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MISSISSIPPI ORIGINS OF THE CAREERS OF E. W. HILGARD AND E. A. SMITH

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INTRODUCTION

Two of America's greatest geologists of the late nineteenth and early twentieth centuries were Eugene Woldemar Hilgard and Eugene Allen Smith. Hilgard is known to geologists as the Father of Gulf Coast Geology and to soil scientists as the Father of Soil Science. Smith served as State Geologist of Alabama for 54 years and was one of the most prominent professors in the history of the University of Alabama. It is of interest that both of these gentlemen began their professional careers on the faculty of the University of Mississippi and on the staff of the Mississippi Geological Survey. They also shared many additional characteristics as are listed below. The loss of this talented team to the state institutions they served was a result of insufficient funding by the legislature. Other states have reaped the benefits.

COMMON CHARACTERISTICS

- Their first names were Eugene.

- They both earned PhD degrees, with honors, from Heidelberg University, one of the most prestigious in Europe - Hilgard in 1853 at age 20 and Smith in 1868 at age 27. They both studied under Robert Bunsen, the chemist who invented the laboratory burner that bears his name.

- Both had long and distinguished careers in the second half of the 19th century and into the 20th.

- Both were college professors for many years, and taught chemistry, mineralogy, and geology. They both began their careers at the University of Mississippi, and were there at the same time from 1868 to 1871. It was at other universities that they gained fame, Smith at the University of Alabama (for 56 years) and Hilgard at the University of California, Berkeley (for 41 years, including 10 years as emeritus professor of agriculture). According to Butts (1928), when Dr. Smith was appointed assistant professor of chemistry in the University of Mississippi in 1868, he came under the influence of Hilgard, to whom he owed much of his interest in geology. Smith lived in the Hilgard household at Ole Miss.

- Both were at their universities during the Civil War, serving their states and the Confederacy. Smith at the University of Alabama was drill master and instructor of tactics (though by all accounts he did not have the bearing of a warrior). Hilgard at the University of Mississippi was in charge of state property, helped in the confederate hospital, and saved the campus from being burned by a Union army.

- Both were state geologists, Hilgard in Mississippi, twice, and Smith in Alabama for 54 years, a longevity second only to James Hall's tenure of 61 years in New York.

- Both were employed as assistant geologists at the Mississippi Geological Survey. For a time Smith was assistant during Hilgard's second term as State Geologist.

● Both had only one report published by the Mississippi Geological Survey. Hilgard's *Report on the Geology and Agriculture of the State of Mississippi*, 1860, served as the standard reference on the geology of the state for decades. Smith's "Report of a Geological Reconnaissance of Parts of the Counties of Yazoo, Issaquena, Washington, Holmes, Bolivar, Tallahatchie, and Coahoma, Mississippi, during the months of October and November 1870," was published by the Mississippi Geological Survey in 1963 in Bulletin 100, a centennial volume with historical information.

● Both worked on the cotton report for the 1880 United States Census. Hilgard was in charge and employed geologists and others in the cotton-producing states to prepare reports on the geology, water resources, soils, and agricultural potential of their states. These were very significant reports; at least two were republished by state geological surveys. Hilgard prepared the reports for Mississippi, Louisiana, and California. He employed Smith to do Alabama and Florida.

● Both concentrated on practical applications of geology. Hilgard's emphasis was primarily toward agricultural science, while Smith's was primarily toward economic minerals.

● Both worked on problems of geological interest today, including the Orange Sand - Lafayette Formation - surficial deposits problems; water resources; and coastal plain stratigraphy. This was Smith's area of specialty at the Geological Survey of Alabama, and Henry Howe and others have referred to Hilgard as the Father of Gulf Coast Geology.

● Both took great interest in botany, zoology, and soils. Hilgard was interested from childhood in what soils developed from different rock types; as a geologist he mapped geologic contacts with the aid of the variations in vegetation. He is also considered the Father of Soil Science because of his work on the physical as well as chemical properties of soils and their subdivision into horizons. According to Butts (1928), Smith's "notes record frequent observations on the relation between rocks, soils, and vegetation."

● Both had voluminous correspondence with colleagues and in reply to requests for information from citzens, about which they were very conscientious. They corresponded a great deal with each other, especially so during their collaboration on the cotton report for the 1880 census.

● Both had memberships in many scientific organizations, participated in meetings and publications, and were honored by their societies. As examples: The Academy of Sciences of Munich presented Hilgard with the Liebig medal for distinguished achievements in the agricultural sciences; Smith was a member of the Council and President of the Geological Society of America.

● Both had long lists of publications, including significant books and papers in prestigious journals. Smith had 116 publications (117 if we include the report published in Bulletin 100), and Hilgard had nearly 300.

● Both died in their 80s - Hilgard in 1916 at age 83 and Smith in 1927 at age 86 (nearly 87).

● Both were memorialized by their colleagues in similar terms, including: gentle, genial, courteous, honest, loyal, lovable, industrious, active (both physically and mentally), and full of energy and activity.

SIGNIFICANCE OF HILGARD AND SMITH

Obviously, both E. W. Hilgard and E. A. Smith were important geologists in the history of our science in this country, and contributed many significant publications. Of interest to us here is the fact that both men began their distinguished careers in Mississippi. They both got their start at the University of Mississippi and the Mississippi Geological Survey. Smith was here for three years, and moved only as far as Tuscaloosa. Hilgard was here for 18 years, and always remembered Mississippi with fondness.

Hilgard originally concentrated on the application of geology to agriculture when he came to Mississippi because of (1) a lifelong interest in the subject; (2) Mississippi's agricultural-based economy; and (3) the state's coastal plain setting and dearth of Paleozoic outcrops, a main focus of American geologists at the time. According to Smith (1914), Hilgard's lifelong work on soils and his great fame "are the logical outcome of researches begun in Mississippi."

Hilgard remained interested in Gulf Coastal Plain geology all his life, publishing on the subject decades after moving to California. Hilgard has been called the Father of Gulf Coast Geology. Smith credited Hilgard with coining the term "Mississippi Embayment." Hilgard has an international reputation as the Father of Soil Science.

Hilgard turned Smith onto geology and was his mentor, colleague, and friend for decades. According to Louisiana's Henry Howe (1964), Hilgard "was a trainer of men and many of those who worked under his guidance went on to greatness in their own right. This was particularly true of Alabama's great State Geologist Eugene A. Smith." Smith became Alabama's most famous geologist - perhaps her most famous scientist. Smith's work on iron ores and coal resources helped make Birmingham and Bessemer important cities.

1872 OR SO

Reconstruction was a difficult time for Mississippi's economy. In 1872 the State Auditor withheld the Mississippi Geological Survey's appropriation. The agency became inactive, but the enabling legislation was never repealed. These were certainly bad times for geology in Mississippi. In

1871 E. A. Smith had departed for Alabama, where he became the University's "most distinguished member" and Alabama's "most celebrated and most useful scientist" - and served as State Geologist for 54 years (Butts, 1928). In 1873 E. W. Hilgard left Mississippi for the University of Michigan, then the country's greatest state university. In 1875 he went to the University of California and on to international fame.

What would have happened if these two men had been able to stay at the University of Mississippi and the Mississippi Geological Survey? Perhaps there would have been no 1872-1906 hiatus in the work of the Survey. Perhaps the University of Mississippi would have become a great center for agricultural research. Hilgard was deeply involved in agricultural education and in the implementation of the Morrill (Land-Grant College) acts. Perhaps if Hilgard had been successful in making Ole Miss a center for agricultural research the state may not have created a separate institution with that mission; we may then have had fewer universities facing possible reorganization. Perhaps if Hilgard and Smith had stayed, Mississippi would have become a center for geological research. Certainly these two men went on to long and distinguished careers in science and academia. These careers could have served as magnets, drawing the country's best students and scholars to this state.

Mississippi had a brush with fame and suffered a terrible loss with the departures of Eugene Allen Smith and Eugene Woldemar Hilgard.

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FISH OTOLITHS FROM THE MATTHEWS LANDING MARL MEMBER (PORTERS CREEK FORMATION), PALEOCENE OF ALABAMA

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ABSTRACT

Otoliths collected from the Matthews Landing Marl Member, the upper member of the Porters Creek Formation in Alabama, revealed the presence of 19 teleost taxa. Six new species are introduced: "genus Argentinoideorum" *sculptissimus*, "genus Chlorophthalmidarum" *postangulatus*, *Dinematichthys midwayensis*, "genus Trachichthyidarum" *stringeri*, "genus Apogonidarum" *rostrosus* and *Nemipterus caribbaeus*. This is the oldest Paleogene otolith assemblage yet published, since the age of the Matthews Landing Marl falls near the Danian-Selandian boundary. The association reflects a non-turbulent inner to middle shelf environment. Quantitatively, the association is characterized by high numbers of albulids and pterothrissids (together 15%) and high numbers of ariids (12%), while the Percoidei accounts for as much as 50% of the association. The absence of gadids, which are present in the Danian NP3 Brightseat Formation of the U. S. east coast, suggests relatively high water temperatures, as does the presence of many apogonids and the genus *Nemipterus*. The lack of typical mesopelagic fishes indicates a continental shelf, exposed to the oceanic realm. The presence of the genus *Nemipterus*, which has a present day Indo-West Pacific distribution, can be explained by the more uniform circumtropical distribution of ancient Tethys faunal elements.

