp, Coll. RGM, st. 155207, 155208.
L: 5.6 mm, H: 3.3 mm, T: 0.6 mm.

Distribution. – Middle Miocene – Lowermost Upper Miocene.

Dentex sp.
(Pl. III, Fig. 2)

Description. – Otolith strong and rather large. Outline irregularly pentagonal; dorsal and ventral rims sharp, especially dorsal rim; dorsal rim irregularly knobbed, with a few big knobs; postdorsal angle far towards the back; ventral rim hardly incised, with numerous small knobs. Inner surface slightly convex; small dorsal furrows cross area; sulcus acusticus deep; cauda bent slightly backwards to ventral side; ostium wider than cauda; ventral furrow difficult to see; big area. Outer surface slightly convex, irregular and not pronounced.
L: 8 mm (estimated), H: 5.2 mm, T: 1.4 mm.

Material. – 1 damaged specimen, Sands of Antwerp, Coll. Gaemers, leg. Cadée, Ploegstraat (ostium is missing almost entirely).

Discussion. – In Gaemers (1969a), this specimen was placed under *Dentex nobilis miocenica* because Weiler (1942) places such forms in this species. This form, however, is too aberrant to be identified as this species. In particular, the position of the postdorsal rim so close to the cauda, the completely different pattern of knobs and the different form of the sulcus acusticus are important distinctions. Moreover intermediate forms between the specimen described here and the characteristic form of *Dentex nobilis miocenica* are not known (to this author).

Genus PAGRUS Cuvier, 1817

Pagrus aff. *distinctus* (Koken, 1891)
(Pl. III, Fig. 4a, b; Pl. VII, Fig. 3a, b)

Description. – Otoliths rather thin, fragile. Outline pentagonal; excisura ostii very distinct, deeply incised; pre- and postdorsal angles well-developed; dorsal rim set with coarser knobs than ventral rim; caudal point sharp. Inner surface convex; small furrows on dorsal part sometimes up to sulcus acusticus; small furrows

on ventral rim up to ventral furrow; sulcus acusticus not very wide, but deeply incised; back part of cauda distinctly bent toward ventral rim. Outer surface concave: ostial furrow very deep; nearly radiating pattern; knobs quite pronounced.
L: 5.8 mm, H: 3.7 mm, T: 0.8 mm.

Material. – 1 sagitta, well-preserved adult specimen, Sands of Antwerp, Coll. Gaemers, leg. Cadée. 2 sagittas, Sands of Antwerp, Coll. RGM, st. 155209 (1 specimen juvenile and eroded, 1 specimen adult and well-preserved).

Distribution. – Middle Oligocene – Uppermost Middle Miocene.

Discussion. – The specimens from the Sands of Antwerp have a much more pronounced knobbing than those described by Koken (1891a) and Weiler (1942). The excisura ostii is incised more deeply. It is uncertain whether these specimens can be identified as *Pagrus distinctus.* Not enough recent material has been studied from this family. The Sparidae is a family with members very difficult to identify because it is a very large group, in which the otoliths of many species resemble each other very closely.

Familia TRACHINIDAE Günther, 1860
Genus TRACHINUS Linnaeus, 1758

Trachinus acutus Weiler, 1942
(Pl. III, Fig. 5a, b; Pl. IX, Fig. 1a, b)

Description. – Otolith medium-sized, strong. Outline oblongly pear-shaped; with a distinct point in front and in back; rims smooth, rather sharp. Inner surface convex; sulcus acusticus rather wide, not far from dorsal rim; cauda shorter than ostium; back part of ostium bent to dorsal side, back part of cauda bent to ventral side. Outside concave; thickening at posterior point, posterior part of dorsal section, in the center and obliquely below anterior point.

Material. – 1 sagitta, somewhat eroded, Sands of Edegem, Coll. RGM, st. 155210.
L: 6.8 mm, H: 3.3 mm, T: 1.2 mm.

Distribution. – Middle Miocene.

Discussion. – *T. mutabilis* and *T. acutus* sometimes resemble each other closely. By determining the ratios of length, height and thickness, reliable determinations are possible.

Trachinus mutabilis Koken, 1891
(Pl. III, Fig. 6; Pl. IX, Fig. 2a, b)

Material. – 3 sagittas, Sands of Edegem, Coll. Gaemers, leg. Cadée. 1 sagitta, juvenile, Sands of Antwerp, Coll. RGM, st. 155211.
L: 6.6 mm, H: 3.2 mm, T: 0.9 mm (largest specimen Sands of Edegem).
L: 3.0 mm, H: 1.5 mm, T: 0.5 mm.

Distribution. – Lower Oligocene – Lowermost Upper Miocene.

Trachinus verus Koken, 1891
(Pl. III, Fig. 7a, b; Pl. IX, Fig. 3a, b)

Material. – 1 sagitta, well-preserved, Sands of Edegem, Coll. RGM, st. 155212.
L: 5.7 mm, H: 2.8 mm, T: 1.2 mm.

Distribution. – Upper Eocene – Middle Miocene.

Familia OPHIDIIDAE Rafinesque, 1810
Genus BAUZAIA Frizzell & Dante, 1965

Bauzaia joachimica (Koken, 1891)
(Pl. III, Fig. 8)

Description. – Otolith medium-sized, very strong. Outline oval, with distinct rostral point; predorsal rim indistinct; caudal part blunt. Inner surface slightly convex; due to erosion no other characteristics visible; internal year rings revealed. Outer surface markedly convex, completely covered with very coarse pronounced knobs.

Material. – 1 sagitta, Sands of Edegem, Coll. Gaemers, leg. Cadée, highly eroded specimen; bluish color (all other otoliths ochre or brown).
L: 5.8 mm, H: 2.8 mm, T: 1.9 mm.

Distribution. – Middle Oligocene – Lowermost Upper Miocene.

Discussion. – Due to the characteristic form of this otolith, the specimen could be easily identified in spite of the poor condition of preservation. This species is very common in the Middle Oligocene 'Boomse klei' (Clay of Boom), upon which the Sands of Edegem are discordant. In Middle Miocene deposits the species is much rarer. Because it has been highly eroded and has a different color than the other otoliths, this specimen presumably is of Middle Oligocene age.

Familia GOBIIDAE Bonaparte, 1831
Genus GOBIUS Linnaeus, 1758

Gobius laevis Weiler, 1942
(Pl. III, Fig. 13a, b; Pl. VIII, Fig. 5a, b)

Gobius aff. *elegans* Prochazka; Posthumus, 1923, p. 115, fig. 20, 21.

Material. – 10 sagittas, Sands of Edegem, Coll. Gaemers, leg. Cadée. 4 sagittas, Sands of Edegem, Coll. RGM, st. 155213. Well-preserved, some specimens slightly eroded.

