

A TELEOST OTOLITH FAUNA FROM THE SANDS OF LEDE, BELGIUM

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The tertiary strata of Belgium is renowned for its rich fish fauna and the elasmobranch remains have been adequately described in the excellent works of Leriche, Casier and others. The teleost remains have received a very limited attention despite their being as common as those of the elasmobranchs but this probably results from the difficulty of identifying such fragmentary specimens. However it is possible to establish a teleost fauna on the evidence of the numerous otoliths which occur in these strata. A few otoliths have been described from the sands of Brussels and the Ieper formation by LERICHE (1905) and CASIER (1946) but all were referred to incorrect genera. None have so far been recorded from the sands of Lede and it is proposed to describe a series obtained by one of us (D.N.). These resulted from the processing of some 300 Kg. of matrix from an outcrop of the Sands of Lede at Balegem. In the present work the basement bed of the sands of Lede is excluded because of its content of reworked material although any forms known to occur at this horizon will be mentioned in the text.

All the otoliths so far found have been sacculiths, all were from fish which had evidently not reached full maturity and all show some degree of erosion. It is probably these factors together with a lack of suitable comparative material from extant fishes which lead to the misidentifications of LERICHE and CASIER, as mentioned by STINTON (1968). 20 teleost species will be established of which 14 are undescribed.

Classification

The scheme accepted by the majority of

ichthyologists in the past has united the ophidioid fishes with the blennioids. However, a study of the otoliths of members of each order immediately reveals the inaccuracies of this system and shows that the ophidioids are closely related to the gadoids. MCALLISTER (1968), proposed the orders *Ophidiidiformes* and *Gadiformes*, consecutively but the relationship shown by the overall characters precludes their ordinal separation. The classification adopted in the present work is that proposed by GREENWOOD, ROSEN, WEITZMAN & MYERS (1946), (see also ROSEN & PATTERSON, 1969), which places each group at subordinal level within the one order *Gadiformes*. The family *Antigoniidae* is included with the berycoids as proposed by STINTON (1967).

Systematic Descriptions

Class *Actinopterygii*
Subclass *Teleostei*
Superorder *Elopomorpha*
Order *Anguilliformes*
Suborder *Anguilloidei*
Family *Anguillidae*
Genus *Anguilla* Shaw, 1803

1803. *Anguilla* Shaw, G. 4, 15: type *Muraena anguilla* Linnaeus (= *Anguilla vulgaris* Shaw).

ANGUILLA RECTANGULARIS sp. n. Pl. figs. 1,2.

Holotype: Registration No. Ht. p. 1588.
Dimensions: Length 3.00 mm (incomplete)
Width 2.55 mm.

Material: The unique holotype.

A thin, rather rectangular, right sacculith which has lost the rostral area. Slightly undulant, horizontal dorsal rim with a small

projection at the junction with the vertical, rounded posterior rim; rounded, somewhat flattened ventral rim; details of anterior rim missing. Markedly concave outer face with radial tuberosities indistinctly visible on all areas. A convex inner face with a median, curved sulcus ending near the posterior rim. The ostium is missing in this specimen but there is a long, narrow cauda present. No collicula.

More complete specimens have been recovered by one of us (F.C.S.) from the lower Barton beds of the English eocene and one of these (fig. 2) shows a very short, wide, deep ostium and a long narrow cauda differentiated by a narrowing of the crista superior and crista inferior. A prominent rostrum and excisura are present but no antirostrum or collicula.

This otolith compares closely with sacculiths of the living *Anguilla reinhardti* Steindachner, both in its peripheral contours and the characters of the sulcus.

Sands of Lede, Balegem, Belgium.

Upper Bracklesham Beds and Lower Barton Beds, England.

Family *Muraenidae*

Genus *Gymnothorax* Bloch, 1795.

1795. *Gymnothorax* Bloch, M.E. 9, 83: type *Gymnothorax reticularis* as first designated by Bleeker, 1865.

Gymnothorax diagonalis sp. n. Pl. fig. 3.

1906. *Otolithus (Congeris)* sp. Priem F., Bull Soc. géol. Fr., (4), 6, 276, figs. 44-45.

Holotype: Registration No. Ht, p. 1589.

Material: 21 sacculiths.

Dimensions: Length 3.96 mm. Width 2.86 mm

A biconvex, regularly rounded, left sacculith with the rims coalescing. The dorsal rim is short, slightly rounded and highest anteriorly; short, slightly obtuse posterior rim; long, regularly rounded ventral rim; long, oblique anterior rim which is notched at its ventral end. Outer face eroded but undulant with a depression from the antero-ventral corner towards the centre of the otolith. Smooth inner face with a conspicuous, slight-

ly undulant sulcus opening on the anterior rim and not reaching the posterior rim in its diagonal course. The sulcus shews little differentiation into ostium and cauda, being equal in depth and width throughout. Crista superior and crista inferior slightly thickened. Rostrum, antirostrum and excisura present but no collicula.

The features of this otolith are very similar to sacculiths of *Gymnothorax ocellatus saxicola* JORDAN & DAVIS, but the outline of the sulcus is more regular in the fossil form. PRIEM (1906), considered this form (as *Otolithus (Congeris)* sp.) to be synonymous with his *Otolithus (Congeris) papointi* but the two types are quite distinct.

Sands of Lede, Balegem, Belgium. Common.

Basement Beds of the sands of Lede, Balegem.

Sands of Aalter, Aalter and Scherpenberg, Belgium.

Upper Bracklesham Beds, England. Rare.

Lutétien, France, Rare.

Family *Moringuidae*

Genus *Moringua* Gray, 1831.

1831. *Moringua* Gray J.E., Zool. Misc., 95: type *Moringua lateralis* Gray.

MORINGUA FISSURA sp. n. Pl. figs. 4a,b

Holotype: Registration No. Ht. p. 1590.

Material: The unique holotype.

Dimensions: Length 4.21 mm. Width 2.06 mm.

A somewhat eroded right sacculith. Slightly concave, almost horizontal dorsal rim; rounded posterior rim; irregularly rounded ventral rim, deepest towards the posterior end; short, oblique anterior rim. Moderately concave outer face which is smoothly rugose. Several concentric growth lines are visible (fig. 4b) through the effects of attrition. Convex inner face with a deep, somewhat diagonal, undulant sulcus which opens on the anterior rim and terminates well short of the posterior rim. Sulcus consisting of a short, rather oval ostium and a long, arcuate cauda with a truncated end. An obtuse upper angle at the junction of ostium and cauda. The crista inferior is continuous and undulant. A feeble rostrum is present but no antirostrum, exci-

suras or collicula. The posterior end of the otolith is expanded and somewhat up-turned giving the otolith a moderate torsion.