INTRODUCTION

Data on Paleocene otoliths are extremely scarce, and almost nil for pre-Thanetian strata. The present report deals with a collection of otoliths from the Matthews Landing Marl Member, the terminal unit of the Porters Creek Formation. The type locality of the Matthews Landing Member is located on the left bank of the Alabama River (Lee Long Bridge 1:24,000 quadrangle, x= 459.375 m, y= 3543.675 m) in Wilcox County, Alabama (Toulmin, 1977, p. 383, point AWi-13). A measured section is figured in LaMoreaux and Toulmin (1959) and refigured here (Figure 1). At present, the Matthews Landing Member is better exposed on the right bank of the Alabama River, about 1.5 km downstream from the type locality and about 150 m downstream from the confluence with Dixon Creek; this is the exposure sampled for the present study (Lee Long Bridge 1:24,000 quadrangle, x= 457.850 m, y= 3543.800 m). The sample was taken by D. Dockery in 1990, in a level that can be considered as the equivalent of bed 4 of LaMoreaux and Toulmin (1959); see our Figure 1. Toulmin (1977, p. 384, point AWi-14) also mentions the contact with the overlying Oak Hill Member of the Naheola Formation at this point. This contact, as noted in 1990, is gradational. The sampled sediment (about 200 kg of screen-washed material) is an olive green, calcareous, fossiliferous, sandy clay that weathers to light gray, crumbling material on the surface of the exposure.

Figure 2 shows the position of the Matthews Landing Marl Member in its regional stratigraphic context. The unit has been dated by planktonic foraminifers and by calcareous nannoplankton respectively as P3a (*Morozoviella angulata* Zone) and NP4. This situates the deposit near the top of the Danian.

If it is generally accepted that the Matthews Landing Member belongs to the above cited biozones, there is less agreement about the correlation of the nannoplankton zonation (Martini, 1971) and the planktonic foraminiferal zonation (Blow, 1969; Berggren, 1969). According to Gibson et al. (1982), the base of the *M. angulata* Zone would lie within the upper part of Zone NP3, and its top within NP4, near the top of this last zone. This correlation is also accepted by Harland et al. (1990). Berggren et al. (1985) place the base of the *M. angulata* Zone within the upper part of NP4 and correlate the top of both zones. Hazel et al. (1984) gave a slightly different interpretation, placing the base of the *M. angulata* Zone within NP4 and the top within NP5. This interpretation has been followed by Haq, Hardenbol and Vail (1988), Gibson and Bybell (1989), and Mancini and Tew (1991).

According to Bolli, Saunders, and Perch Nielsen (1985), the whole *M. angulata* Zone would fall within NP5, but this conflicts with observations in Alabama (studies of nannoplankton by Bybell in the above cited publications, studies of planktonic foraminifera by Gibson and Mancini in the above cited papers, by Mancini, 1984, and by Fluegeman et al., 1990). Finally it should be mentioned that Siesser (1983) advocates a more prudent interpretation of the nannoplank-

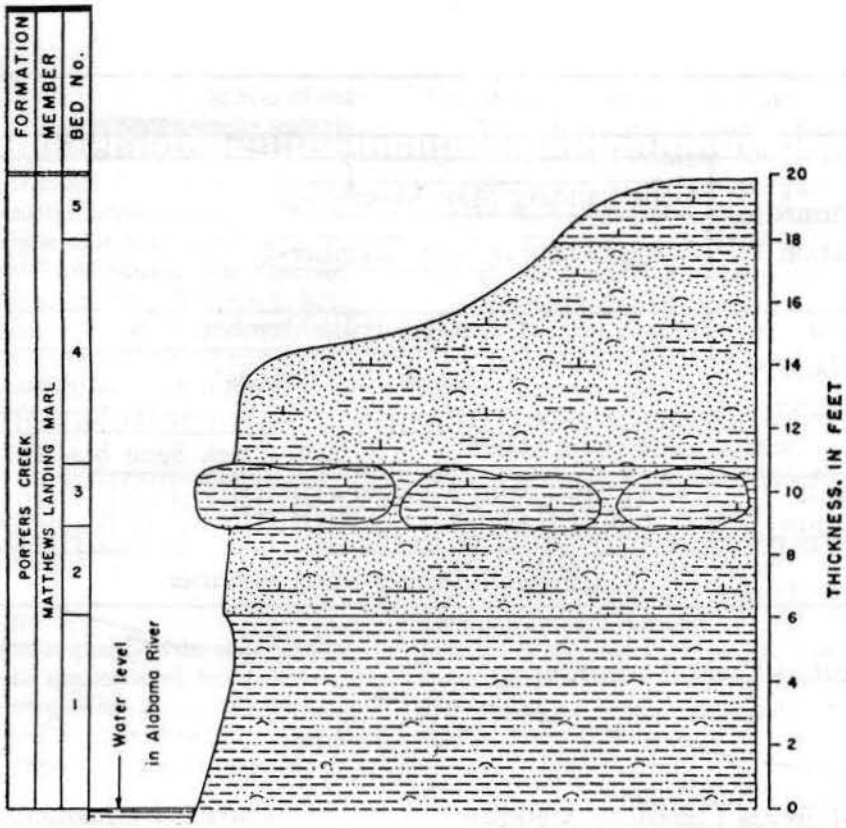


Figure 1. Section of Matthews Landing Marl Member at Matthews Landing on Alabama River (from LaMoreaux and Toulmin, 1959).

ton association of the Matthews Landing Marl, postulating a NP3/NP4 age.

There is also little agreement on the calibration of the above mentioned biostratigraphic zonations with the standard chronostratigraphic scale. Gibson et al. (1982), Hazel et al. (1984), Berggren et al. (1985), Gibson and Bybell (1989), and Mancini and Tew (1991) suggest that the upper boundary of the Danian (or the Lower/Upper Paleocene boundary) should coincide with the base of the *M. angulata* Zone. Perch Nielsen (1985) places this boundary at the top of NP4; this is in contradiction with all the above cited calibrations between planktonic foraminiferal and nannoplankton zonations, except for the one proposed by Bolli et al. (1985). Thomsen and Heilmann-Clausen (1985), in their study of the Danian/Selandian boundary, postulated that the top of the Danian at Harre and Viborg (Denmark) is "of upper NP4 or lower NP5 age." Unfortunately, no planktonic foraminiferal data are yet available for the topmost Danian of the type area.

In the presence of such disparate data, we prefer to limit ourselves to the presentation of the lithostratigraphy (Figure 2), stating only that the Matthews Landing Marl must be situated "near the top of the Danian."

From the foregoing it is clear that the calibration of the standard planktonic microfossil zonations is still imperfectly established. The integrated stratigraphic analysis (bio-, magneto- and sequence stratigraphy) of the Paleocene strata of Alabama may contribute much to the elucidation of this problem.

SYSTEMATICS

For general information about otoliths (morphological nomenclature, composition, diagnostic value, ontogenetic changes, variability, etc.), the reader is referred to the otolith volume of the *Handbook of Paleoichthyology* (Nolf, 1985) and to Nolf and Dockery (1990, p. 2) for additional comments on collective (or open) generic nomenclature as used for species of uncertain generic position, i.e. of which the systematic position can only be identified at familial, subordinal or ordinal level.

The classification followed is the one proposed by Eschmeyer (1990).

Subdivision: TELEOSTEI Mueller, 1846
Order: ALBULIFORMES Jordan, 1923
Family: ALBULIDAE Bleeker, 1859

Albulid otoliths are fairly common at the Matthews Landing Member type locality, compared with their rather scarce occurrence in most other Paleogene associations. A total of 137 specimens has been collected. Unfortunately, the majority of this material is much eroded, and 14 specimens are unsuitable for further generic or specific identification.