L: 1.8 mm, H: 1.7 mm, T: 0.5 mm.
L: 1.7 mm, H: 1.8 mm, T: 0.4 mm.

Distribution. – Middle Miocene – Pliocene.

Familia TRIGLIDAE Risso, 1826
Genus TRIGLA Linnaeus, 1758

Trigla asperoides Schubert, 1906
(Pl. III, Fig. 11a, b; Pl. VIII, Fig. 4a, b)

Material. – 1 sagitta, well-preserved, Sands of Edegem, Coll. Gaemers, leg. Cadée.
L: 3.3 mm, H: 2.1 mm, T: 0.3 mm.

Distribution. – Upper Oligocene – Pliocene.

Trigla rhombica Schubert, 1906
(Pl. III, Fig. 12a, b; Pl. VIII, Fig. 3a, b)

Material. – 7 sagittas, well-preserved, Sands of Edegem, Coll. RGM, st. 155214, 155215. 6 sagittas, well-preserved, Sands of Edegem, Coll. Gaemers, leg. Cadée. 1 sagitta, markedly eroded, Sands of Antwerp, Coll. RGM, st. 155216.
L: 3.0 mm, H: 2.4 mm, T: 0.3 mm.

Distribution. – Upper Eocene – Lowermost Upper Miocene.

Subfamilia PERISTEDINIAE
Genus PERISTEDION Lawley, 1876

Peristedion acutum Weiler, 1942
(Pl. III, Fig. 9a, b; Pl. VIII, Fig. 2a, b)

Material. – 2 sagittas, Sands of Edegem, Coll. RGM, st. 155217, 155218. One well-preserved specimen and one somewhat eroded specimen.
L: 4.8 mm, H: 2.9 mm, T: 0.9 mm.

Distribution. – Lower Oligocene – Upper Miocene.

Familia AGONIDAE
Genus AGONUS Schneider, 1801

Agonus primus Koken, 1891
(Pl. III, Fig. 10a, b; Pl. IV, Fig. 8a, b)

Material. – 2 sagittas, moderately eroded, Sands of Edegem, Coll. RGM, st. 155219, 155220. 1 fragment of sagitta, Sands of Edegem, Coll. Gaemers, leg. Cadée.
L: 6.4 mm, H: 2.6 mm, T: 0.9 mm.

Distribution. – Middle Oligocene – Lowermost Middle Miocene.

Discussion. – Up to now this species was only known from Middle Oligocene. The possibility cannot be excluded that the above-mentioned eroded specimens are allochthonous, thus eroded from the Clay of Boom.

Ordo PLEURONECTIFORMES
Familia SOLEIDAE Bonaparte, 1833
Genus SOLEA Quensel, 1806

Solea approximata Koken, 1891
(Pl. III, Fig. 16a, b; Pl. IX, Fig. 5a, b)

Material. – 2 sagittas, well-preserved, Sands of Edegem, Coll. RGM, st. 155221, 155222. 1 sagitta, eroded, Sands of Edegem, Coll. Gaemers, leg. Cadée. 2 sagittas, eroded, Sands of Antwerp, Coll. RGM, st. 155223.
L: 3.1 mm, H: 2.0 mm, T: 1.1 mm.

Distribution. – Many flatfishes have otoliths which closely resemble each other. Usually the otoliths do not have characteristic protuberances, angles or knobs, as do most other groups of fish. For these reasons, and also because not enough is known about recent fishes in this group, determinations are very difficult for the flatfish group.

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PLATES

PLATE I

Fig. 1a, b. (Clupeidarum) sp. Sands of Antwerp (Coll. Gaemers).
Fig. 2a, b. *Myctophum debile*. Sands of Antwerp (Coll. RGM, st. 155171).
Fig. 3a, b. *Diaphus* sp. Sands of Antwerp (Coll. Gaemers).
Fig. 4a, b. *Trisopterus* sp. Sands of Edegem (Coll. RGM, st. 155182).
Fig. 5a, b; 6a, b. *Trisopterus friedbergi* nov. comb. Sands of Edegem (Coll. RGM, st. 155176).
Fig. 7a, b. *Trisopterus luscus spectabilis*. Sands of Edegem (Coll. RGM, st. 155178).
Fig. 8a, b. *Trisopterus antwerpiensis* nov. sp. Sands of Edegem (Coll. RGM, st. 155173).
Fig. 9a, b. *Merlangius cognatus*. Sands of Edegem (Coll. RGM, st. 155183).
Fig. 10a, b. *Macrurus debilis*. Sands of Antwerp (Coll. Gaemers, leg. M. C. Cadée).
Fig. 11a, b. *Urophycis simplex*. Sands of Edegem (Coll. RGM, st. 155189).
Fig. 12a, b. *Macrurus communis*. Sands of Edegem (Coll. RGM, st. 155192).
Fig. 13a, b. *Merlangius pseudaeglefinus*. Sands of Edegem (Coll. Gaemers, leg. M. C. Cadée).

Magnification of all specimens 7.5 ×.