This otolith shows a considerable resemblance to the sacculith of the living *Moringua microchir* Bleeker, figured by KOTTHAUS (1968, fig. 112 p. 48) differing in its concave dorsal rim and irregular ventral rim.

Sands of Lede Balegem Belgium.

Family *Congridae*

Genus *Paraconger* Kanazawa 1961.

1961. *Paraconger* Kanazawa R.H., Proc. U.S. Nat. Mus., 113, 4: type *Echelus caudilimbatus* Poey.

PARACONGER SAUVAGEI (Priem) Pl. fig. 5.

1906. *Otolithus (Sparidarum) sauvagei* Priem F., Bull. Soc. géol. Fr., (4), 6, 274, figs. 36, 37.

1932. *Congromuraena amoris* Sulc J., Rozpr. geol. Úst. čl., Praze, 7, 62, pl. 1 figs. 10 a, b.

1933. *Otolithus (Platessa) sector* Koken; Burton E.St.J., Proc. Geol. Ass., 44, 160. Name only. errore.

1933. *Otolithus (Congromuraena) amoris* Sulc; Frost G.A., Ann. Mag. Nat. Hist., (10), 12, 394, pl. 12 fig. 19.

1968. *Paraconger amoris* (Sulc); Stinton, F.C. Coll. Eoc. p. 157, pl. fig. 11.

Registration No. 24/181.

Dimensions: Length 5.55 mm. Width 4.40 mm.

Material: 54 sacculiths.

This sacculith is less eroded than those figured by PRIEM (1906) and SULC (1932). The posterior rim is seen to be feebly crenulated, the dorsal rim is faintly crenulated and the cauda has a bulbous extremity.

This otolith is remarkably similar to the sacculiths of the living *Paraconger macrops* (Günther), as noted in an earlier paper (STINTON, 1968).

Localities:

Sands of Lede, Balegem, Belgium. Common.

Basement beds of the sands of Lede, Balegem.

Sands of Aalter, Aalter and Scherpenberg.

Bracklesham beds with *N.laevigatus*; upper Bracklesham beds with *N. variolarius*, Lower Barton beds, England. Common in the *Miocardia* Bed (CURRY, 1958) = Fischer Bed 17, Bracklesham Bay, Sussex.

Calcaire grossier and Auvers formation, France.

Superorder *Scopelomorpha*

Order *Myctophiformes*

Suborder *Myctophoidae*

Family *Synodontidae*

Genus *Synodus* Gronow, 1763.

1763. *Synodus* Gronow L.T., Zoophyl., 112: type *Salmo synodus* Linnaeus.

SYNODUS RECTUS (Frost) Pl. fig. 6.

1933. *Otolithus (Elops) rectus* Frost G.A., Ann. Mag. Nat. Hist., (10), 12, 389 pl. 12 fig. 2.

Material: 3 sacculiths.

Registration: No. 24/181.

Dimensions: Length 4.25 mm. (incomplete)

Width 2.12 mm.

The holotype of Frost is a very eroded specimen in which the peripheral contours have been considerably modified. It has become pointed posteriorly and has lost much of the detail of the sulcus. In the present specimen it will be seen that the dorsal rim is crenulated while the posterior rim is rounded and bilobed. Also, the ostium is deeper than the cauda from which it is separated by distinct upper and lower angles.

This specimen compares exactly with well-preserved examples found by one of us (F.C.S.) in the lower Barton beds of Hampshire, England. It is undoubtedly the species described by Frost although it is evident that he was misled by the contours of his holotype. The widely divergent features of the fossil form and sacculiths of *Elops* confirm the misidentification. However, sacculiths from living species of *Synodus* Gronow, show distinct similarities to the fossil which must be referred to this genus.

Localities:

Sands of Lede, Balegem, Belgium.

Upper Bracklesham Beds and Lower Barton Beds, England.

Superorder *Paracanthopterygii*
Order *Gadiformes*
Suborder *Ophidioidei*
Family *Ophidiidae*
Genus *Lepophidium* Gill, 1895.

1895. *Lepophidium* Gill, T.N., Amer. Nat., 29, 167: orthotype *Leptophidium profundorum* Gill. Substitute for *Leptophidium* Gill, preoccupied in Snakes.
LEPOPHIDIUM AEQUALIS sp. n. Pl. fig. 7.

Holotype: Registration No. Ht. p. 1592.
Material: 112 sacculiths.
Dimensions: Length 5.80 mm. Width 3.79 mm.

A slightly eroded left sacculith, pointed posteriorly and bluntly rounded anteriorly. Dorsal rim sloping slightly upwards towards the anterior end where it forms a marked prominence at its junction with the anterior rim; short, oblique, slightly undulant posterior rim which coalesces with the dorsal rim to form a very slight rounded angle; rounded ventral rim which is scalloped on the posterior part; irregularly rounded anterior rim, slightly produced centrally and feebly crenulated on the antero-dorsal projection. Outer face prominently and irregularly tuberculated in unworn specimens. A convex inner face with a median sulcus which is completely enclosed apart from a very narrow, short shallow groove to the anterior rim. It is elliptical and undifferentiated, being rounded at the caudal end in unworn specimens. Eroded specimens usually shew a tapered caudal end. Sulcus completely filled with a colliculum. The lower area is faintly ornamented with scalloped ridges on the posterior part.

This otolith shews a marked similarity to sacculiths of the living *Lepophidium cervinum* GOODE & BEAN, but differs in being relatively thinner while *L. cervinum* has a differentiated sulcus, the cauda being very short, bulbous and indistinct.

Localities:
Sands of Lede, Balegem, Belgium. Very common.
Basement bed of the sands of Lede.
Upper Bracklesham Beds, England. Very rare.

Family *Brotulidae*
Genus *Hoplobrotula* Gill, 1863.

1863. *Hoplobrotula* Gill T.N., Proc. Acad. Nat. Sci. Philad., 15, 255: type *Brotula armata* Temminck & Schlegel.
HOPLOBROTULA LERICHEI sp. n. Pl. fig. 8.

Holotype: Registration No. Ht. p. 1591.
Material: 48 sacculiths.
Dimensions: Length 5.04 mm. Width 2.75 mm.

A rather worn, elongate right sacculith, produced to a blunt posterior point. Dorsal rim undulant, rising to an anterior point; short, concave posterior rim; shallowly rounded ventral rim; obtuse, slightly undulant anterior rim. Concave outer face, smoothly undulant but in occasional specimens radial ribbing to a median ridge is evident, indicating that unworn examples would have crenulated rims. Convex inner face with a median, wide sulcus which opens very narrowly on the anterior rim and does not reach the posterior rim. Sulcus consisting of a long, oval ostium sharply delineated from the short, uncinata cauda which forms a marked lower angle at its junction with the ostium. Crista superior continuous. Ostium filled with a colliculum. No rostrum, antirostrum or excisura.

