ADDITIONS TO THE ELASMOBRANCH FAUNA FROM THE LATE CRETACEOUS OF NEW JERSEY (LOWER NAVESINK FORMATION, EARLY MAASTRICHTIAN)

by

Gerard Ramon CASE* and Henri CAPPETTA**

SOMMAIRE

* P.O. Box 689, Ridgefield Park, N.J. 07660-0689, U.S.A.

** Equipe Paléontologie-Paléobiologie-Phylogénie, UMR 5554 "Institut des Sciences de l'Evolution", Université de Montpellier II, C. C. 064, Place E.-Bataillon, 34095 Montpellier cedex 5, France, cappetta@isem.univ-montp2.fr

Mots-clés: Elasmobranches, espèce nouvelle, Crétacé supérieur, New Jersey, USA

Key-words: Elasmobranchs, new species, upper Cretaceous, New Jersey, USA

Palaeovertebrata, Montpellier, **33** (1-4): 1–16, 2 fig., 3 pl.
(Publié le 15 Décembre 2004)

ABSTRACT

A recently discovered, almost complete specimen of a hybodont tooth, allows us to describe as a new species, fairly common, but usually fragmentary teeth in the Navesink Formation of New Jersey: *Hybodus novojerseyensis* nov. sp.

Three additional taxa are also described : *Heterodontus creamridgensis, Squalicorax* sp. and *Pseudocorax affinis* which is noted for the first time in North America.

The whole elasmobranch fauna of the Early Maastrichtian localities of New Jersey is reevaluated and several generic assignments are changed in comparison to the list previously published in 1975 (Cappetta & Case).

RESUME

Un spécimen récemment découvert et presque complet de dent d'hybodonte permet de décrire une nouvelle espèce d'après des dents habituellement fragmentaires mais assez communes dans la Navesink Formation du New Jersey: *Hybodus novojerseyensis* nov. sp.

Trois taxa additionnels sont également décrits: *Heterodontus* cf. *creamridgensis, Squalicorax* sp. et *Pseudocorax affinis* qui est signalé pour la première fois en Amérique du Nord.

L'ensemble de la faune d'élasmobranches du Maastrichtien inférieur du New Jersey est réévaluée et plusieurs attributions génériques sont modifiées par rapport à la liste précédemment publiée en 1975 (Cappetta & Case).

INTRODUCTION

In their monograph published in 1975a, Cappetta and Case described a rich elasmobranch fauna including 28 species from the late Cretaceous (Early Maastrichtian) of New Jersey. The same year, Cappetta described a new *Ptychotrygon* species (*P. vermiculata*) from the same origin, previously attributed to *P. triangularis*. Posteriorly, few studies have been done on this topic. In 1986, Lauginiger publishes a short article on a vertebrate assemblage from the Big Brook locality, but without bringing new data about the elasmobranch list. The same year, Gallagher *et al*. cite some previously known elasmobranch taxa from New Jersey; these authors give a stratigraphic table putting the Wenonah, Mount Laurel and Navesink Formations in the lower Maastrichtian.

The succession of the formations occurring in New Jersey is summarized in the plate 3, figure 1. The Mount Laurel (late Campanian, see the discussion below) and Navesink Formations (early/middle Maastrichtian) are located in two brooks in Monmouth County, New Jersey. Firstly, at Willow Brook, in the banks of that brook, and at Ramanessin Brook nearby in the same County.

The only remnant of the upper portion of the Navesink Formation is still standing at Atlantic Highlands near Sandy Hook, opposite Staten Island and New York Harbor (which can be seen from the Highlands). The only other remainder of the upper and lower Navesink Formation is located at nearby Navesink and Shrewsbury Rivers, in their banks.

The lower portion of the Navesink is still exposed in Big Brook on both sides of Boundary Road in Marlboro, Monmouth County, New Jersey. It is highly probable that some of the teeth found upon the gravel bars in Big Brook come from the lower

Navesink, but since the specimens are separated from their original sediment, it would be very difficult to tell if the material recovered on the gravel bars and in the creek bed came from the existing lower Navesink or from the reworked and re-deposited upper Navesink that came southwesterly from present day Leonardo and Keansburg along the Raritan River.