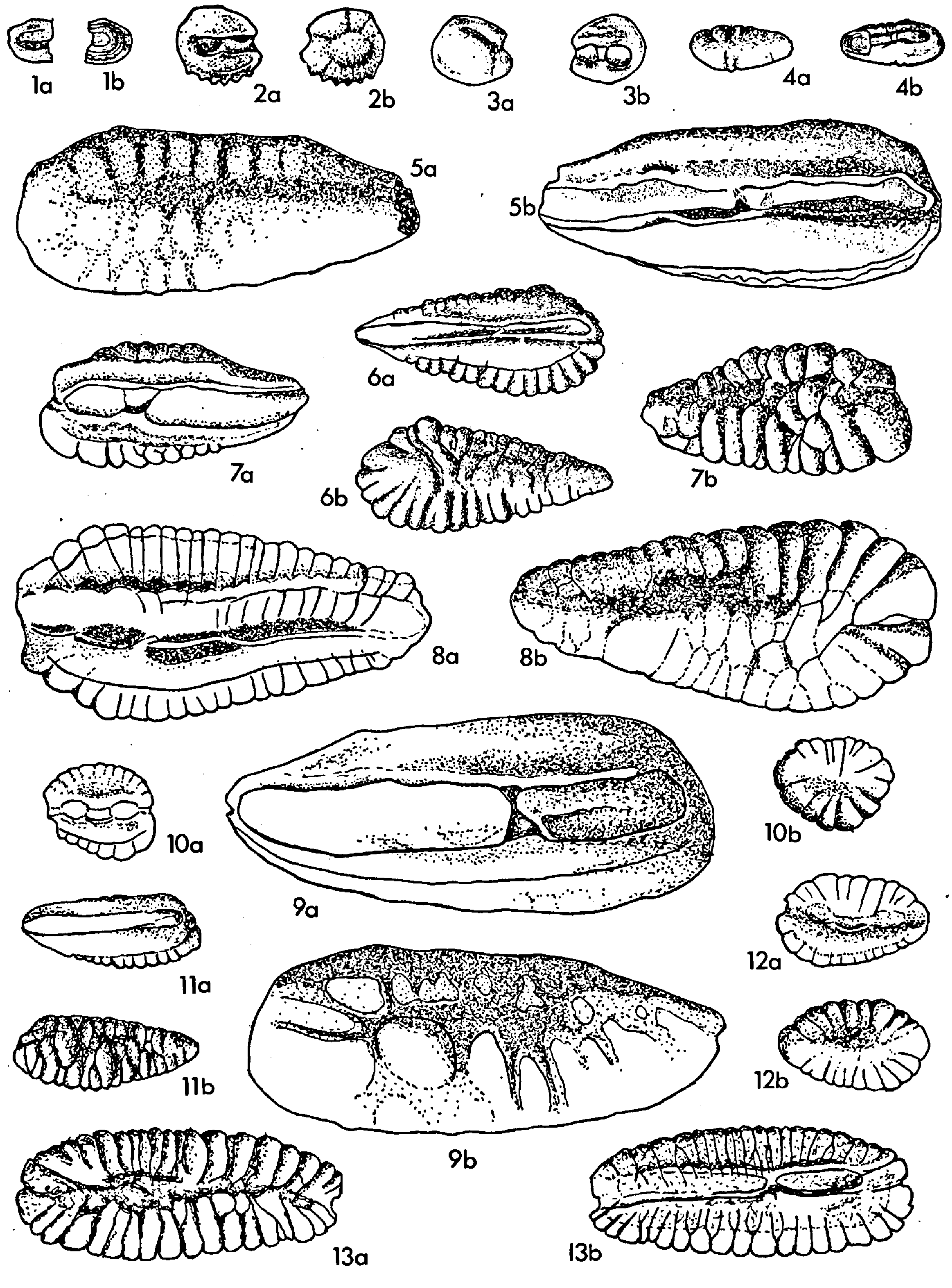
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PLATE II

Fig. 1a, b. *Merluccius vulgaris*. Sands of Antwerp (Coll. RGM, st. 155187).
Fig. 2a, b. *Serranus noetlingi*. Sands of Edegem (Coll. RGM, st. 155199).
Fig. 3a, b. *Merlangius cognatus* (juvenile). Sands of Antwerp (Coll. RGM, st. 155185).
Fig. 4a, b. (Macruridarum) *miniscudus*. Sands of Antwerp (Coll. RGM, st. 155197).
Fig. 5. *Morone limburgensis*. Sands of Antwerp Ploegstraat (Coll. Gaemers, leg. M. C. Cadée).
Fig. 6. *Morone limburgensis*. Sands of Antwerp (Coll. RGM, st. 155202).
Fig. 7a, b. *Corvina speciosa*. Sands of Antwerp (Coll. RGM, st. 155203).
Fig. 8a, b. *Dentex gregarius*. Sands of Edegem (Coll. RGM, st. 155204).

Magnification of all specimens, except *Serranus noetlingi* 7.5 ×.

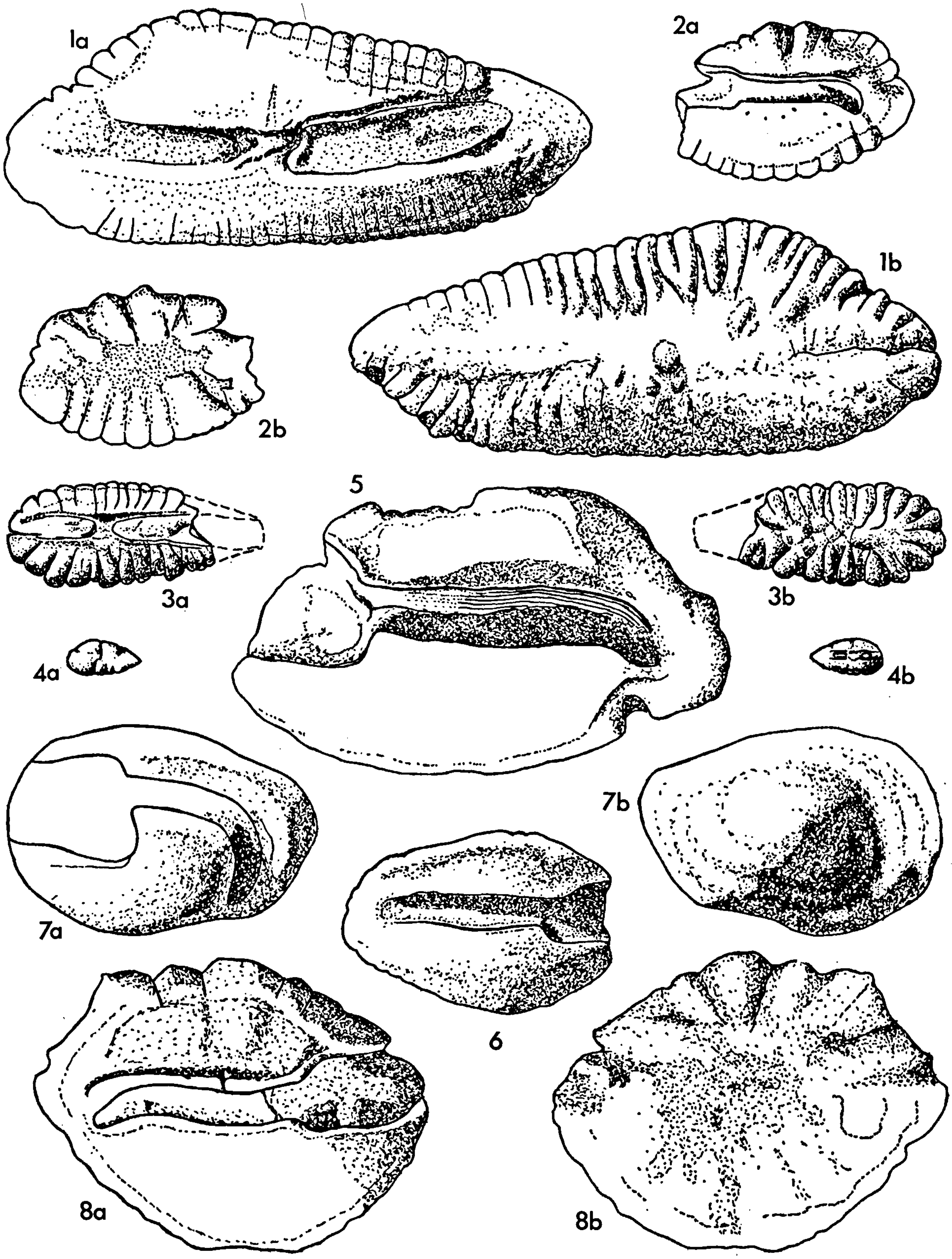
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PLATE III