This form is remarkably similar to sacculiths of the living Japanese species *Hoplobrotula armata* (TEMMINCK & SCHLEGEL), differing only in the deeper ventral rim in the fossil form.

Localities:
Sands of Lede, Balegem, Belgium.
Basement bed of the sands of Lede, Balegem.
Calcaire grossier, France.
Genus *Ogilbia* (Jordan & Evermann)
Evermann & Kendall, 1898.

1898. *Ogilbia* (Jordan & Evermann) Evermann B.W. & Kendall W.C., Bull. U.S. Fish. Comm., 17, (1897) 132: orthotype *Ogilbia cayorum* Evermann & Kendall.
OGILBIA SUBREGULARIS (Schubert) Pl. figs. 9, 10.

1916. *Otolithus* (*Ophidiidarum*) *subregularis* Schubert R.J., Jahrb. der k.k. geol. Reichs., 65, 285, pl. 7 figs. 35-37.

1933. *Otolithus (Ophidiidarum) cf. acutangulum* Koken; Burton E.St.J., 1933. Proc. Geol. Ass., **44**, 160. Name only. errore. *Otolithus (Ophidiidarum) subregularis* Schubert; Burton E.St.J., *ibid.*, **44**, 160. Name only.

1934. *Otolithus (Ophidiidarum) planus* Frost G.A., Ann. Mag. Nat. Hist., (10), **14**, 444. pl. 12 fig. 6.

Materials: 13 sacculiths.

Dimensions:

Left sacculith (Fig. 9) Length 4.86 mm. Width 2.39 mm.

Right sacculith (Fig. 10) Length 3.07 mm. Width 1.75 mm.

An eroded left sacculith (fig. 9). Smoothly rounded dorsal rim which becomes concave posteriorly; posterior rim very short, obtuse and very faintly crenulate; long, gently rounded ventral rim which is slightly undulant at the posterior end; oblique anterior rim backed by a rounded protuberance of the outer face. Outer face smooth, longitudinally thickened on the ventral periphery and a small central depression. Smooth, convex inner face with a sulcus which is virtually enclosed apart from a very indistinct, tiny groove to the anterior rim. Sulcus consisting of a long, elliptical ostium and a very short, uncinata cauda. A lower angle present at the junction of ostium and cauda; crista superior continuous. Sulcus partially filled with collicula. In more eroded specimens it appears that the sulcus is completely filled. The smaller, less eroded right sacculith (fig. 10) shews crenulated dorsal, anterior and ventral rims with a denticulated posterior rim. The outer face is convex, with irregular central tuberculations and prominent radial ribs on all peripheries. It is common to find specimens modified to a sharp point where the posterior rim has been lost entirely.

This is undoubtedly the species described by SCHUBERT (1916) from the Bartonian of England.

Localities:

Sands of Lede, Balegem, Belgium. Common.

Basement bed of the sands of Lede. Sands of Aalter, Aalter, Belgium.

Upper Bracklesham Beds and Barton Beds, England, where it is very common at some horizons.

Calcaire grossier, France. Rare.

Superorder *Acanthopterygii*

Order *Beryciformes*

Suborder *Berycoidei*

Family *Trachichthyidae*

Genus *Trachichthodes* Gilchrist, 1903.

1903. *Trachichthodes* Gilchrist J.D.F., Mar. Invest. S. Afr., **2**, 203: type species *Trachichthodes spinosus* Gilchrist.

TRACHICHTHODES CIRCULARIS (Shepherd) Pl. fig. 11.

1916. *Otolithus (Apogonidarum) circularis* Shepherd C.E., Knowledge, **39**, (N.S. 13), 183. fig. 154 (3) top two figures only.

1933. *Otolithus (Monocentris) lemoinei* Priem; Burton E. St.J., Proc. Geol. Ass., **44**, 160. Name only. errore.

Material: 3 sacculiths.

Dimensions: Length 2.80 mm. Width 2.50 mm.

An eroded, circular left otolith. Dorsal rim faintly crenulate, rising to an anterior point and notched at its posterior end; short, vertical posterior rim; rounded ventral rim; rounded anterior rim which becomes oblique in its upper part. Outer face smoothly rugose with a central depression across the median area. A somewhat convex inner face with a prominent sulcus opening widely on the anterior rim and just opening on the posterior rim also, though this latter feature may result from slight erosion. The sulcus is situated slightly above the mid-line of the otolith and consists of a wide, oval, rather deep ostium with a narrower, slightly undulant cauda. The undulant crista superior is markedly accentuated by a depression above it. There is no upper angle but a prominent lower angle is present at the junction of ostium and cauda. There is no evidence of a rostrum, antirostrum or excisura in this specimen. No collicula.

The figures of SHEPHERD (1916), are virtually unrecognisable but comparison with the original specimens in the collections of the

Department of Palaeontology, British Museum (Natural History) prove that the present specimen is the same species. The redescription and present figure is intended to clarify the situation.

This species closely resembles sacculiths of the living Australian species *Trachichthodes affinis* (Günther), differing only in its more circular outline. This feature also distinguishes it from the Yprésien species *T. lemoinei* (Priem).

Localities:

Sands of Lede, Balegem, Belgium.

Basement bed of the sands of Lede, Balegem.

Lower Bartonian, England.

Lutétien, France.

Family *Antigoniidae*

Genus *Antigonia* Lowe, 1843.

1843. *Antigonia* Lowe R.T., Proc. Zool. Soc., 11, 85: orthotype *Antigonia capros* Lowe.

ANTIGONIA ANGUSTA sp. n. Pl. figs. 12, 13.

Holotype: Left sacculith, fig. 13. Registration No. Ht. p. 1593.

Material: 2 sacculiths.

Dimensions: Fig. 12. Length 1.85 mm. Width 2.51 mm. 13. Length 2.49 mm. Width 2.90 mm.

Holotype (fig. 13), an eroded, biconvex left sacculith. High, rounded dorsal rim which is irregularly crenulated; short, slightly rounded, obtuse, faintly crenulated posterior rim; deeply rounded, angular, denticulated ventral rim; rounded, notched anterior rim. Outer face ornamented with irregular ridges. Smooth inner face with a sulcus slightly above the mid-line, opening on the anterior rim and almost extending to the posterior point of the otolith. Sulcus consisting of a wide, spatulate, deep ostium set diagonally, and an horizontal, slightly arcuate, narrow cauda of moderate depth, tapering at its extremity. There is a very slight rounded upper angle and a marked lower angle at the junction of ostium and cauda. Crista superior undulant and strongly accentuated by a depression above it. A small

rostrum, antirostrum and excisura are present but no collicula. A smooth, semicircular lower area with a suggestion of peripheral ribbing on the ventral rim. The juvenile sacculith (fig. 12) shews a markedly crenulate periphery with prominent ribbing on the outer face.