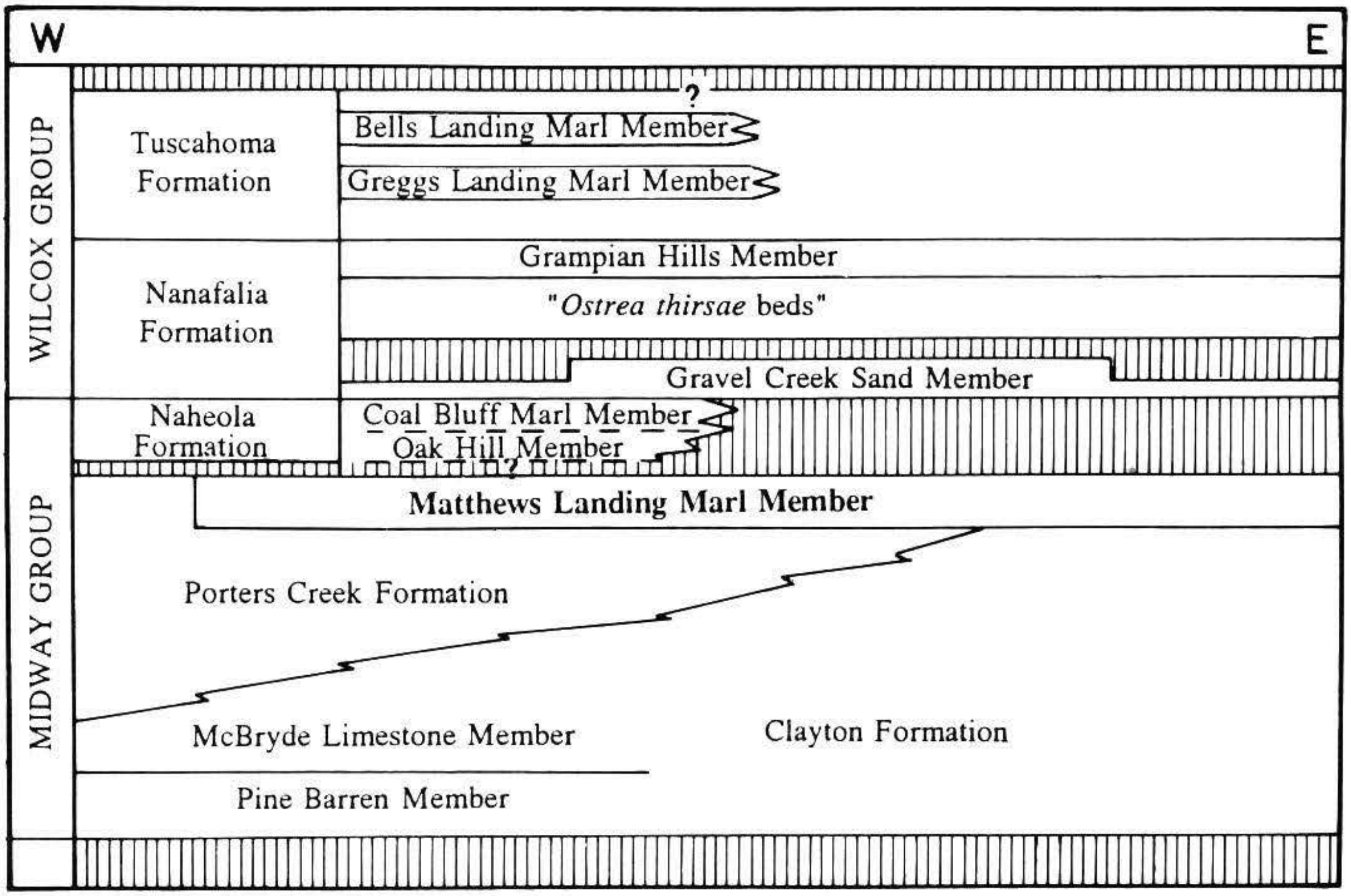


Figure 2. Stratigraphy of the Paleocene strata in Alabama (after Gibson, Mancini, and Bybell, 1982, redrawn).

The remaining 23 otoliths belong to at least two different taxa.

***Albula* aff. *bashiana* (Frizzell, 1965)**
Plate 1, figures 1-2

Material.- 15 otoliths.

Discussion.- Among the 15 collected otoliths, only the two figured specimens are perfectly preserved. The largest one falls in the same size class as the holotype and only known specimen of *Metalbula bashiana* from the Bashi Marl, Lower Ypresian at Meridian, Mississippi. The outline, convexity and sulcus configuration of both specimens agree very well, except for the somewhat straighter dorsal rim in the ones figured here. More and better preserved material from both the Matthews Landing Member and the Bashi Marl is required to judge variability in both populations, and establish with certainty their specific identity. However, the very rounded and prominent antero-ventral rim and the pointed posterior end seem to be good diagnostic features for the taxon.

Frizzell (1965, p. 102) attributed the otoliths discussed here to a fossil genus, *Metalbula*. We see no morphological argument for such splitting, and attribute the fossils to the Recent genus *Albula* Scopeli, 1777. Moreover, we are wary of the use of exclusively otolith-based fossil genera and higher taxa; see discussion in Nolf, 1985, p. 30-31 and in Nolf and Dockery, 1990, p. 2.

"genus Albulidarum" sp.
Plate 1, figure 3

Material.- Eight otoliths.

Discussion.- Among our material, only the figured specimen is perfectly preserved. It is a juvenile otolith of 5.3 mm length, essentially characterized by a very regular cauda that is equal in width and depth at every point of its stretch. The cauda is only very slightly bent in ventral direction at its posterior end. Such configuration suggests a juvenile or a plesiomorph condition. In large albulid otoliths, the posterior portion of the cauda is usually somewhat wider than the anterior one, more strongly incised, and more markedly bent in the ventral direction. These three features gradually become more evident with growth.

The largest specimen in our series is 8.2 mm long; its cauda shows essentially the same morphology as the figured juvenile, but with the caudal end a bit more bent in ventral direction. In other albulid taxa, the above discussed modifications of the cauda are fully developed at the size of our specimen. Frizzell (1965, p. 99) describes a single, strongly eroded otolith from the Matthews Landing Member as *Archaealbula alabamae*. Although this specimen shows a vague resemblance to the fossils described here, it lacks any diagnostic feature, and the species is to be rejected.

Another albulid from the Bashi Marl (Lower Ypresian) was named *Eoalbula meridiana* by Frizzell (1965, p. 101). The holotype of this species, a 9 mm long otolith, also resembles our specimens, but more well preserved material, both from the Matthews Landing Marl and Bashi Marl, is required to decide about their specific identity.

Family: PTEROTHRISSIDAE Gill, 1893

***Pterothrissus* sp.**
Plate 1, figure 5

Material.- Four otoliths.

Remarks.- The preservation quality of the material does not allow identification at the species level, but there is no doubt that these otoliths belong to the genus *Pterothrissus* Hilgendorf, 1877; see Nolf and Dockery, 1990, pl. 1, figs. 4-8, for the iconography of comparative Recent material.

Order: ANGUILLIFORMES Regan, 1909
Family: CONGRIDAE Kaup, 1856

***Rhynchoconger* sp.**
Plate 1, figures 7-9

Material.- Six otoliths.

Discussion.- The available material consists of small otoliths (length less than 4 mm), apparently from juvenile fishes. The figured material is fairly well preserved and probably belongs to a new species, characterized by thick otoliths, showing markedly convex inner and outer faces, and aculeate anterior and posterior ends. More and larger material is required for an adequate formal description of the species, and to elucidate its relationships to the many otolith-based species of *Rhynchoconger* Jordan and Hubbs, 1925. Many of these have been described in the genus *Hildebrandia* Jordan and Evermann, 1927, but D. G. Smith (1989) synonymized this genus with *Rhynchoconger* in his revision of Recent Western Atlantic conger eels. The otoliths of *Rhynchoconger ectenurus* (Jordan and Richardson, 1909), type species of the genus (see Steurbaut and Jonet, 1982, pl. 1, fig. 10 for iconography), are a bit more elongate than those of all Recent *Hildebrandia* species that we examined; otherwise, their morphology provides no argument against the synonymy of both genera, as proposed by Smith.

Since the nomenclature of fossil congrid otoliths is somewhat unclear as a result of the proposed synonymy, a list of all valid otolith-based *Rhynchoconger* species is provided here. Each species is followed by the generic name used in the original description, and by the stratigraphic and geographic origin of the type material.

--*Rhynchoconger aftonensis* (Stinton, 1975) *(Lemkea)*. Middle Eocene; southern England.

--*Rhynchoconger casieri* (Bauza Rullan, 1955) *(Congermuraena)*. Pliocene; Majorca, Spain.

--*Rhynchoconger donzacquensis* (Nolf, 1988) *(Hildebrandia)*. Middle Eocene; Aquitaine, France.

--*Rhynchoconger ellipticus* (Weiler, 1958) *(Congermuraena)*. Upper Oligocene; Germany.

--*Rhynchoconger eocenicus* (Shepherd, 1916) (Apogonidarum). Upper Eocene; southern England.

--*Rhynchoconger fallax* (Koken, 1891) (incertae sedis). Upper Oligocene; Germany.

--*Rhynchoconger pantanellii* (Bassoli and Schubert, 1906) *(Ophidium)*. Upper Miocene; Italy.

--*Rhynchoconger sanctus* (Frizzell and Lamber, 1962) *(Conger)*. Oligocene; Alabama.

--*Rhynchoconger transversus* (Sulc, 1932) *(Uroconger)*. Upper Eocene; Aquitaine, France.

--*Rhynchoconger weileri* (Jonet, 1973) *(Congermuraena)*. Middle Miocene; Portugal.

Otoliths of the Recent *Rhynchoconger flavus* (Goode and Bean, 1896) have been reported (as *Hildebrandia*) from the Pliocene of the Dominican Republic by Nolf and Stringer (1992).

"genus Congridarum" sp.
Plate 1, figure 4

Material.- Three otoliths.

Discussion.- These otoliths, which are characterized by a considerable postero-dorsal extension of their dorsal area, are most similar to those of "genus Congridarum" *websteri* Frost, 1933, from the Middle Eocene of southern England and Belgium, but the available material does not allow precise specific identification.

Order: SILURIFORMES Cuvier, 1817
Family: ARIIDAE Guenther, 1864

Ariids are represented by utricular otoliths of two different species in the Matthews Landing Member. Ariid otoliths seem to be fairly common in the North Atlantic Paleocene. They are known from the Brightseat Formation (Danian, NP3) of the Washington, D. C., area (Nolf, unpublished data), from the Selandian (Lower Thanetian) of Denmark (Koken, 1885 and 1891), and they occur in large quantities in the Sands of Orp, Lower Thanetian of Belgium. In this last unit, they constitute a nearly monospecific association of ariid utricular otoliths (Leriche, 1902; Nolf, 1978), a type of association known from nowhere else. Present day ariids are marine and estuarine catfishes in shallow tropical and subtropical waters.

"genus Ariidarum" sp. 1
Plate 2, figures 5-6

Material.- Fifteen otoliths.

Remarks.- A first ariid species is represented by subcircular otoliths that are slightly accuminate anteriorly.

Unfortunately, none of the specimens is sufficiently well preserved for an adequate description, especially considering that in ariid otoliths it is difficult to find adequate diagnostic features. It is clear, however, that the otoliths figured here are different from the common European type of Paleocene ariid otoliths, "genus Ariidarum" *danicus* Koken, 1891, which have a more quadrangular outline and a flatter inner face.

"genus Ariidarum" sp. 2
Plate 2, figure 4

Material.- Two otoliths.