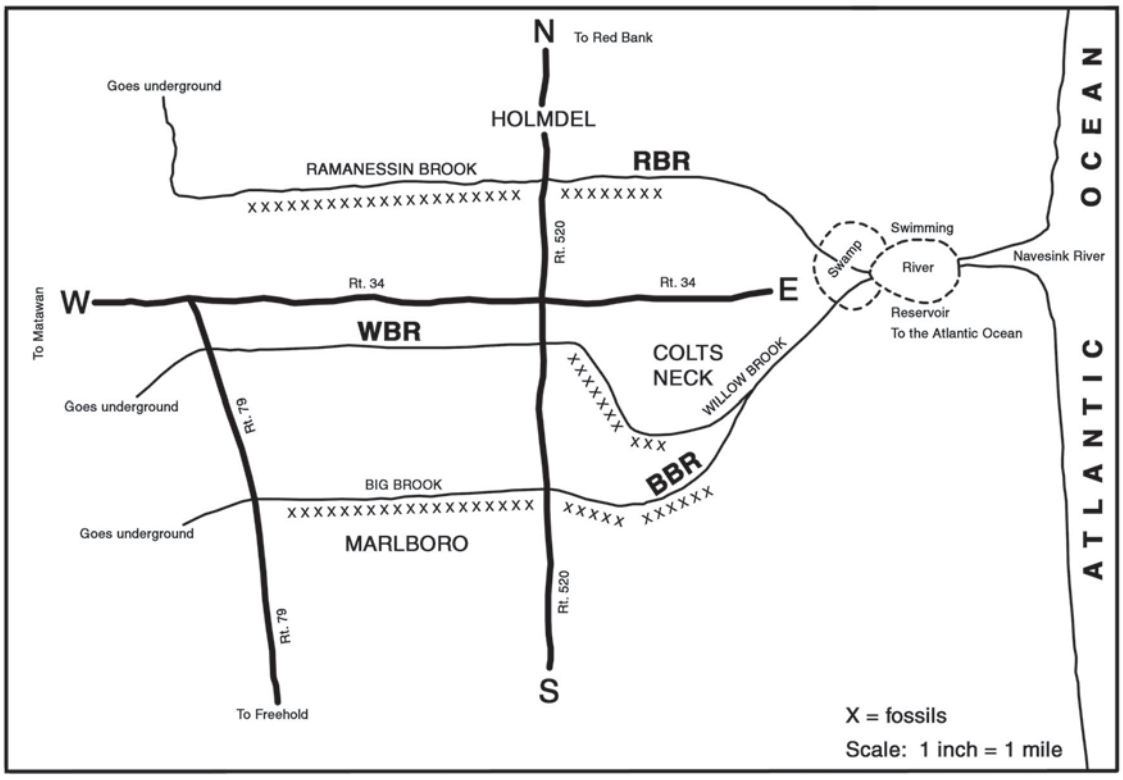

Figure 1.— Schematic map of the fossiliferous areas outcropping, Monmouth County.

The main localities from where the material published in 1975a was collected are indicated on the map of the figure 1. These localities were first considered as late Campanian in age, in Cappetta & Case (1975a), on the light of the works published at that moment, based on foraminifers and ammonites (Owens *et al.*, 1970). Their age was then reevaluated by Petters (1976) as early to middle Maastrichtian.

In fact, the age of the different formations has varied according to the authors and to the studied groups. It is out of the scope of this article to discuss in detail the different interpretations that are scattered in many publications. We shall only rapidly remind of some conclusions.

Stephenson *et al.*, 1942 considered the Mount Laurel Sands as early Maastrichtian and the Navesink Marl as middle Maastrichtian, like Olsson 1963, 1964, and Brouwers & Hazel, 1978. Spangler & Peterson, 1950 put the Campanian/Maastrichtian boundary between the Mount Laurel Formation and the Navesink Formation.

On the basis of foraminifera, Olsson (1964) includes the Wenonah, Mount Laurel and Navesink Formations in the early Maastrichtian.

For Owens & Sohl, 1973, and Perry *et al.*, 1974, the Mount Laurel Sand and the

base of the Navesink Formation have a late Maastrichtian age. For Petters, 1976, the Wenonah, Mount Laurel and Navesink Formations are in the lower part of the Maastrichtian.

In 1991, Olsson put the Wenonah and Mount Laurel Sands in the lower Maastrichtian (*G. tricarinata* Zone) and the Navesink Formation in the middle Maastrichtian (*G. gansseri* Zone), following Olsson & Wise, 1987.