This otolith has a strong affinity with those of the living *Antigonia capros* Lowe, both in its contours and the characters of the sulcus, and is undoubtedly referable to this genus.

Localities:

Sands of Lede, Balegem, Belgium.

Basement bed of the sands of Lede, Balegem.

Sands of Aalter, Aalter, Belgium.

Upper Bracklesham Beds, England.

Order *Scorpaeniformes*

Suborder *Platycephaloidei*

Family *Platycephalidae*

Genus *Platycephalus* Bloch, 1795.

1795. *Platycephalus* Bloch M.E., Naturg. Ausl. Fische., 9, 96: type *Callionymus indicus* Linnaeus = *Platycephalus spathula* Bloch = *Cottus insidiator* Forskål.

Non *Platycephalus* Ribeiro, A. de M. 1902., 7: type *Sciaena undecimalis* Bloch.

PLATYCEPHALUS ACULEATUS sp. n. Pl. fig. 14.

Holotype: Registration No. Ht. p. 1594.

Material: 3 sacculiths.

Dimensions: Length 2.99 mm. Width 1.34 mm.

A slender, elliptical left sacculith. Rounded, irregularly crenulated dorsal rim continuous with the crenulated posterior rim; posterior point slightly truncated and crenated; slightly undulant, almost horizontal, crenated ventral rim; oblique, crenated anterior rim. Concave outer face, longitudinally thickened in the central area with short, tuberculated ribs on all the peripheral areas. Convex inner face with a narrow, almost straight sulcus opening obliquely on the anterior rim and following a slightly upward course a little above the mid-line of the otolith to terminate well short of the posterior rim. It consists of a long, narrow ostium only slightly wider than the slightly

undulant cauda which turns downwards slightly at its tip. A very indistinct, obtuse upper angle and a small lower angle are present at the junction of ostium and cauda, these features being lost in eroded specimens. A small rostrum, very slight antirostrum and excisura are present but no collicula. Crista superior accentuated by a depression above it. A smooth lower area with very short ribbing on the ventral periphery. Posterior end of otolith compressed and rugose.

These otoliths have a strong affinity with sacculiths of the living *Platycephalus indicus* (Linn.), and *P. bassensis* Cuv. & Val., in their peripheral contours and the characters of the sulcus.

Localities:

Sands of Lede, Balegem, Belgium.

Basement beds of the sands of Lede, Balegem.

Upper Bracklesham Beds, England.

Calcaire grossier, France.

Order *Perciformes*

Suborder *Percoidei*

Family *Apogonidae*

Genus *Apogon* Lacépède, 1802.

1802. *Apogon* Lacépède B.G., Hist. nat. Poiss., 3, 411: type *Apogon ruber* Lacépède.

APOGON ARAMBOURGI Pl. figs. 16a,b.

Holotype: Registration No. Ht. p. 1595.

Material: 21 sacculiths.

Dimensions: Length 5.54 mm. Width 4.54 mm.

A slightly eroded left, oval sacculith with a bluntly rounded, crenulated posterior end. Dorsal, posterior and ventral rim continuous and crenulated; obtuse anterior rim with a small indentation where the sulcus opens. Outer face strongly ornamented with radial ribbing on the peripheral areas, an irregularly raised central umbo and several verrucose projections. Convex inner face with a prominent median sulcus opening obliquely on the anterior rim and not reaching the posterior point on the otolith. Sulcus consisting of a rather rectangular, wide, shallow ostium equal in length to the narrower cauda. There is a concavity of the crista superior and a

moderate lower angle at the junction of ostium and cauda. A shallow depression above the crista superior, accentuating it, and this depression is traversed by radial ribbing in unworn specimens. A blunt rostrum, slight antirostrum and excisura are present and collicula partially fill both ostium and cauda, the two being separated by a slight diagonal groove. There is a smooth, semicircular lower area.

The rectangular ostium distinguishes this form from other described species which all have an oval ostium.

Locality:

Sands of Lede, Balegem, Belgium. Common.

Basement beds of the sands of Lede, Balegem.

Family *Ambassidae*

Genus *Ambassis* Cuvier & Valenciennes, 1828.

1828. *Ambassis* Cuvier G. & Valenciennes A., Hist. Nat. Poiss., 2, 175: type *Centropomus ambassis* Lacepede (= *Ambassis commersoni* Cuv. & Val.

AMBASSIS ELECTILIS sp. n. Pl. fig. 15.

Holotype: Registration No. Ht. p. 1598

Material: 3 sacculiths.

Dimensions: Length 2.34 mm. (incomplete), Width 2.01 mm.

A thin, rather angular right sacculith with part of the rostral area missing. Short, crenulate dorsal rim; nearly vertical, slightly concave posterior rim which forms a slight rounded «boss» at its junction with the dorsal rim; relatively deep, angular, prominently denticulated ventral rim; dorsal part of anterior rim crenulated. Outer face thickened centrally, with tuberosities on the dorsal periphery and short, radial ridges on the ventral periphery. Slightly convex inner face with a median sulcus opening on the anterior rim and terminating short of the posterior rim. Sulcus consisting of a short, deep, spatulate ostium and a straight, narrow, shallower cauda which is rounded at its extremity. Crista superior continuous, almost horizontal and somewhat accentuated by a

depression above it. A marked lower angle at the junction of ostium and cauda. Slight antirostrum and excisura. Rostrum probably present in entire specimens. No collicula. Ventral periphery ornamented with short parallel ribs.

This ornate sacculith has similar characters to those of the living *Ambassis macleayi* (Castelnau), differing in its crenulated rims, more circular outline and truncated posterior rim.

Localities:

Sands of Lede, Balegem, Belgium.

Basement bed of the sands of Lede.

Upper Bracklesham Beds and Lower Barton Beds, England.

Family *Pseudopriacanthidae*

Genus *Pseudopriacanthus* Bleeker, 1869

1869. *Pseudopriacanthus* Bleeker P., Versl. Akad. Amsterdam (2), 3, 241: orthotype *Priacanthus nipponius* Cuv. et Val. PSEUDOPRIACANTHUS RUTOTI (Leriche) Pl. fig. 17.

1905. *Sparidarum rutoti* Leriche M., Mém. Mus. Roy. d'Hist. Nat. Belg., 3, 165. Pl. 12, figs. 9,10.

1916. *Otolithus (Pagellus ?) gregarius* Koken; Schubert R.J., Jahrb. der k.k. geol. Reichsanst., 65, 278. Pl. 7 figs. 14, 14a. (errore).