Fig. 1a, b. *Dentex nobilis miocenica*. Sands of Antwerp (Coll. RGM, st. 155207).
Fig. 2. *Dentex* sp. Sands of Antwerp (Coll. Gaemers, leg. M. C. Cadée).
Fig. 3a, b. *Dentex gregarius* (juvenile). Sands of Antwerp (Coll. RGM, st. 155206).
Fig. 4a, b. *Pagrus aff. distinctus*. Sands of Antwerp (Coll. Gaemers, leg. M. C. Cadée).
Fig. 5a, b. *Trachinus acutus*. Sands of Edegem (Coll. RGM, st. 155210).
Fig. 6. *Trachinus mutabilis*. Sands of Edegem (Coll. Gaemers, leg. M. C. Cadée).
Fig. 7a, b. *Trachinus verus*. Sands of Edegem (Coll. RGM, st. 155212).
Fig. 8. *Bauzaia joachimica*. Sands of Edegem (Coll. Gaemers, leg. M. C. Cadée).
Fig. 9a, b. *Peristedion acutum*. Sands of Edegem (Coll. RGM, st. 155217).
Fig. 10a, b. *Agonus primus*. Sands of Edegem (Coll. RGM, st. 155219).
Fig. 11a, b. *Trigla asperoides*. Sands of Edegem (Coll. Gaemers, leg. M. C. Cadée).
Fig. 12a, b. *Trigla rhombica*. Sands of Edegem (Coll. RGM, st. 155214).
Fig. 13a, b; 14. *Gobius laevis*. Sands of Edegem (Coll. RGM, st. 155213).
Fig. 15. *Dentex gregarius*. Sands of Antwerp Ploegstraat (Coll. Gaemers, leg. M. C. Cadée).
Fig. 16a, b. *Solea approximata*. Sands of Edegem (Coll. RGM, st. 155221).

Magnification of all specimens 7.5 ×.

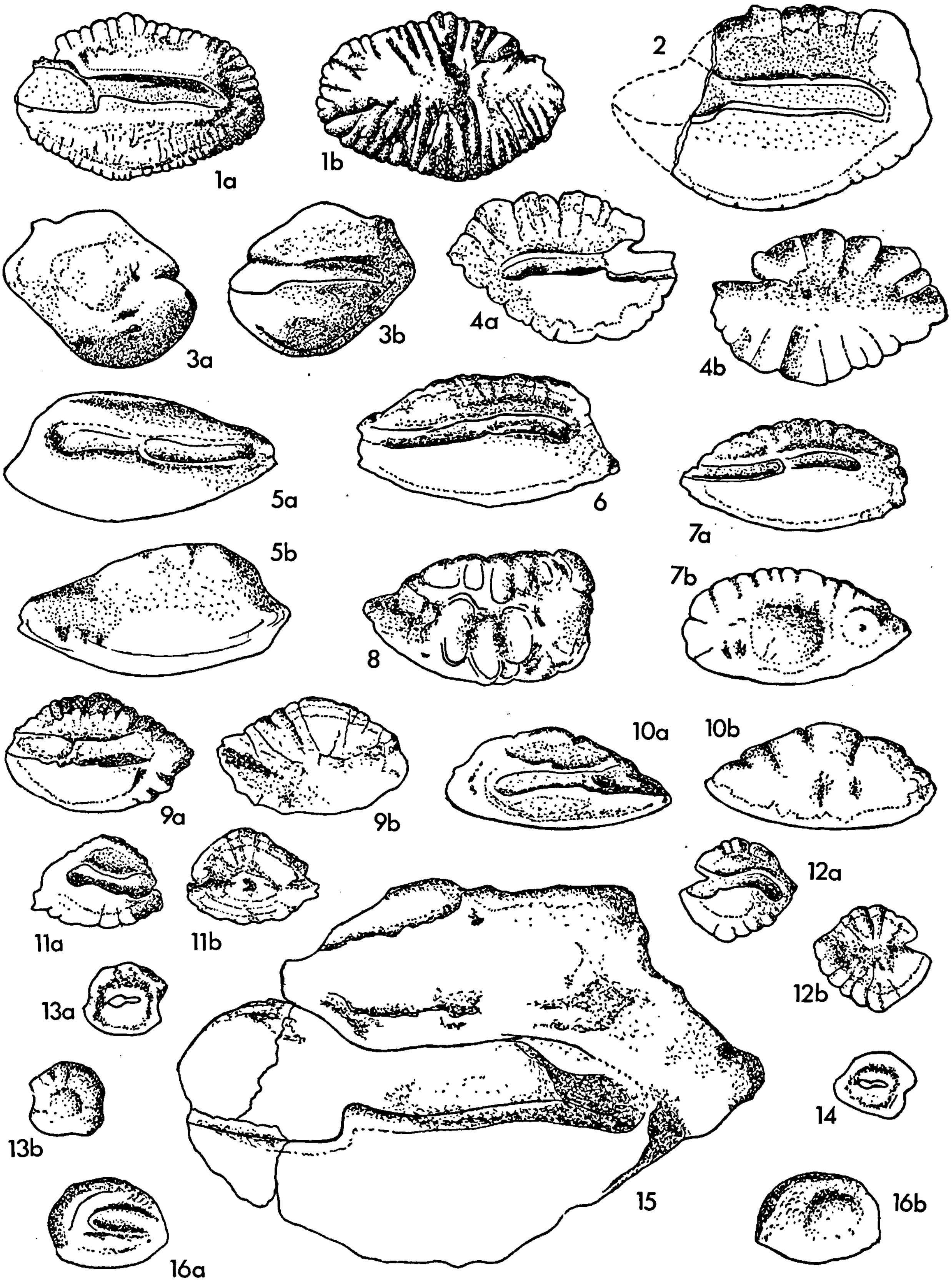
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PLATE IV

Fig. 1a, b. (Clupeidarum) sp. Sands of Antwerp (Coll. Gaemers) 22.5 ×.
Fig. 2a, b. *Diaphus* sp. Sands of Antwerp (Coll. Gaemers) 22.5 ×.
Fig. 3a, b. *Myctophum debile*. Sands of Antwerp (Coll. RGM, st. 155171) 23.5 ×.
Fig. 4a, b. *Macrurus communis*. Sands of Edegem (Coll. RGM, st. 155192) 13.5 ×.
Fig. 5a, b. (Macruridarum) *minisculus*. Sands of Antwerp (Coll. RGM, st. 155197) 26.75 ×.
Fig. 6a, b. *Macrurus debilis*. Sands of Antwerp (Coll. RGM, st. 155195) 15.5 ×.
Fig. 7a, b. *Trisopterus* sp. Sands of Edegem (Coll. RGM, st. 155182) 24.5 ×.
Fig. 8a, b. *Agonus primus*. Sands of Edegem (Coll. RGM, st. 155219) 11.7 ×.