Remarks.- A second species of ariid is readily distinguished from "genus Ariidarum" sp. 1 by its markedly triangular otoliths, but these small, slightly eroded otoliths are almost devoid of any other diagnostic feature which would allow an adequate description.

Order: SALMONIFORMES Bleeker, 1859
Suborder: ARGENTINOIDEI Bertelsen, 1958
Family: incertae sedis

"genus Argentinoideorum" *sculptissimus* n. sp.
Plate 2, figure 7

Type material.- Holotype and only specimen: a perfectly preserved right otolith (Plate 2, figure 7) (IRSNB P 6096).

Dimensions of the holotype.- Length: 3.4 mm; height: 1.3 mm; thickness: 0.5 mm.

Stratum typicum.- Matthews Landing Member, exposure on the right bank of Alabama River, 150 m downstream of its confluence with Dixon Creek.

Derivatio nominis.- *Sculptissimus, a, um* (Latin) = very sculpted; refers to the very incised and ornate rims and marginal areas of the otolith.

Diagnosis.- The holotype of this species is a very elongated otolith with a well marked salient rostrum. The outer face is nearly flat in antero-posterior direction, and convex in dorso-ventral direction. Its central portion is flat and smooth, but the marginal zones bear radial groves that separate the crenelations of the rims. The inner face is smoothly convex in all directions. The sulcus consists of a short ostium and long narrow cauda that is about twice as long as the ostium. The posterior part of the caudal crista superior is markedly shorter than the corresponding end of the crista inferior, which allows for a deepening of the posterior end of the sulcus, and its dorsal widening.

Affinities.- The type of posterior sulcus end described here is a feature observed only in salmonids and argentinids. The general pattern of the sulcus agrees best with the one observed in Recent argentinids, but no taxon in that family has such slender, elongate otoliths. Therefore, our fossil represents an extinct taxon of the family Argentinidae, or belongs to an extinct family within the suborder Argentinoidei.

Order: AULOPIFORMES Rosen, 1973
Family: CHLOROPHTHALMIDAE Jordan, 1923

"genus Chlorophthalmidarum" *postangulatus* n. sp.
Plate 2, figures 1-2

Type material.- Holotype: a left otolith (Plate 2, figure 1) (IRSNB P 6091); two paratypes of which one is figured (Plate 2, figure 2) (IRSNB P 6092).

Dimensions of the holotype.- Length: 2.4 mm; height: 1.2 mm; thickness: 0.5 mm.

Stratum typicum.- Matthews Landing Member, exposure on the right bank of Alabama River, 150 m downstream of the confluence with Dixon Creek.

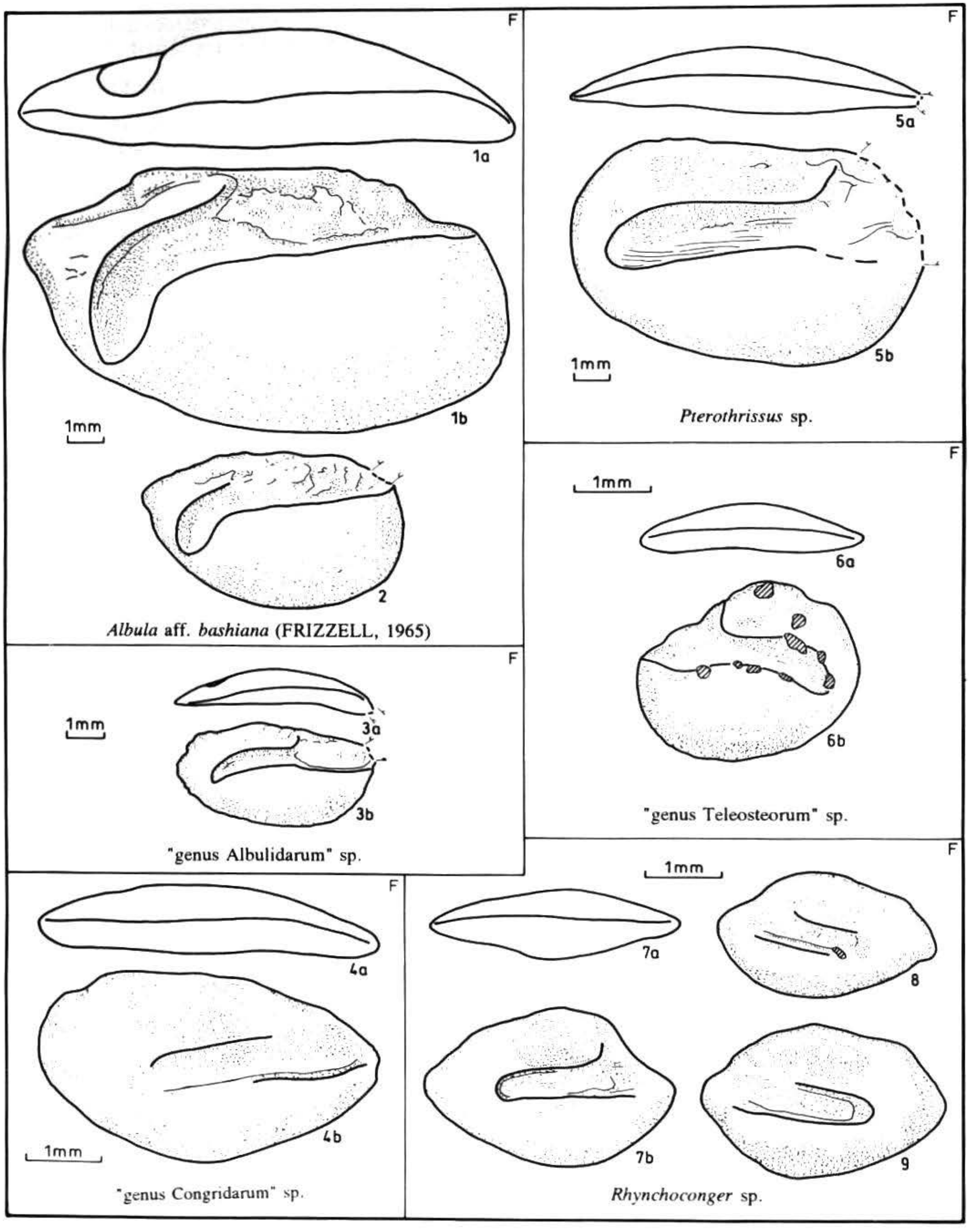
Explanation of the plates

All specimens are deposited in the collections of the Institut Royal des Sciences Naturelles de Belgique (IRSNB). The fossil otoliths bear numbers of the collection of types and figured fossil fish specimens in the IRSNB. The Recent otoliths are part of the reference collection of Recent otoliths, kept at the same institution. The latter collection is arranged in a systematic order, without numbering; therefore, such specimens, when figured, bear only the mention "coll. IRSNB".

The abbreviations F and R in the right corner of each compartment of the plates indicate if the figured specimens in that compartment are fossils (F) or belong to Recent (R) species. In the text of the explanations, L stands for left otolith and R for right otolith.

Plate 1

Fig. 1-2	*Albula* aff. *bashiana* (Frizzell, 1965) L; Matthews Landing Member (IRSNB P 6082, P 6083).
Fig. 3	"genus Albulidarum" sp. L; Matthews Landing Member (IRSNB P 6084).
Fig. 4	"genus Congridarum" sp. L; Matthews Landing Member (IRSNB P 6085).
Fig. 5	*Pterothrissus* sp. L; Matthews Landing Member (IRSNB P 6086).
Fig. 6	"genus Teleosteorum" sp. R; Matthews Landing Member (IRSNB P 6087).
Fig. 7-9	*Rhynchoconger* sp. 7=L, 8-9=R; Matthews Landing Member (IRSNB P 6088-6090).



Albula aff. *bashiana* (FRIZZELL, 1965)

"genus Albulidarum" sp.

Pterothrissus sp.

"genus Teleosteorum" sp.

"genus Congridarum" sp.

Rhynchoconger sp.

Derivatio nominis.- *Postangulatus, a, um* (Latin): provided with a posterior angle.

Diagnosis.- This species has relatively thick elliptical otoliths, with a sharp rostrum and a postero-dorsal angle. The outer face is smooth and convex. The inner face is slightly convex. In transverse section of the otolith, the dorsal profile is blunt, but the ventral periphery has a somewhat cutting profile. The anterior part of the ventral rim shows a delicate, fine serration. The sulcus is constituted by a wide ostium and a long, narrow cauda with clear cristae. Its posterior end is slightly bent in ventral direction. Above the crista superior, a depression marks the ventral area. Collicular formations are very flat, nearly indiscernable.

Affinities.- Otoliths of the species described here show much similarity with those of "genus Chlorophthalmidarum" *pseudoperca* (Nolf and Dockery, 1990) from the Campanian Coffee Sand of Mississippi, but they have a narrower, more elongate cauda, a less convex inner face, and a clear postero-dorsal angle.

Otoliths of "genus Chlorophthalmidarum" *pseudoperca* were originally referred to the related family Synodontidae (Nolf and Dockery, 1990, p. 6, pl. 2, fig. 12-16). In that paper, we overlooked otoliths of the Recent New Zealand species *Chlorophthalmus nigripinnis* Guenther, 1878 (Plate 2, figure 3), which show much more similarity with the two fossil taxa discussed here than does any synodontid. It should be said, however, that most other Recent *Chlorophthalmus* species have quite different otoliths, with a blunt rostrum and a less precise outline of the cauda (compare the otoliths figured by Nolf, 1985, p. 13, fig. 12 G-J).

Order: OPHIDIIFORMES Berg, 1937
Family: OPHIDIIDAE Rafinesque, 1810

***Ampheristus* sp.**
Plate 4, figure 3

Material.- Three otoliths.