1933. *Otolithus (Psetta) praemaxima* Shepherd; Burton E.St.J., Proc. Geol. Ass., 44, 160. Name only. errore.

1934. *Otolithus (Trigla) rhombicus* Schubert; Frost G.A., Ann. Mag. Nat. Hist., (10), 14, 442. pl. 12 fig. 1. errore.

Material: 12 sacculiths.

Dimensions: Length 2.96 mm. Width 2.45 mm.

A well-preserved left sacculith with several features not seen in the eroded holotype of Leriche. This otolith is subquadrilateral and thin. The rounded dorsal rim is crenulated; posterior rim short, obtuse, with two crenulations on its upper half; the markedly angular, deep ventral rim is keeled and prominently denticulated; anterior rim notched and continuous with the dorsal rim. Concave outer face

which is smoothly tuberculated in the central area and is delicately ornamented with short radial ribbing on the peripheral areas. Convex inner face with an undulant sulcus opening narrowly on the anterior rim and ending near the postero-ventral point of the otolith. Sulcus consisting of a moderately long ostium, tapering towards the cauda from which it is separated only by a constriction of the crista superior and crista inferior, both of which are continuous and undulant. Also, the ostium is slightly deeper than the cauda which is arcuate and tapers at its extremity. Crista superior accentuated by a depression above it which is traversed by indistinct radial, scalloped ribs to the dorsal rim. Moderate rostrum, antirostrum and excisura present. No collicula. A deep, triangular, smooth lower area with short, parallel ridges on the ventral periphery. In eroded examples the contours of the otolith become much more rounded.

These sacculiths are almost identical with those of the living *Pseudopriacanthus altus* Gill, differing only in the more rounded and markedly denticulate dorsal rim with the somewhat concave posterior rim seen in the living type. Leriche supposed this form to be referable to the group *Sparidarum*, as defined by Koken, but was obviously not familiar with the sacculiths of *Pseudopriacanthus*.

Localities:

Sands of Lede, Balegem and sands of Brussels, Belgium. Uncommon.

Basement bed of the sands of Lede.

Upper Bracklesham Beds, England.

Calcaire grossier, and Auvers formation, France.

Family *Serranidae*

Genus *Serranus* Cuvier, 1817.

1817. *Serranus* Cuvier G., Règne Anim., Ed. 1, 2, 276: type *Perca cabrilla* Linn., by common consent.

subgenus *Serranellus* Jordan & Eigenmann, 1888.

1890. *Serranus (Serranellus)* Jordan D.S. in Jordan D.S. and Eigenmann C.H., Bull. U.S. Fish. Comm., 8, (1888), 399:

orthotype *Perca scribe* Linn.
SERRANUS (SERRANELLUS) DELICATULUS
sp. n. Pl. fig. 18.

Holotype: Registration No. Ht. p. 1596.
Material: The unique holotype.
Dimensions: Length 3.18 mm. (incomplete)
Width 1.72 mm.

An elliptical, thin left sacculith with the tip of the rostrum missing. Very slightly curved, broadly bi-lobed dorsal rim which is notched at its junction with the obtuse, short, tri-lobed posterior rim; long, slightly rounded, denticulated ventral rim; long, oblique, undulant anterior rim. Strongly concave outer face ornamented with broad, radial, pectinated ribbing on the dorsal area. Convex inner face with an arcuate sulcus opening obliquely on the anterior rim and terminating before reaching the posterior point of the otolith. Sulcus consisting of a rather narrow, moderately deep ostium and a narrower cauda which is undulant and turns downwards near its rounded extremity. An undifferentiated, undulant crista superior which is accentuated by a shallow depression above it. Two broad ridges traverse the depression to the dorsal periphery. An obtuse lower angle is present at the junction of ostium and cauda. Prominent rostrum and excisura present but no visible antirostrum or collicula. The posterior end of the otolith is compressed and rugose. Smooth, semicircular lower area and a narrowly keeled ventral periphery.

This ornate otolith is typically serranid in character and compares closely with sacculiths of the living *Serranellus scribe* (Linn.), in its ornamentation and sulcus characters but is relatively shorter and broader in its contours.

Locality:

Sands of Lede, Balegem, Belgium.
Basement bed of the sands of Lede.

Genus *Centropristes* Cuvier, 1829.

1829. *Centropristes* Cuvier G., Règne Anim., Ed. II, 2, 145. (Cuv. et Val., 3, 56): type *Centropristes nigricans* Cuv. et Val. (*Labrus striatus* Linn.). Later written *Centropristis*.

CENTROPRISTES EXSCULPTUS sp. n. Pl. fig. 19.

Holotype: Registration No. Ht. p. 1597.
Material: The unique holotype.
Dimensions: Length 4.78 mm. (incomplete)
Width 2.89 mm.

An elegant, thin, elliptical right sacculith. Strongly denticulated dorsal and posterior rims which are continuous; long, curved, denticulated ventral rim, the denticulations being more strongly marked at the posterior point; oblique, denticulate, notched anterior rim. Concave outer face strongly ornamented with an irregular network of internal ridges and radial ribbing on all rims. Convex inner face with a median, arcuate sulcus opening on the anterior rim and terminating near the posterior end of the ventral rim. Sulcus consisting of a relatively long, narrow, rectangular ostium and a narrower, curved cauda. A rounded upper angle and an obtuse lower angle are present at the junction of ostium and cauda. The crista superior is accentuated by a depression above it and the dorsal area is traversed by wide, parallel ridges. It is likely that the prominent rostrum is continued to a sharp point but the tip has broken off. A slight antirostrum and excisura are present but no collicula. The posterior end of the otolith is compressed and prominently sculptured. A smooth, semicircular lower area.

This otolith compares closely with sacculiths of the living *Centropristes striatus* (Linn.), in its peripheral contours and characters of the sulcus, differing only in the more elegant sculpturing of the dorsal and ventral rims.

Locality: Sands of Lede, Balegem, Belgium.

Family *Lutianidae*

Genus *Lutianus* Bloch, 1790.

1790. *Lutianus* Bloch M.E., Naturg. Ausl. Fische, 4, 105: type *Lutianus lutianus* Bloch. Also spelled *Lutjanus*.

LUTIANUS KOKENI (Leriche) Pl. fig. 20.

1905. *Percidarum kokeni* Leriche M., Mèm. Mus. Roy. d'hist. nat. Belg., 3, 162. pl. 12 figs. 1-8.

1906. *Otolithus (Percidarus) concavum* Priem F., Bull. Soc. géol. Fr., (4), 6, 269.

figs. 16-18 only.

Non Bauza Rullan J., 1957.