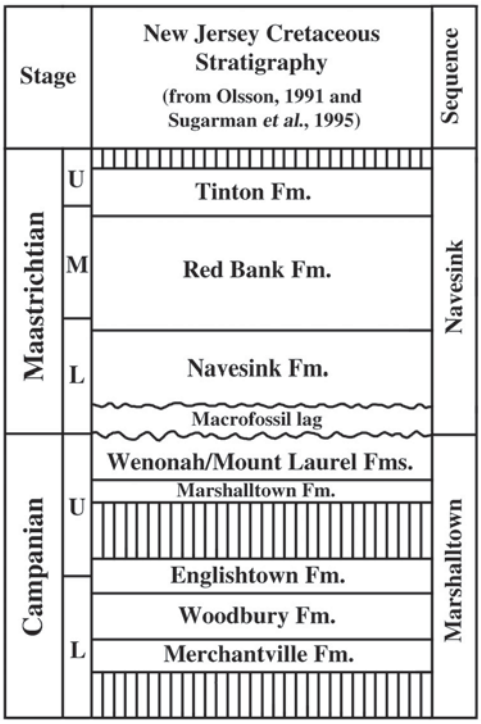

Figure 2.— New Jersey upper Cretaceous stratigraphy (modified after Becker *et al*., 1996).

Anyway, it seems obvious that the faunas contained in the lag deposits at the base of the Navesink Formation, just above the contact with the Mount Laurel Sands, are partly reworked (Becker *et al*., 1996, 2002). Sugarman *et al*., 1995) consider that there is a gap of about 3.1 My at the Campanian/Maastrichtian boundary (corresponding to the Mount Laurel Sands/Navesink Formation contact) in some parts of New Jersey according to the Sr87/Sr86 radiometric dating of pycnodont shells. The same authors give a synthetic figure showing the different interpretations of the Campanian/Maastrichtian boundary according to different groups (1995, p. 34); the planktonic foraminifera indicate a lower Maastrichtian age for the Wenonah and Mount Laurel Formations, and a middle Maastrichtian age for the Navesink Formation. According to the cephalopods, the Campanian/Maastrichtian boundary is located between the Mount Laurel Formation and the Navesink Formation; the ammonite *Nostoceras hyatti* disappears at the top of Campanian, when the first occurrence of *Belemnella lanceolata* is the marker of the base of Maastrichtian (Burnett *et al*., 1992). The same conclusion is reached on the basis of the bivalves and calcareous nannofossils studies.

Recently, the Campanian /Maastrichtian boundary has been defined in the Tercis quarry, southwestern France. On the basis of the ammonites, the top of the Campanian is marked by the occurrence of *Nostoceras hyatti* and the base of the Maastrichtian is

marked by the first occurrence of *Pachydiscus neubergicus* (Ward & Orr, 1997).

Concerning the upper Cretaceous series of New Jersey, it seems that there is an agreement for locating the Campanian/Maastrichtian boundary between the Mount Laurel and the Navesink Formations. Therefore, it can be considered that the elasmobranch fauna collected at the base of the Navesink Formation is of early Maastrichtian age, even it cannot be excluded that some teeth could be reworked from more ancient formations; yet, in this case, the physical aspect of teeth allows usually to characterise the reworked material.

SYSTEMATICS

Classification and terminology follow Cappetta, 1987.

Class Chondrichthyes HUXLEY, 1880
Subclass Elasmobranchii BONAPARTE, 1833
Cohort Euselachii HAY, 1902
Superfamily Hybodontoidea ZANGERL, 1981
Family Hybodontidae OWEN, 1846

Genus ***HYBODUS*** AGASSIZ, 1837

Hybodus novojerseyensis nov. sp.
(Plate 1, fig. 1-3, plate 2, fig. 1-5)

1975a - *Hybodus* sp. 1, Cappetta and Case, p. 4, p. 5, textfig. 2., pl. 1, fig. 1-6.

1986 - *Hybodus* sp., Lauginiger, p. 55, pl. 1, fig. 16.

? 1988 - *Hybodus* sp. 1, Case & Schwimmer, p. 291, p. 293, fig. 4/1-2.

Material: New material represented by three lateral teeth, one fairly complete and the other ones incomplete (missing side cusps and roots). Many incomplete teeth in the Montpellier collections.

Holotype: (RBR 1), 12 mm in height and 13 mm in width. Plate 1, fig. 1a-e.

Paratypes: 8 mm in height, pl. 1, fig . 2a-c (RBR 2); 8 mm in height, pl. 1, fig. 3a-c (RBR 3).

Referred specimens: an incomplete cephalic hook, 26 mm in overall height (from tip of the posterior spine to the broken segment of the barb stalk in the **anterior**), plate 2, fig. 3a-b (RBR 4). Another incomplete cephalic hook lacking a posterior spine and broken off at the anterior barb-stalk, plate 2, fig. 4a-b (RBR 5). An incomplete (mesial section) dorsal fin spine, 2.5 cm in height, plate 2, fig. 5a-d (RBR 6). Two cephalic hook cusps, pl. 2, fig. 1a-c (AMNH 6642) and 2 (BMNH P4919).