Discussion.- The available otoliths are too eroded to evaluate their precise affinity with those of the London Clay (Ypresian) species *Ampheristus toliapicus* Koenig, 1825.

Family: BYTHITIDAE

***Dinematichthys midwayensis* n. sp.**
Plate 4, figures 4-5

Type material.- Holotype: a right otolith (Plate 4, figure 5) (IRSNB P 6109); four paratypes, of which one is figured (Plate 4, figure 4) (IRSNB P 6108).

Dimensions of the holotype.- Length: 3.7 mm; height: 1.8 mm; thickness: 0.7 mm.

Stratum typicum.- Matthews Landing Member, exposure on the right bank of Alabama River, 150 m downstream of the confluence with Dixon Creek.

Derivatio nominis.- This species is named after its stratigraphic position, in the Midway Group.

Diagnosis.- This species is characterized by robust, but not very thick, otoliths. Their outline is elongate and regularly elliptical, except for a slightly hollow ostial rim. The outer face is smooth and clearly convex; the inner face is also convex, the most marked convexity being situated in the dorso-ventral direction.

The sulcus does not open directly on the ostial rim, and consists of a broad ostium and a small narrow cauda. The ostium is about three times as long as the cauda, and about two times as broad. Both ostium and cauda have extremely flattened collicula that lie deeper than the main inner surface of the otoliths. One observes no clear ostial channel, but the position of such a channel is marked by a crest-like structure linking the anterior part of the ostium with the ostial rim. The crest probably corresponds to the dorsal boundary of the ostial channel. There is a well marked ventral furrow, and a slight longitudinal depression is observed in the dorsal area.

Affinities.- It is difficult to judge whether these otoliths belong to a plesiomorph *Dinematichthys* species or to a plesiomorph neobythitine ophidiid. We attribute them to *Dinematichthys* Bleeker, 1885 (see Nolf, 1980, pl. 14, fig. 1-3 for iconography of comparative Recent material), especially because of the absence of a clear ostial channel, and also because of the relative proportions of the ostial and caudal part of the sulcus, which resemble those in Recent *Dinematichthys* species.

Order: BERYCIFORMES Regan, 1901
Family: TRACHICHTHYIDAE Bleeker, 1859

"genus Trachichthyidarum" *stringeri* n. sp.
Plate 3, figures 1-5

Type material.- Otoliths of this species occur both in the Matthews Landing Member and in the Brightseat Formation (Danian, NP3 Zone) of the Washington, D. C., vicinity.

Plate 2

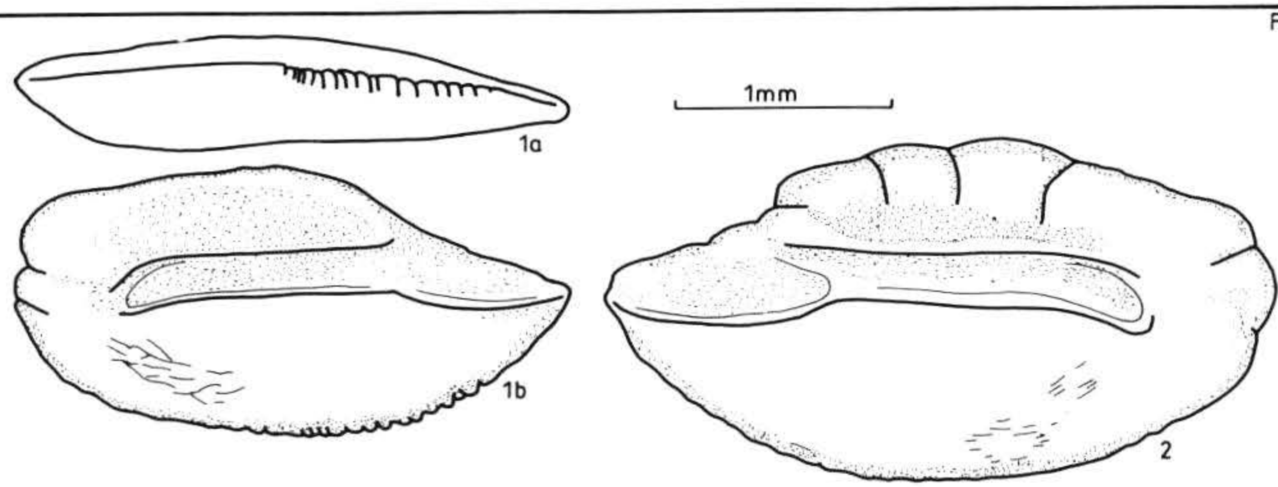
Fig. 1-2 "genus Chlorophthalmidarum" *postangulatus* n. sp.
1=L, holotype (IRSNB P 6091); 2=R, paratype (IRSNB P 6092); Matthews Landing Member.

Fig. 3 *Chlorophthalmus nigripinnis* Guenther, 1878
L; Recent, off Wellington, New Zealand (coll. IRSNB).

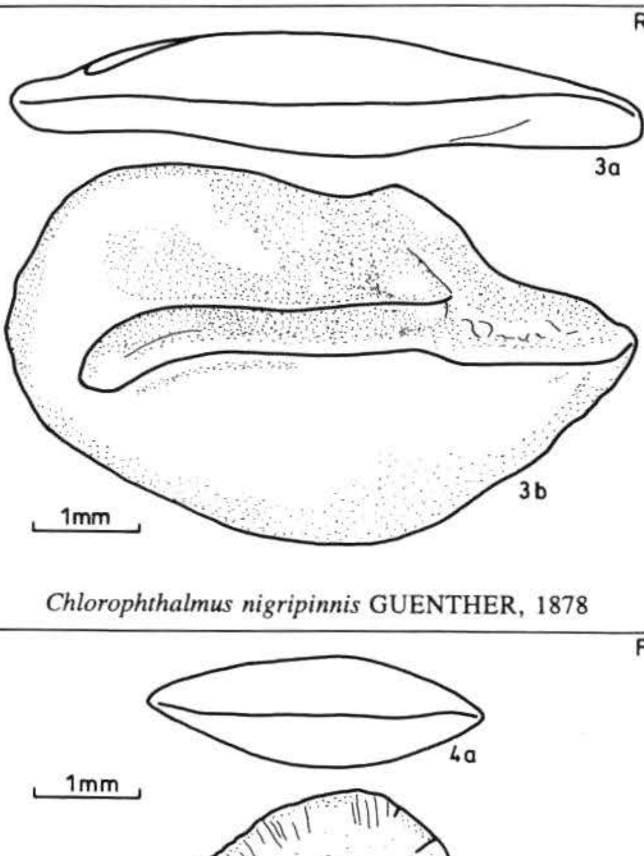
Fig. 4 "genus Ariidarum" sp. 2
L, utricular otolith; Matthews Landing Member (IRSNB P 6093).

Fig. 5-6 "genus Ariidarum" sp. 1
L, utricular otolith; Matthews Landing Member (IRSNB P 6094, P 6095).

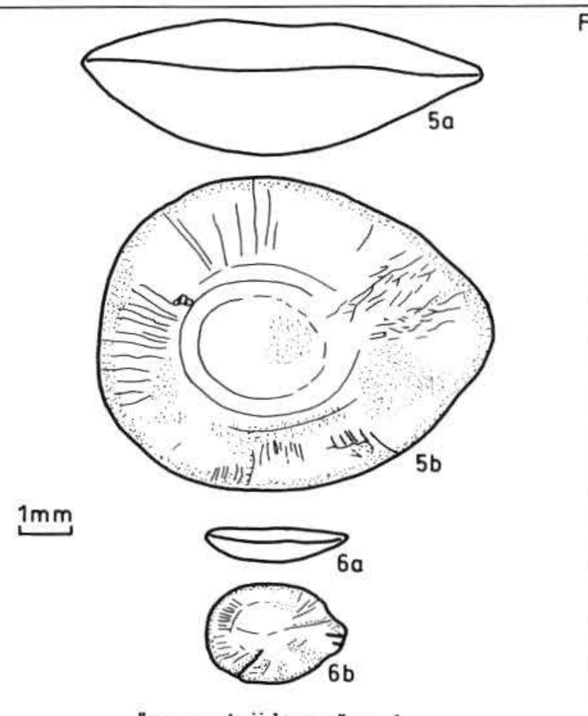
Fig. 7 "genus Argentinoideorum" *sculptissimus* n. sp.
R, holotype; Matthews Landing Member (IRSNB P 6096).



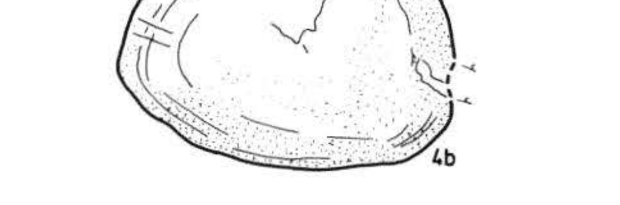
"genus Chlorophthalmidarum" *postangulatus* n.sp.



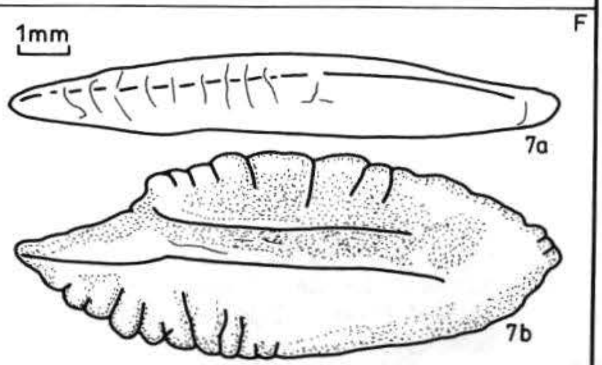
Chlorophthalmus nigripinnis GUENTHER, 1878



"genus Ariidarum" sp.1



"genus Ariidarum" sp.2



"genus Argentinoideorum" *sculptissimus* n.sp.