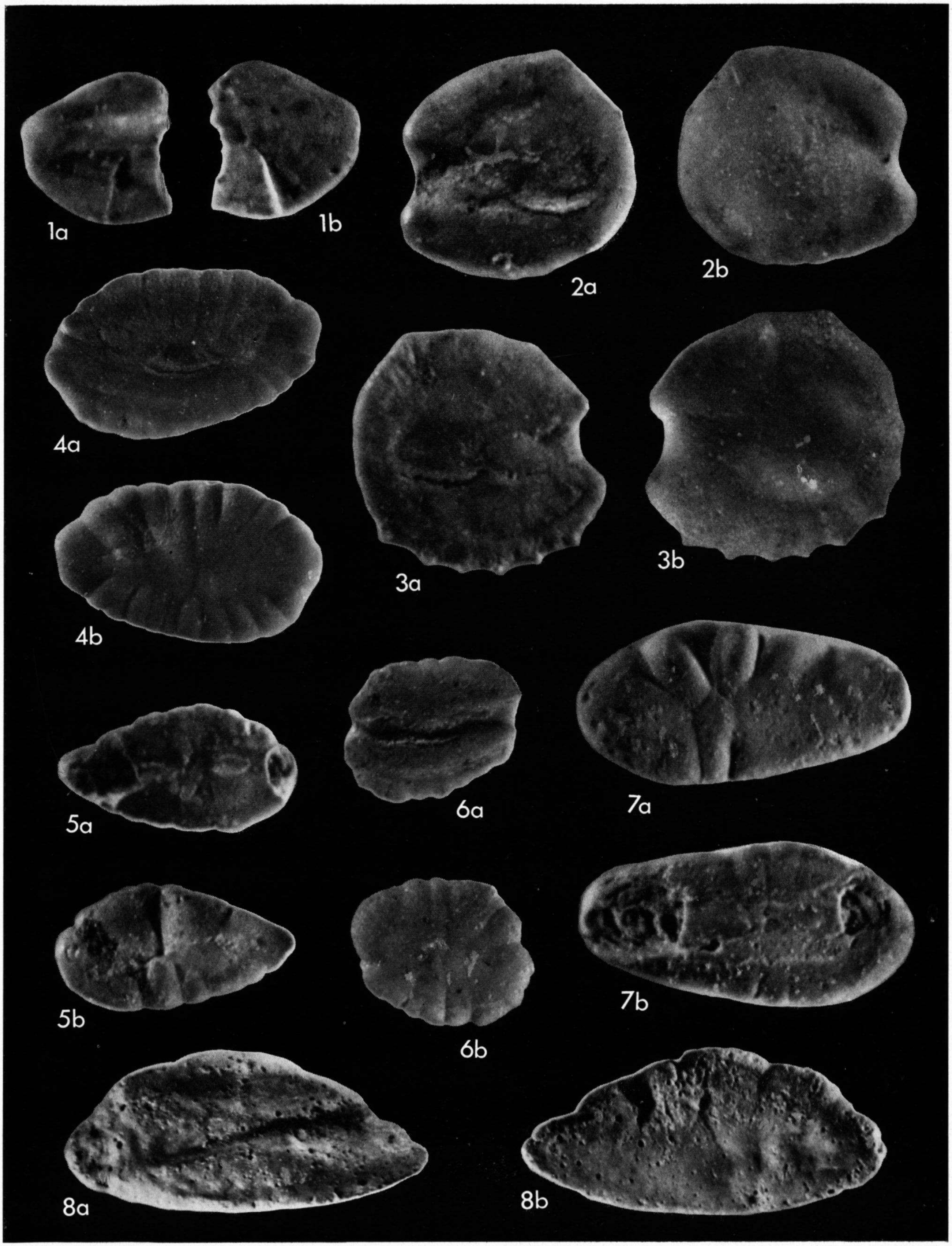
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PLATE V

Fig. 1a, b. *Trisopterus esmarki*. Recent (Coll. Gaemers) 8.25 ×.
Fig. 2a, b. *Trisopterus friedbergi*. Sands of Edegem (Coll. RGM, st. 155176) 7.75 ×
Fig. 3a, b. *Trisopterus antwerpiensis*. Sands of Edegem (Coll. RGM, st. 155173) 6.5 ×.
Fig. 4a, b. *Merluccius vulgaris*. Sands of Antwerp (Coll. RGM, st. 155187) 5.0 ×.
Fig. 5a, b. *Merlangius cognatus*. Sands of Edegem (Coll. RGM, st. 155183) 6.5 ×.
Fig. 6a, b. *Merlangius pseudaeglefinus*. Sands of Edegem (Coll. Gaemers, leg. M. C. Cadée) 9.25 ×.