1906. *Otolithus (Percidarum) obtusus* Priem F., loc. cit., 270, text figs. 21-23 only.
1911. *Otolithus (Percidarum) concavus* Priem F., Ann. Pal. Soc., suppl., 28-29. text-figs. 26, 27.
1912. *Otolithus (Percidarum) concavus* Priem F., Bull. Soc. géol. Fr., (4), 12, 246. Name only.
1912. *Otolithus (Percidarum) concavus* Priem F., loc. cit., 248. text-figs. 7,8.
1913. *Otolithus (Percidarum) aff. concavus* Priem F., loc. cit., (4), 13, 152. text-figs. 2,3.
1916. *Otolithus (Percidarum) bartonensis* Schubert R.J., Jahrb. der k.k. geol. Reichsanst., 65, 278. pl. 7 figs. 9-11.
1916. *Otolithus (Serranidarum) bartonensis* Shepherd C.E., Knowledge, 39, *Otolithus (Serranidarum) concavus* (N.S. 13), 184. fig. 154 (8).
1933. *Otolithus (Serranus) bartonensis* Schubert; Burton E.St.J., Proc. Geol. Ass., 44, 160. Name only. errore.
1934. *Otolithus (Percidarum) concavus* Priem; Frost G.A., Ann. Mag. Nat. Hist., (10), 13, 426. pl. 15 fig. 1.
1934. *Otolithus (Percidarum) bartonensis* Priem; Frost G.A., ibid. 426. pl. 15, fig. 2.
1965. *Allomorone bartonensis* (Priem); Frizzell D.L. & Dante J.H., Journ. Pal., 39, no. 4, 703. Name only.
1968. *Lutianus concavus* Stinton F.C., Mém. B.R.G.M., No. 58, 158. pl. (unnumbered) fig. 19.

Material: One fragmentary sacculith.

Although fragmentary, sufficient of the specimen remains to identify it as typical of the species described by LERICHE (1904) 1905. It occurs in vast numbers in the upper Eocene of France and England. The many synonyms result from the degrees of erosion or the growth-stage of the various specimens cited as holotypes.

Localities:

Sands of Lede, Balegem, Belgium. Rare. Upper Bracklesham and Barton Beds, England.

Lutétien and Bartonien, France.

Family Sparidae
Subfamily Denticinae
Genus Dentex Cuvier, 1815.

1815. *Dentex* Cuvier G., Mem. Mus. Hist. Nat. Paris. 1 (6), March, 456: 1817. Regne Anim., II, 273: type *Sparus dentex* Linn.
DENTEX NOTA (Shepherd) Pl. figs. 21,22.
1915. *Otolithus (Pagellus ?) gregarius* Schubert R.J., Jahrb. der k.k. Reichsanst., 65, 278. Taf. 7 figs. 12,13. errore. *Otolithus (Berycidarum) bouryi* Schubert R.J., loc. cit., 280. fig. 22.
1916. *Otolithus (Apogonidarum) nota* Shepherd C.E., Knowledge, 39, n.s. 13, 183. fig. 154 (6). Bottom two figures. *Otolithus (Pagellus) praecentrodon* Shepherd C.E., loc. cit., 180. fig. 155 (1a). *Otolithus (Sargus) pre-rondolettii* Shepherd C.E., loc. cit., 180. fig. 155 (1b).
1933. *Otolithus (Serranus) concavus* Burton E.St.J., Proc. Geol. Ass., 44, 160. name only.
1934. *Otolithus (Dentex) pulcher* Frost G.A., Ann. Mag. Nat. Hist., (10), 13, 380. pl. 14 fig. 1. *Otolithus (Dentex) regularis* Frost G.A., loc. cit., 384. pl. 14, fig. 12.

Material: 2 specimens.

Dimensions: Fig. 21. Length 5.14 mm. Width 3.80 mm. Fig. 22. Length 2.83 mm. Width 1.97 mm.

Figure 21 represents an eroded left sacculith. Dorsal rim very faintly crenulated; posterior rim missing; a somewhat deeply rounded, crenulated ventral rim; obtuse anterior rim. A concave outer face with indistinct tuberosities and a suggestion of radial ribbing on the dorsal area. A convex inner face with a median sulcus opening on the anterior rim and terminating near the postero-

ventral corner of the otolith. Sulcus consisting of a wide, spatulate ostium, slightly deeper than the narrow, arcuate cauda which tapers to a point at its extremity. There is an obtuse upper angle and a marked lower angle at the junction of ostium and cauda. Crista superior accentuated by a depression above it. Rostral area somewhat eroded. No collicula. Fig. 22 represents a juvenile specimen and shows an oval outline with a suggestion of a blunt rostrum but part of the rostrum is missing.

These otoliths show a strong resemblance to the form described by SHEPHERD (1916), as far as can be judged from such eroded specimens.

Localities:

Sands of Lede, Balegem, Belgium.

Basement bed of the sands of Lede, Balegem.

Upper Brackleshem Beds and Lower Barton Beds, England.

Subfamily *Sparinae*

Genus *LAGODON* Holbrook, 1855.

1855. *LAGODON* Holbrook J.E., Ichthyology of S. Carolina. 59: orthotype *Sparus rhomboides* Linn.

LAGODON PECTINOIDES sp. n. Pl. fig. 23.

Holotype: Registration No, Ht. p. 1601.

Material: The unique holotype.

Dimensions: Length 3.77 mm. (incomplete)

Width 2.26 mm.

A thin, left sacculith. An irregularly crenulated dorsal rim, concave posteriorly; vertical, tridentate posterior rim; rounded ventral rim, indistinctly crenulated posteriorly; oblique, prominently notched anterior rim. Concave outer face with broad radial ribs on the dorsal and posterior areas and a concentric growth line paralleling the periphery. Convex inner face with a sulcus opening on the anterior rim and extending somewhat diagonally to terminate near the postero-ventral corner of the otolith. Sulcus consisting of a fairly deep, somewhat oval ostium and a rather wide, undulant cauda which turns downwards at its extremity. A very slight, rounded upper angle and an obtuse lower angle present at the junction of ostium and

cauda. An undulant crista superior accentuated by a depression above it and this is traversed by wide, tuberoso ribs. A prominent rostrum is probably present in entire specimens but it is lost in this example. Antirostrum and excisura present but no collicula. A smooth, semicircular lower area. Posterior end of otolith compressed and traversed by three ridges to the posterior rim.

This sacculith is closely similar to those of the living species *LAGODON rhomboides* (Linn.), differing only in the fewer, wider denticulations of the posterior rim and the widely crenulated dorsal rim.

Locality: Sands of Lede, Balegem, Belgium.

Subfamily *Pagellinae*

Genus *Oblada* Cuvier, 1829.

1829. *Oblada* Cuvier G., Règne Anim., Ed. II, 2, 185: type *Sparus melanurus* Linn., monotypic.