Because the Brightseat material is much better preserved, our type material was chosen from this sample. Holotype: a left otolith (Plate 3, figure 1) (IRSNB P 6097) and 133 paratypes of which three are figured (Plate 3, figures 2-4) (IRSNB P 6098-6100) from the Brightseat Formation at Cabin Branch locality, Washington, D. C.; one other paratype (Plate 3, figure 5) (IRSNB P 6101) is from the Matthews Landing Member.

Dimensions of the holotype.- Length: 3.6 mm; height: 3.8 mm; thickness: 1.2 mm.

Stratum typicum.- Brightseat Formation at Cabin Branch locality, Washington, D. C.

Derivatio nominis.- This species is dedicated to Gary L. Stringer, Monroe, Louisiana.

Diagnosis.- This species is characterized by otoliths with a subhexangular outline, somewhat distorted along a postero-dorsal / antero-ventral axis. All well preserved specimens show a strong postero-ventral angle, which is accentuated by a slight hollowing of the ventral rim, situated immediately before the angle. The outer face is smooth and convex, especially in the dorso-ventral direction. The greatest thickness of the otoliths is localized in their ventral half. The inner face is nearly flat in the dorso-ventral direction and slightly convex in the antero-posterior direction. The sulcus consists of an ostium strongly widened ventrally, and a much narrower cauda of about equal length to the ostium. Both ostium and cauda are provided with colliculum, and there is a well developed collicular crest near the crista inferior.

Affinities.- The otoliths of this species show a close relationship with those of Recent trachichthyids, but differ from all of them by their considerably greater height. They differ from otoliths of the Late Cretaceous "genus Trachichthyidarum" *coffeesandensis* Nolf and Dockery, 1990 (see Nolf and Dockery, 1990, pl. 3, fig. 1-4; Stringer, 1991, pl. 1, fig. 5) by the more expanded ventral widening of the ostium and by their more salient postero-ventral angle.

Family: BERYCIDAE Lowe, 1843

***Centroberyx* sp.**
Plate 3, figure 6

Material.- One otolith.

Remarks.- The available specimen is a much worn juvenile otolith, which shows reasonable affinities with those of the Recent genus *Centroberyx* Gill, 1862 (see Schwarzhans, 1980, p. 104, fig. 328-331, there named *Trachichthodes*, for iconography of Recent species), but does not allow an identification at species level.

Family: SERRANIDAE Swainson, 1839

Serranidae ind.
Plate 3, figure 7

Material.- One otolith.

Remarks.- A single juvenile otolith, not identifiable at the species or genus level.

Family: APOGONIDAE Jordan and Gilbert, 1882

"genus Apogonidarum" *rostrosus* n. sp.
Plate 4, figures 6-11

Type material.- Holotype: a left otolith (Plate 4, figure 6) (IRSNB P 6110); 34 paratypes, of which five are figured (Plate 4, figures 7-11) (IRSNB P 6110-6114).

Dimensions of the holotype.- Length: 3.9 mm; height: 2.1 mm; thickness: 0.8 mm.

Stratum typicum.- Matthews Landing Member, exposure on the right bank of Alabama River, 150 m downstream of the confluence with Dixon Creek.

Derivatio nominis.- *Rostrosus, a, um* (Latin)= characterized by a strong rostrum.

Diagnosis.- This species is characterized by robust, elongate otoliths, with a strong rostrum that is directed somewhat upwards. The outer face is nearly smooth, except for some low relief tuberculation near the dorsal rim. The face shows a slightly convex, nearly flat antero-posterior profile, and a clearly convex dorso-ventral profile.

The inner face is regularly convex in both antero-posterior and dorso-ventral directions. The cauda is slightly longer than the ostium, and is straight over the whole of its length. Its central part is somewhat widened, which is usual in apogonids. Near the caudal crista inferior, there is a well marked collicular crest.

Affinities.- All otoliths of Recent apogonid taxa known to us have a more or less blunt rostrum. The otoliths described here are clearly characterized by a long and pointed rostrum, giving them an outline which, at a first glance, is suggestive of acropomatids, e.g. *Parascombrops* Alcock, 1889 (see Nolf, in press, fig. 8N), but the aspect of their cauda is typically apogonid. Acropomatids have only a weakly

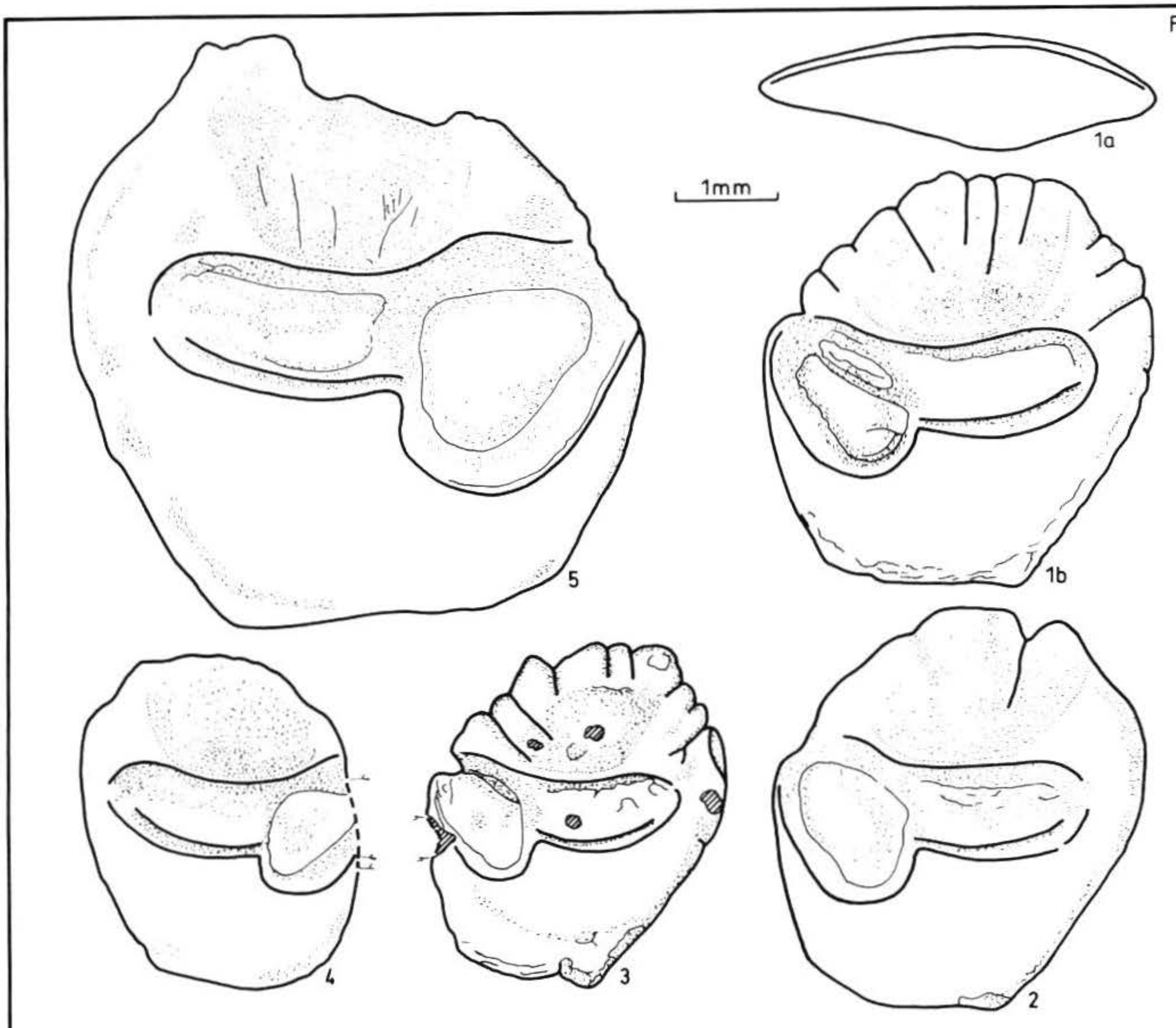
Plate 3

Fig. 1-5 "genus Trachichthyidarum" *stringeri* n. sp. 1-3=L, 4-5=R; 1-4: Brightseat Formation, at Cabin Branch locality, Washington, D. C.; 5: Matthews Landing Member; 1= holotype (IRSNB P 6097), 2-5= paratypes (IRSNB P 6098-6101).

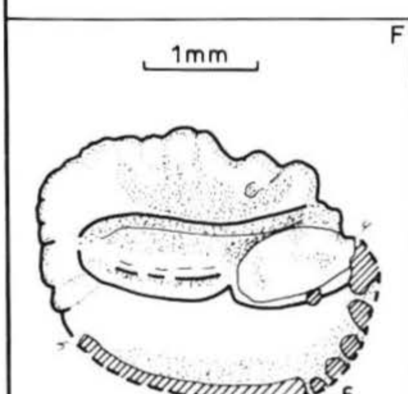
Fig. 6 *Centroberyx* sp. L; Matthews Landing Member (IRSNB P 6102).

Fig. 7 Serranidae ind. L; Matthews Landing Member (IRSNB P 6103).