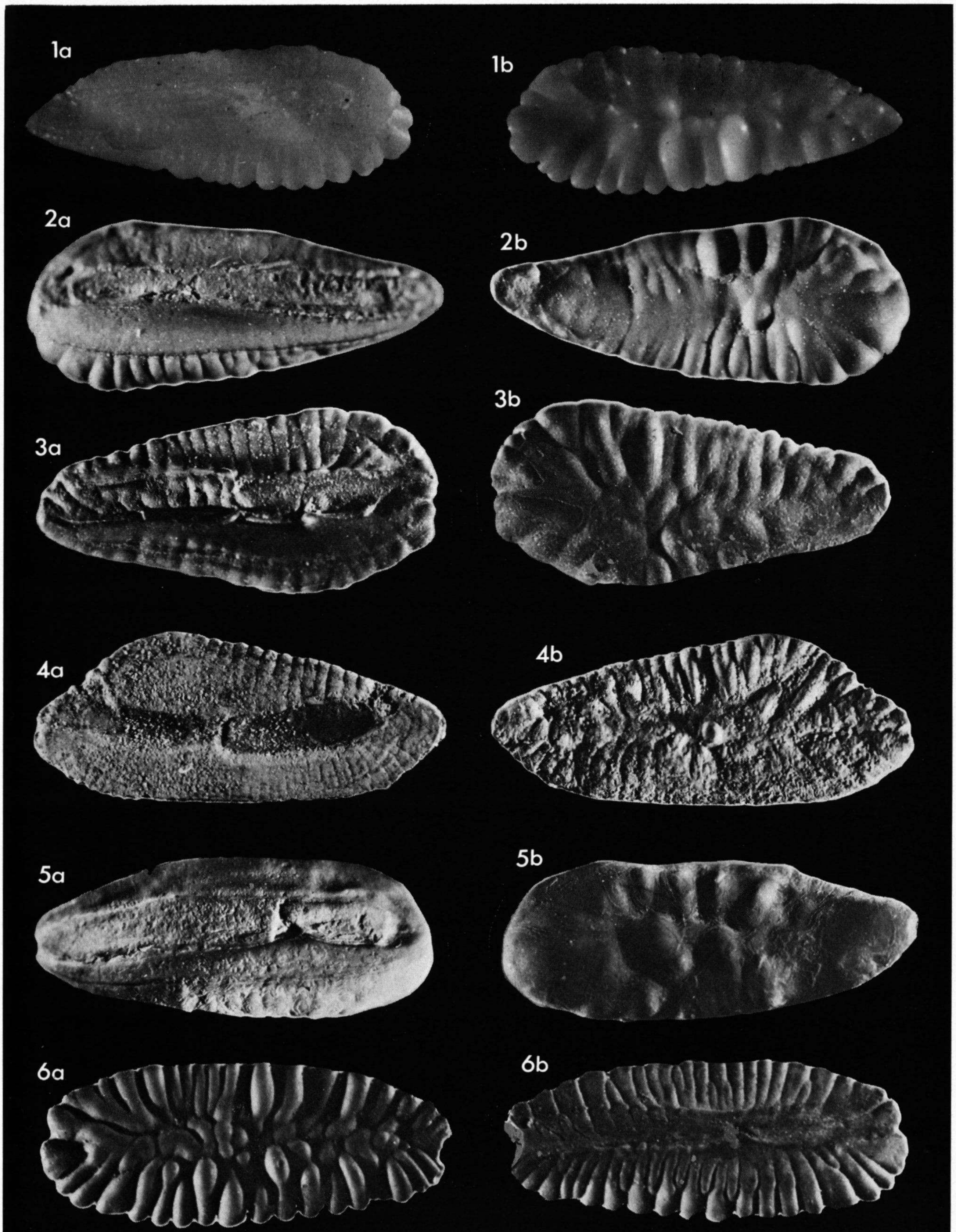
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PLATE VI

Fig. 1a, b. *Merlangius cognatus* (juv.). Sands of Antwerp (Coll. RGM, st. 155185) 13 ×
Fig. 2a, b. *Urophycis simplex*. Sands of Edegem (Coll. RGM., st. 155189) 17.75 ×.
Fig. 3a, b. *Trisopterus friedbergi* (juv.). Sands of Edegem (Coll. RGM, st. 155176) 15 ×
Fig. 4a, b. *Trisopterus luscus spectabilis*. Sands of Edegem (Coll. RGM, st. 155178) 10.75 ×
Fig. 5. *Trisopterus luscus spectabilis*. Sands of Antwerp (Coll. RGM, st. 155180) 10.75 ×

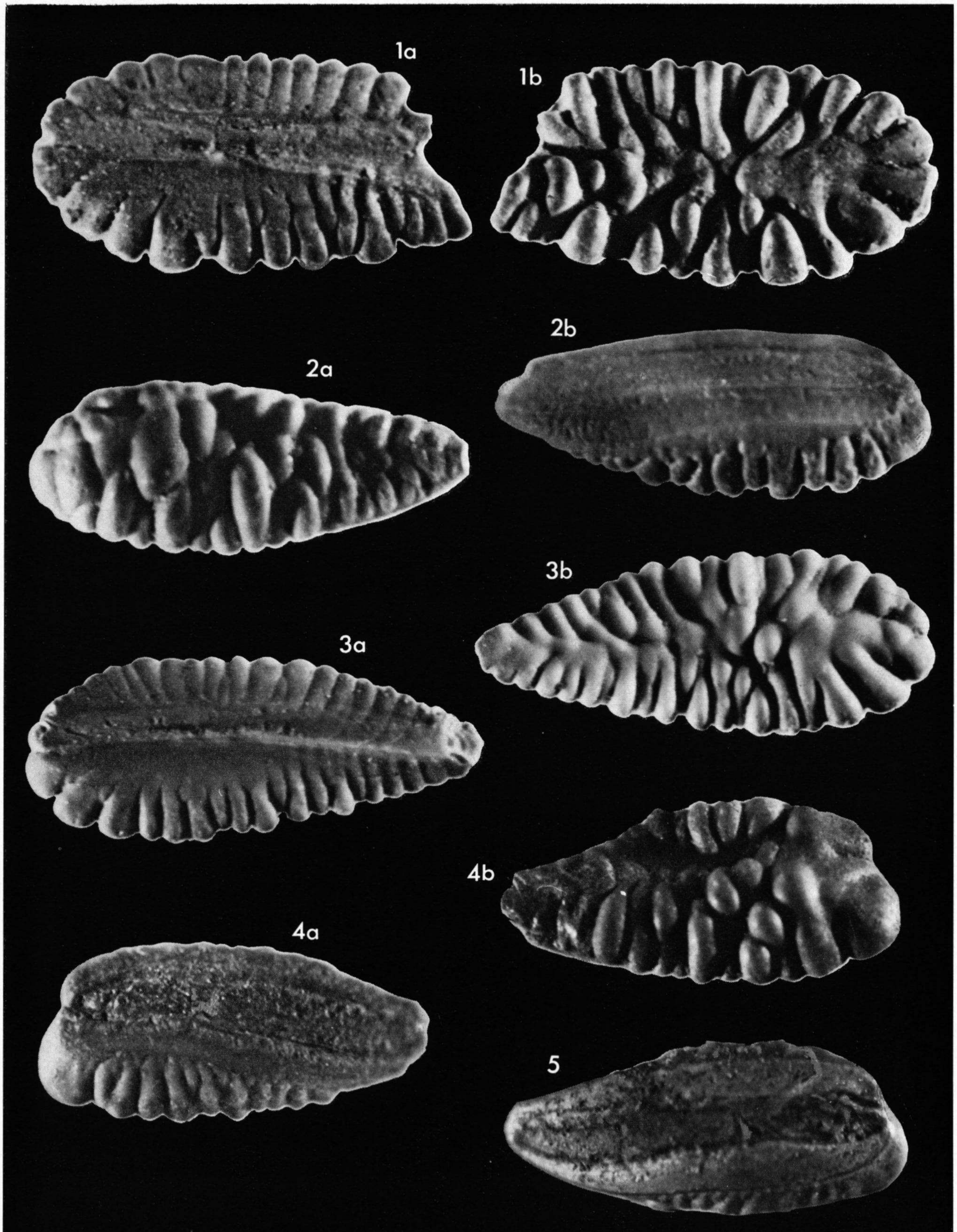
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PLATE VII

Fig. 1a, b. *Dentcx nobilis miocenica*. Sands of Antwerp (Coll. RGM, st. 155207) 12.5 ×.
Fig. 2a, b. *Dentex gregarius*. Sands of Edegem (Coll. RGM, st. 155204) 7 ×.
Fig. 3a, b. *Pagrus* aff. *distinctus*. Sands of Antwerp (Coll. Gaemers, Leg. M. C. Cadée) 12.25 ×.
Fig. 4a, b. *Morone limburgensis*. Sands of Antwerp (Coll. Gaemers, Leg. M. C. Cadée) 6.5 ×.