OBLADA JONETI sp. n. Pl. fig. 24.

Holotype: Registration No. Ht. p. 1600.

Material: The unique holotype.

Dimensions: Length 3.70 mm. (incomplete)

Width 2.58 mm.

An eroded, elliptical, left sacculith. Rounded, faintly crenulate dorsal rim; short, obtuse posterior rim; rounded, smooth ventral rim; oblique, broken anterior rim. Concave outer face with an indistinct central umbo and radial ridges to the dorsal and posterior rims. The degree of ornamentation has been markedly affected by erosion. Ventral periphery thickened. Convex inner face with an arcuate sulcus opening widely on the anterior rim and terminating near the postero-ventral border. Sulcus consisting of a fairly deep, spatulate ostium and a narrower, arcuate cauda. The rims of the ostium become straight towards the anterior end but, this feature is largely lost in the present incomplete specimen. The crista superior is markedly accentuated by a depression above it. Marked upper and lower angles at the junction of ostium and cauda. Characters of rostral area missing. No collicula. Smooth lower area.

This eroded otolith somewhat resembles sacculiths of the living *Oblada melanura*

(Linn.), especially in the character of the sulcus, but the fossil form is relatively wider and shorter.

Locality: Sands of Lede, Balegem, Belgium.

Basement beds of the sands of Lede, common.

All the described specimens are lodged in the collections of the Musée Royal d'Histoire Naturelle de Belgique and bear the registration numbers. 24/181 of the general inventory of that Institution.

Discussion

Although much work still remains to be done on the teleost faunas of the zones of the Eocene of Belgium and France it is possible to establish certain relationships between them.

Points of Comparison

Belgian Basin

A sufficient number of species for comparative purposes have been obtained only from the sands of Aalter. Only three species (as otoliths) are known from the sands of Brussels, two of which occur in the sands of Lede. No otoliths have so far been recorded from the sands of Wemmel.

Paris Basin

Otoliths have been described by Priem and Leriche from the Paris Basin and one of us (F.C.S.) has collected from a number of horizons of the French Eocene. A reasonable fauna is known from the Sables de Cuise and from the Lutétien but otoliths are scarce in the sands of Auvers and Marines. This scarceness probably results from the very littoral or beach-like character of this facies. It is evident that further investigations are required before firm conclusions on correlation with other areas can be made.

Hampshire and London Basins

Many otoliths have been described from the English Eocene and one of us (F.C.S.) has

extensive MS. species to make a tentative correlation with the geological horizons in other areas.

From the below tables it is evident that the teleosts of the sands of Lede have a close affinity with those of the Upper Bracklesham beds of England. There is also evidence that this fauna is comparable with that of the Lower Barton beds, and of the Calcaire Grossier but this may be due to a more extensive vertical distributions of some species. A more intensive investigation of the sands of Brussels and Auvers would undoubtedly produce further evidence in this field of research. However, it is quite evident that few species are common to the Nummulites laevigatus zone of England and the sands of Lede. Nevertheless it must be noted that the sands of Aalter which are probably of the same age (or less older) as the N. laevigatus beds of England, have five species in common with the sands of Lede.

Some Biological Characteristics of the Teleosts from the Sands of Lede
Dredging experiments today reveal that heavy concentrations of otoliths are to be found at depths of not less than 40 metres and investigations of bottom deposits off the Woods Hole area of the east coast of the United States revealed a marked concentration of sacculiths of the ophidioid *Lepophidium cervinum* GOODE & BEAN, among the numerous otoliths. This parallels the abundance of the sacculiths of *Lepophidium aequalis* sp. n., in the Lédien deposits.

The absence of clupeoid otoliths from this assemblage is a common feature of Eocene strata. One of us (F.C.S.) has recovered occasional sacculiths of several extant genera of clupeids from various horizons of the English Upper Bracklesham Beds, thus establishing the presence of this large group of teleosts in the seas of Lede.

Acknowledgements

Dr. C. PATTERSON and Mrs. WELCH, of the Department of Palaeontology, British Museum (Natural History) have accorded most

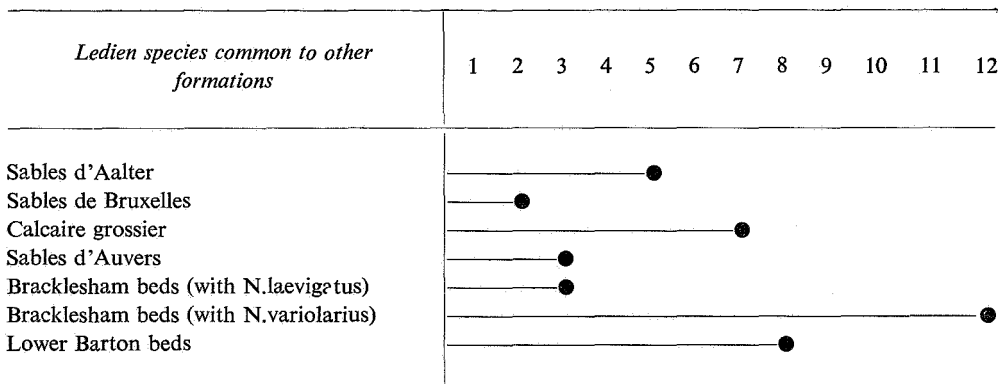


Table of the stratigraphical distribution of the otolith based teleosts from the sands of Lede

	Sands of Aalter	Sands of Brussel	Basement bed sands of Lede	Sands of Lede	Calcaire grossier	Assise d'Auvers	Bracklesham beds (with <i>N.laevigatus</i>)	Upper bracklesham beds	Lower Barton beds
<i>Anguilla rectangularis</i> n. sp.				L				Up	B
<i>Gymnothorax diagonalis</i> n. sp.	A		(L)	L	G			Up	
<i>Moringua fissura</i> n. sp.				L					
<i>Paraconger sauvagei</i> (PRIEM)	A		(L)	L	G	A	Lo	Up	B
<i>Synodus rectus</i> (FROST)				L				Up	B
<i>Hoplobrotula lerichei</i> n. sp.			(L)	L	G				
<i>Lepophidium aequalis</i> n. sp.			(L)	L			Lo	Up	
<i>Ogilbia subregularis</i> (SCHUBERT)	A		(L)	L	G		Lc	Up	B
<i>Trachichthodes circularis</i> (SHEPHERD)			(L)	L	G				B
<i>Antigonia angusta</i> n. sp.	A		(L)	L				Up	
<i>Platycephalus aculeatus</i> n. sp.			(L)	L	G			Up	
<i>Apogon arambourgi</i> n. sp.			(L)	L					
<i>Pseudopriacanthus rutoti</i> (LERICHE)		Br	(L)	L	G	A		Up	
<i>Serranus delicatulus</i> n. sp.			(L)	L					
<i>Centropristes exsculptus</i> n. sp.				L					
<i>Ambassis electilis</i> n. sp.			(L)	L				Up	B
<i>Lutianus kokeni</i> (LERICHE)	A	Br		L	G	A		Up	B
<i>Dentex nota</i> (SHEPHERD)			(L)	L				Up	B
<i>Oblada joneti</i> n. sp.			(L)	L					
<i>Lagodon pectinoides</i> n. sp.				L					

valuable advice on the format and relevant literature in this paper. Most grateful thanks are extended to all institutions and people

throughout the world who have supplied the necessary fish and otoliths, without which this paper could not have been prepared.