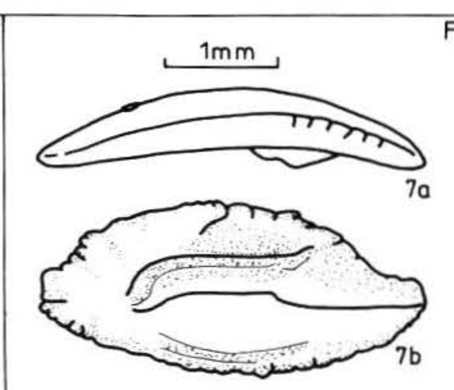
Fig. 8 ? Sparidae ind. R; Matthews Landing Member (IRSNB P 6104).



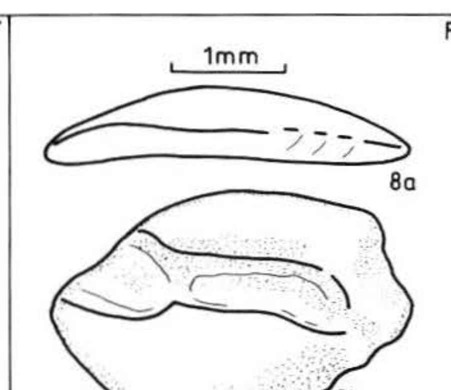
"genus Trachichthyidarum" *stringeri* n.sp.



Centroberyx sp.



Serranidae ind.



? Sparidae ind.

developed or no collicular crest, and their cauda shows no central widening and no ventral inflection of the posterior end.

Family: ACROPOMATIDAE Gill, 1891

"genus ? Acropomatidarum" sp.
Plate 4, figures 1-2

Material.- Two otoliths.

Discussion.- We assume that the two available specimens probably represent a juvenile and an adult otolith of a new species that we attribute tentatively to the acropomatids. More material is required to establish whether the two specimens really belong to the same species, and to clarify their precise taxonomic affinities.

Family: NEMIPTERIDAE Regan, 1930

***Nemipterus caribbaeus* n. sp.**
Plate 5, figures 8-13

Type material.- Holotype: a left otolith (Plate 5, figure 8) (IRSNB P 6116); 27 paratypes, of which five are figured (Plate 5, figures 9-13) (IRSNB P 6117-6121).

Dimensions of the holotype.- Length: 4.1 mm; height: 2.4 mm; thickness: 0.8 mm.

Stratum typicum.- Matthews Landing Member, exposure on the right bank of Alabama River, 150 m downstream of the confluence with Dixon Creek.

Derivatio nominis.- Alludes to the unusual occurrence of nemipterids, a typical Indo-West Pacific family in the realm of the northern Gulf of Mexico.

Diagnosis.- This species is characterized by robust, elongate otoliths. Their outline shows a well marked rostrum, a little antirostrum, and a clear postero-dorsal angle. Also the posterior end is slightly angular. Juvenile specimens show a marked serration on their antero-ventral rim. The outer face is nearly smooth, showing only some rudimentary marginal tuberculation in juvenile specimens. Its antero-posterior profile is nearly flat but its dorso-ventral profile is clearly convex. The inner face is strongly convex in the antero-posterior direction. The sulcus consists of a wide ostium and a somewhat longer and much narrower cauda, with a ventrally bent posterior end. The junction of the ostial and caudal crista inferior lies clearly behind the corresponding junction in the crista inferior. Some of the specimens show a rudimentary developed ventral furrow.

Affinities.- These otoliths fit perfectly in the morphological variation seen in the otoliths constituting the genus *Nemipterus* Swainson, 1839; see Plate 5, figures 1-7 for the iconography of comparative Recent species. The Recent distribution of the genus *Nemipterus* is exclusively Indo-West Pacific (Russell, 1990; Springer, 1982). The occurrence of a Paleocene species in the Gulf region must be seen as evidence for an ancient Tethyan distribution of the genus.

Family: SPARIDAE Bonaparte, 1832

? Sparidae ind.
Plate 3, figure 8

Material.- One otolith.

Remarks.- A somewhat eroded juvenile otolith can probably be attributed to the sparid family.

TELEOSTEI incertae sedis

"genus Teleosteorum" sp.
Plate 1, figure 6

Material.- One otolith.

Remarks.- This small eroded otolith does not show clear relationships with any Recent taxon. As far as its preservation status allows to conclude, it probably belongs to an elopiform or to a plesiomorph euteleostean.

CONCLUSIONS

Characterization of the Matthews Landing Marl fauna.- The otolith study reveals the presence of 19 taxa of teleosteans in the Matthews Landing Member, among which six are new species. This is the oldest yet published Paleocene otolith assemblage in the world, situated near the Lower/Upper Paleocene boundary. The association reflects a non-turbulent, inner to middle shelf environment, poorly exposed to the oceanic realm. Five features in the quantitative composition of this association appear relevant with respect to other Late Cretaceous and Paleocene associations.

--Albulid and pterothrissid otoliths make up 15% of the association.

--Ariid otoliths make up 12.5% of the association.

--The suborder Percoidei accounts for 50% of the association.

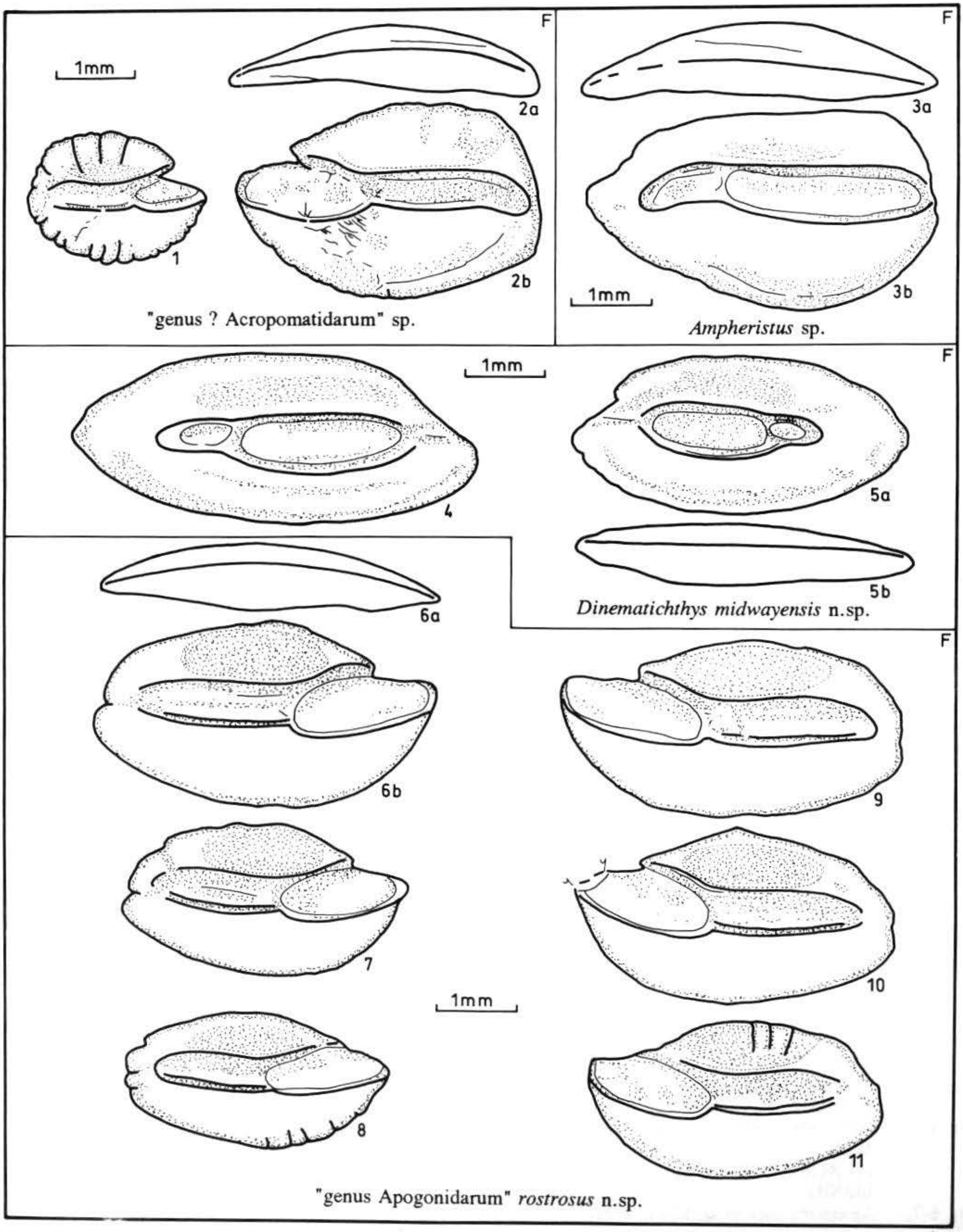
Plate 4

Fig. 1-2 "genus ? Acropomatidarum" sp. 1=L, 2=R; Matthews Landing Member (IRSNB P 6105, P 6106).

Fig. 3 *Ampheristus* sp. L; Matthews Landing Member (IRSNB P 6107)

Fig. 4-5 *Dinematichthys midwayensis* n. sp. 4=L, paratype (IRSNB P 6108), 5=R, holotype (IRSNB P 6109).

Fig. 6-11 "genus Apogonidarum" *rostrosus* n. sp. 6-8=L, 9-11=R; Matthews Landing Member. 6= holotype (IRSNB P 6110), 7-11= paratypes (IRSNB P 6110-6114).



"genus ? Acropomatidarum" sp.

Ampheristus sp.

Dinematichthys midwayensis n.sp.

"genus Apogonidarum" *rostrosus* n.sp.

--The association contains no gadids.

--The association contains no typical mesopelagic elements.