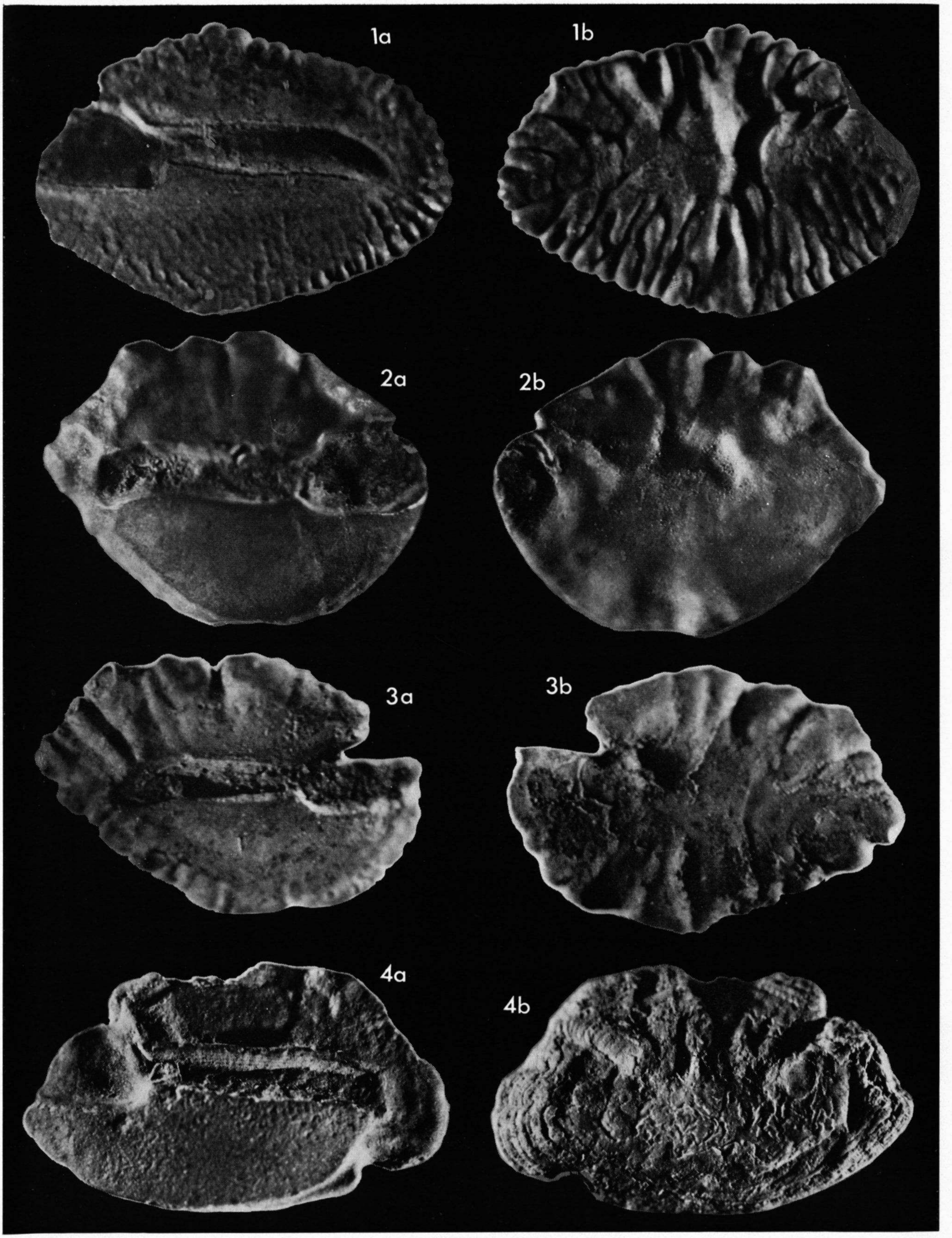
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PLATE VIII

Fig. 1a, b. *Corvina speciosa*. Sands of Antwerp (Coll. RGM, st. 155203) 9.5 ×.
Fig. 2a, b. *Peristedion acutum*. Sands of Edegem (Coll. RGM, st. 155217) 14.5 ×.
Fig. 3a, b. *Trigla rhombica*. Sands of Edegem (Coll. RGM, st. 155214) 17 ×.
Fig. 4a, b. *Trigla asperoides*. Sands of Edegem (Coll. Gaemers, leg. M. C. Cadée) 16.5 ×.
Fig. 5a, b. *Gobius laevis*. Sands of Edegem (Coll. Gaemers, leg. M. C. Cadée) 22 ×.