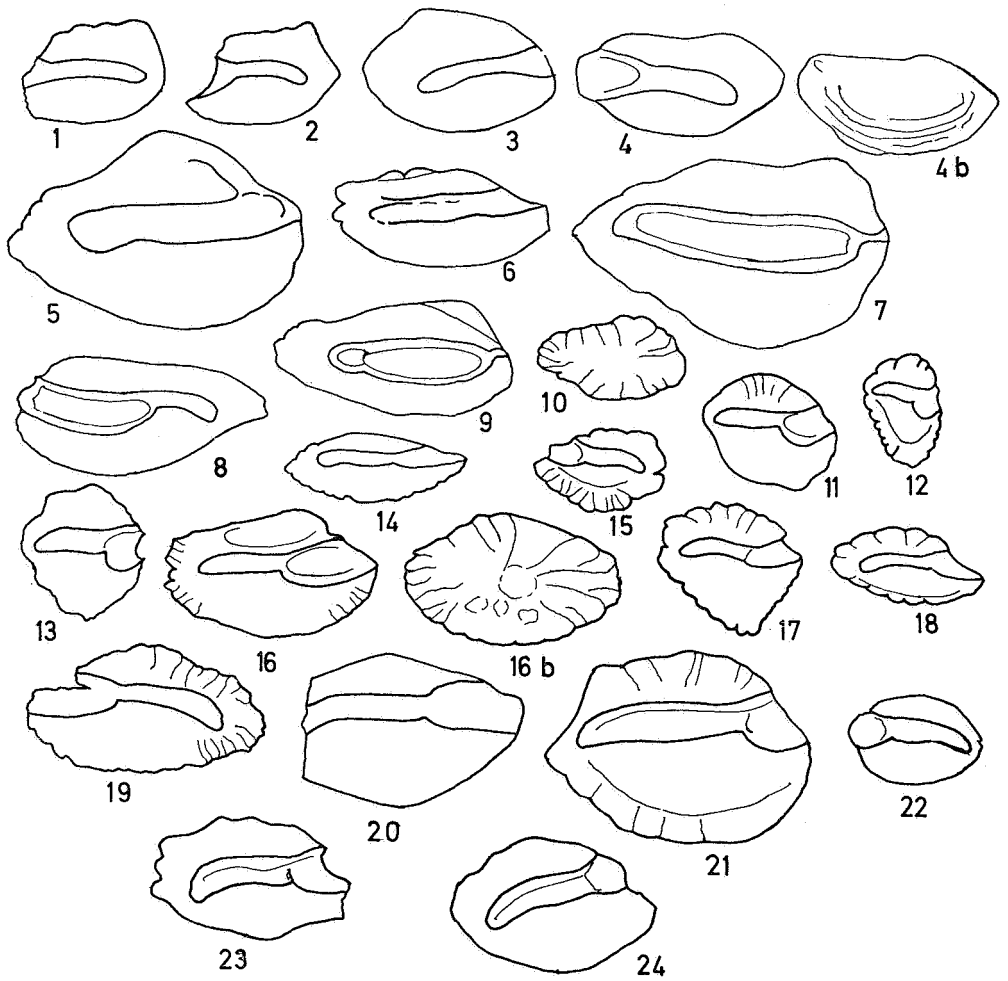
EXPLANATION OF PLATE

Fig. 1. <i>Anguilla rectangularis</i> sp. n. Right sacculith, inner face. Holotype	x 8
2. <i>Anguilla rectangularis</i> sp. n. Right sacculith, inner face. Lower Barton Beds, Hor. A3, Highcliff, Hants.	x 9
3. <i>Gymnothorax diagonalis</i> sp. n. Left sacculith, inner face. Holotype.	x 8
4. a, b. <i>Moringua fissura</i> sp. n. Right sacculith, inner and outer faces. Holotype.	x 9
5. <i>Paraconger sauvagei</i> (Priem). Left sacculith, inner face.	x 8
6. <i>Synodus rectus</i> (Frost). Left sacculith, inner face.	x 8
7. <i>Lepophidium aequalis</i> sp. n. Left sacculith, inner face. Holotype.	x 9
8. <i>Hoplobrotula lerichei</i> sp. n. Right sacculith, inner face. Holotype.	x 8
9. <i>Ogilbia subregularis</i> (Schubert). Left sacculith, inner face.	x 8
10. <i>Ogilbia subregularis</i> (Schubert). Juvenile right sacculith, outer face.	x 8
11. <i>Trachichthodes circularis</i> (Shepherd). Left sacculith, inner face.	x 8
12. <i>Antigonia angusta</i> sp. n. Juvenile left sacculith, inner face.	x 7
13. <i>Antigonia angusta</i> sp. n. Left sacculith, inner face. Holotype.	x 8
14. <i>Platycephalus aculeatus</i> sp. n. Left sacculith, inner face. Holotype.	x 10
15. <i>Ambassis electilis</i> sp. n. Right sacculith, inner face. Holotype.	x 9
16. a, b. <i>Apogon arambourgi</i> sp. n. Left sacculith, inner and outer faces. Holotype.	x 6
17. <i>Pseudopriacanthus rutoti</i> (Leriche). Left sacculith, inner face.	x 9
18. <i>Serranus (Serranellus) delicatulus</i> sp. n. Left sacculith, inner face. Holotype.	x 8
19. <i>Centropriustes exsculptus</i> sp. n. Right sacculith, inner face. Holotype.	x 8
20. <i>Lutianus kokeni</i> (Leriche). Left sacculith, inner face.	x 8
21. <i>Dentex nota</i> (Shepherd). Left sacculith, inner face.	x 8
22. <i>Dentex nota</i> (Shepherd). Juvenile right sacculith, inner face.	x 8
23. <i>Lagodon pectinoides</i> sp. n. Left sacculith, inner face. Holotype.	x 9
24. <i>Oblada joneti</i> sp. n. Left sacculith, inner face. Holotype.	x 8

Except where indicated, all the specimens are from the sands of Ledde, Balegem, Belgium.

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