Data on other Late Cretaceous and Paleocene faunas.- Although little is known about Late Cretaceous and Paleocene otoliths, a comparison with the known data shows the significance of the Matthews Landing Marl fauna. Data on teleosts, both for skeleton- and otolith-reconstructed faunas, are poor for the Maastrichtian and Paleocene interval. Except for a few isolated discoveries, data on otoliths are available for the following Late Cretaceous and Paleocene deposits only:

--Coffee Sand Formation, Campanian of northeastern Mississippi (Nolf and Dockery, 1990);

--Ripley Formation, Early Maastrichtian of Mississippi (Stringer, 1991);

--Severn Formation, Early to Middle Maastrichtian of the Washington, D. C., vicinity (Huddleston and Savoie, 1983);

--Brightseat Formation, Danian (calcareous nannoplankton Zone NP3) of the Washington, D. C., vicinity (Nolf, unpublished data);

--Selandian of Denmark (Middle Paleocene, calcareous nannoplankton Zone NP5) (Koken, 1885); only a very restricted fauna is known; no quantitative data;

--Sables d'Orp, Early Thanetian (? calcareous nannoplankton Zone NP6) of Belgium (Leriche, 1902; Nolf, 1978);

--Tuffeau de Lincent, Thanetian (calcareous nannoplankton Zone NP8) of Belgium (Nolf, 1978);

--Sables de Châlons-sur-Vesle, Thanetian (calcareous nannoplankton Zone NP8, Steurbaut, unpublished data) (Nolf, unpublished data).

An otolith association is also known from the English Late Paleocene (Stinton, 1965), but the paper of Stinton is in need of revision (see Nolf, 1978 and 1985), and is not a good source of quantitative data. This association is much poorer in valid taxa than Stinton's paper suggests, and most of the valid taxa also occur in the association of the Sables de Châlons-sur-Vesle.

On albulids and pterothrissids.- The presence of 15% of combined albulid and pterothrissid otoliths in the Matthews Landing Member association is a typical pre-Eocene faunal feature. These families have never been recorded with such high percentages in post-Paleocene deposits. In the Coffee Sand association (Campanian), the two families constitute 45% of the investigated sample. In the other deposits cited here, albulids and (or) pterothrissids are represented, but with lower percentages.

On ariids.- Otolith associations characterized by high numbers of ariids (marine catfishes) are unknown from post-Paleocene deposits. In the Maastrichtian Severn Formation, marine catfishes make up 62% of the association, whereas the early Thanetian Sands of Orp (Belgium) contain a nearly monospecific ariid assemblage.

On percoids.- Percoids are rare in Cretaceous deposits; they are unknown in the osteological record (Patterson, 1990), but in the otolith-based record they are known with 6.5% from the Coffee Sand Formation (Campanian), with 10% from the Ripley Formation (Maastrichtian), and with 27% from the Severn Formation (Maastrichtian). Only a low percentage of percoids is recorded from the Brightseat Formation (Danian, NP3), but in the Matthews Landing Member (Paleocene, NP4), they constitute as much as 50% of the total association. For the Thanetian Sables de Châlon-sur-Vesle, we do not yet have precise numerical data, but a rough estimation suggests that percoids constitute at least 70% of the association (mainly haemulids). Apogonids are typical constituents of Late Cretaceous and Early Paleocene percoid associations, except in the case of the Brightseat Formation.

On gadiforms.- Neritic gadiform fishes (essentially gadids and merluciids) are mainly cold water fishes. They have not yet been recorded from the Cretaceous (the so called gadiform of pl. 2, fig. 4 in Stringer, 1991 does not belong to that taxon), but their absence in the deposits sampled should be interpreted as temperature-linked rather than as a result of evolutionary processes.

In the Danian (Zone NP3) Brightseat Formation of the Washington, D. C., area, they suddenly appear (probably about 5% of the association; precise quantitative data are not yet available). In the Matthews Landing Member (Zone NP4) they are not present, probably due to the more southern position of this deposit. They are also known in the Danish Selandian (? Zone NP5) and in the Paris Basin. The Sables de Châlons-sur-Vesle (Thanetian, Zone NP8) contain at least seven gadid and one merlucciid species (Nolf, unpublished data), although their percentages remain low (due to the presence of huge quantities of haemulids in the association). In the more northern contemporaneous Tuffeau de Lincent

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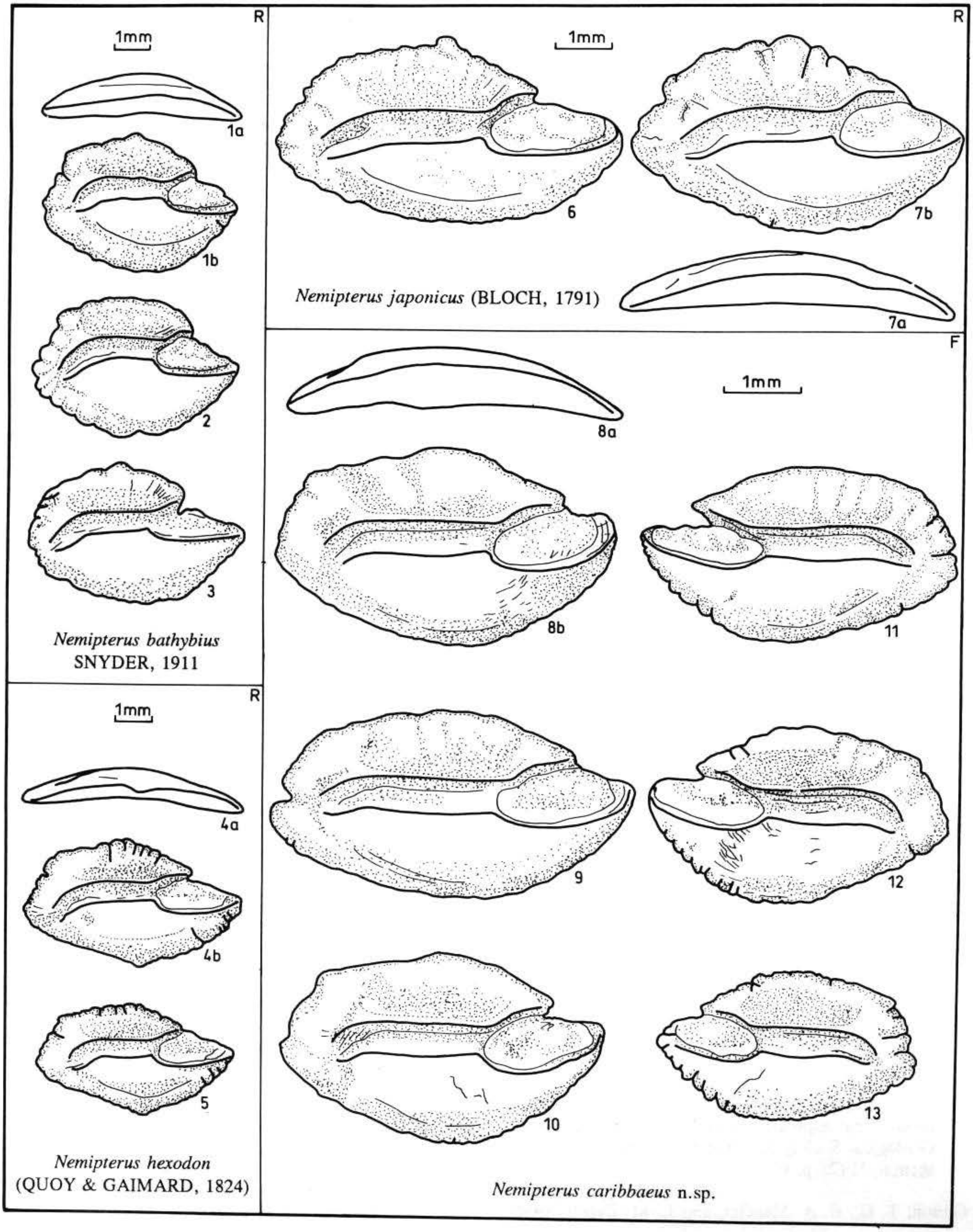
Plate 5

Fig. 1-3 *Nemipterus bathybius* Snyder, 1911
L; Recent, off Hong Kong (coll. IRSNB).

Fig. 4-5 *Nemipterus hexodon* (Quoy and Gaimard, 1824)
L; Recent, off Philippine Islands (coll. IRSNB).

Fig. 6-7 *Nemipterus japonicus* (Bloch, 1791)
L; Recent, off Philippine Islands (coll. IRSNB).

Fig. 8-13 *Nemipterus caribbaeus* n. sp.
8-10=L, 11-13=R; Matthews Landing Member. 8= holotype (IRSNB P 6116), 9-13= paratypes (IRSNB P 6117-6121).



Nemipterus bathybius SNYDER, 1911

Nemipterus hexodon (QUOY & GAIMARD, 1824)

Nemipterus japonicus (BLOCH, 1791)

Nemipterus caribbaeus n.sp.

(eastern Belgium), 65% of the association is constituted by a single gadiform species.

On mesopelagic fishes.- Typical mesopelagic elements, e.g. myctophids and gonostomatids, are also lacking in the studied fauna. This indicates that the Matthews Landing Marl was deposited in an environment that was not broadly open to the oceanic realm, and probably at a depth of less than 100 m.

Tethys distribution of nemipterids.- The last fact to discuss is the presence of the tropical and subtropical genus *Nemipterus*, with its Recent Indo-West Pacific distribution. Although the occurrence of this genus in the Gulf realm seems odd in terms of present-day biogeography, it can be explained by the more uniform circumtropical distribution of ancient Tethyan faunal elements.

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