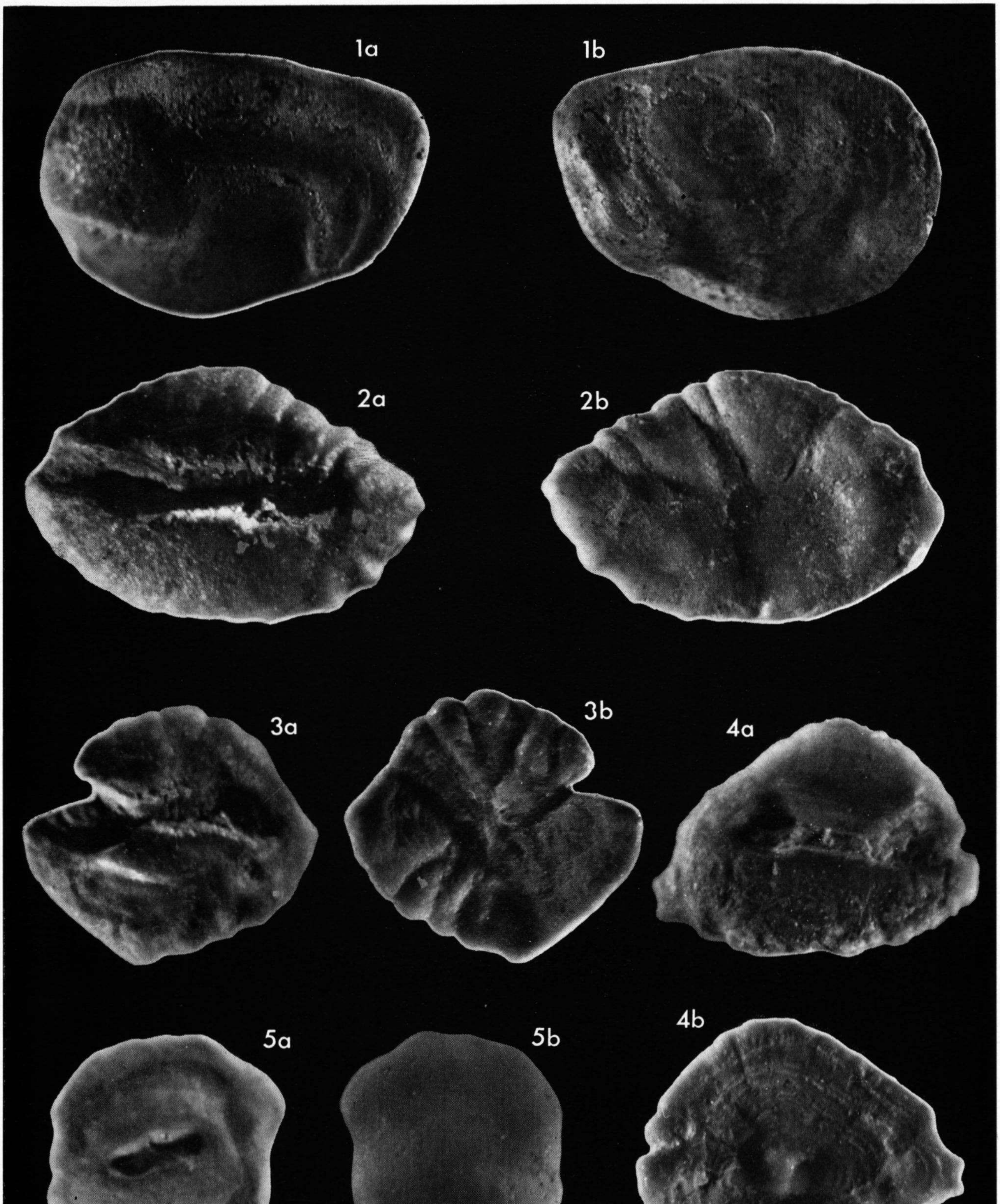
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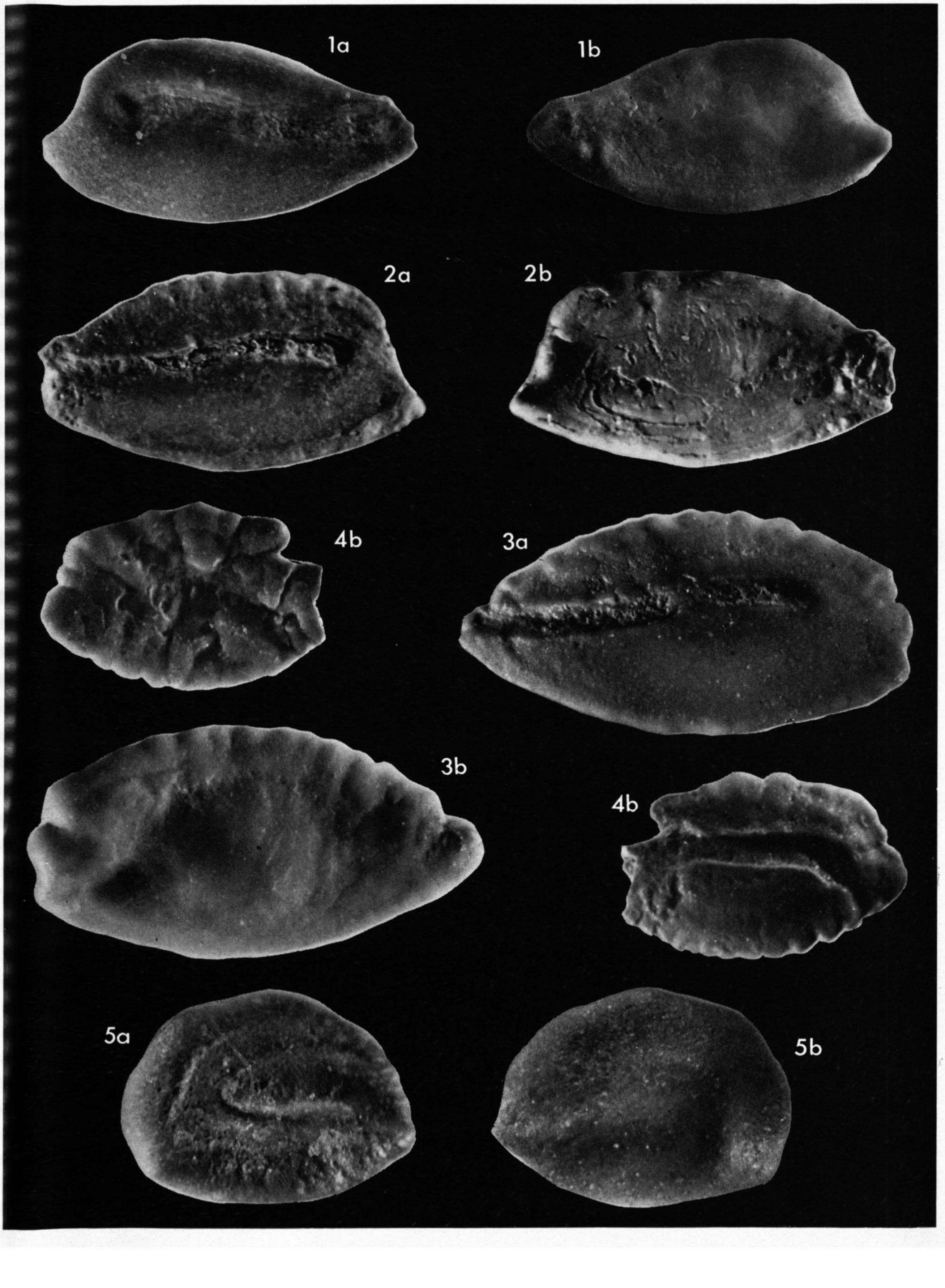
PLATE IX

Fig. 1a, b. *Trachinus acutus*. Sands of Edegem (Coll. RGM, st. 155210) 10 ×.
Fig. 2a, b. *Trachinus mutabilis*. Sands of Edegem (Coll. Gaemers, leg. M. C. Cadée) 10.5 ×.
Fig. 3a, b. *Trachinus verus*. Sands of Edegem (Coll. RGM, st. 155212) 14.5 ×.
Fig. 4a, b. *Serranus noetlingi*. Sands of Edegem (Coll. RGM, st. 155199) 17,5 ×.
Fig. 5a, b. *Solea approximata*. Sands of Antwerp (Coll. RGM, st. 155223) 17 ×.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