Derivation of name: Species named after the State of New Jersey in which the

specimen was recovered.

Locality: Ramanessin Brook, Holmdel, Monmouth County, New Jersey.

Age: Early Maastrichtian, Navesink Formation.

Diagnosis: Medium sized teeth (up to 12 mm of total height). The cusp is triangular in labial view, rather broad at its base, with straight and salient cutting edges. Labial face slightly convex, bearing short but very prominent and parallel folds on the lateral parts of the teeth. Lingual face of the cusp very convex transversally, with folds reaching two-third of its heigth. There are two pairs of lateral cusplets well separated from the main cusp and directed lingually in profile view. The root is not very high with a flat basal face and a rounded lingual part in profile view. In lateral files, the cusp is slightly distally leaning.

Description:

The holotype is fairly complete and is probably a latero-anterior tooth. The main cusp is symmetrical with a triangular outline in labial view. It is leaning lingually in profile view. The cutting edges are straight and very salient. The labial face of the cusp is convex transversally. It bears short vertical and parallel folds located on the lateral parts of the tooth, the median part of the cusp being devoid of folds. The lingual face is very convex transversally; the basal two-thirds of its height is covered by strong vertical and parallel folds. In profile view, the cusp is leaning lingually.

There were probably a pair of lateral cusplets but only one is preserved on one side. The cusplets are rather low and well separated from the cusp. In profile view, they are more lingually curved than the main cusp. They show the same folds as the main cusp, lingually and labially.

The root is not very high and well preserved. Its basal face is very flat. There is no a labial hollow, contrary to what can be observed in many hybodont species. In labial view, the basal edge is rectilinear and the lingual part of the root is rounded, with a clear and broad groove below the cusp boundary.

A lateral tooth (pl. 1, fig. 3a-b) is very incomplete and is devoid of lateral cusplets that are replaced by low cutting heels.

Discussion:

Cappetta and Case (1975a) reported fragmentary teeth of this species (all were incomplete) from the Navesink Formation (derived) of Ramanessin Brook (= Hop Brook) under the name of *Hybodus* sp. 1. Due to the poor state of preservation of the first available specimens (just central cusps, with no traces of lateral cusps nor roots) a better identification was not possible. In December of 1983, the senior author discovered a tooth with two lateral cusps and a well preserved root. This has made possible a more detailed study of this species and its comparison with previously described *Hybodus* species of similar age.

In fact, very few hybodont species have been described in the late Cretaceous of the United States.

Case (l978) described *Hybodus montanensis* from the Judith River Formation (Late Campanian) of Northern Montana, in Blaine County. Most teeth of this species

have 4 lateral cusps (two on either side of the central blade), with short evenly shaped lateral cusps and only slight rugose striae on the labial side of the crown, while other specimens are devoid of lateral cusps.

Case (1987) also described *Hybodus wyomingensis* from the so-called Mesaverde Formation (Late Campanian), Big Horn Basin. The teeth of *Hybodus wyomingensis* differ from both *Hybodus montanensis* and *Hybodus novojerseyensis* nov. sp. by having from two to three lateral cusplets (short) and slight striations surrounding the cusp.

Rees (1999) considers that *H. montanensis* could represent juvenile specimens of *H. wyomingensis*, on the basis of arguments resting on the size, and also on similarities between the fin spines. Rees (1999) has figured incomplete *Hybodus* sp. teeth and fragmentary fin spines from the early Campanian of Sweden. The teeth from Sweden seem to have a broader crown and very low and obtuse lateral cusplets; they are also much smaller than the New Jersey teeth.

Case (2001) finally described another species of Hybodont shark tooth from the Coleraine Formation (Cenomanian) at the Old Taconite Iron mine in Hibbing, Itasca County, Minnesota. This species, named *H. rajkovichi*, has teeth showing two large, distinctive lateral cusps or none on some specimens and bearing rather strong rugose folds that cover almost 50% of the height of the cusps (including the central one).

Hybodus novojerseyensis nov. sp. is also found in Delaware's Cretaceous (Lauginiger, 1984) and as far west as in the Cretaceous (Frankstown fauna) of north-eastern Mississippi (Manning & Dockery, 1992), and will be probably discovered in other Cretaceous outcrops in the eastern and middle United States.

Besides the teeth of *Hybodus novojerseyensis* nov. sp., cephalic hooks and dorsal fin spine fragments are collected in the same localities of New Jersey; they probably correspond to the same species. Such pieces were described and illustrated by Cappetta & Case (1975a) as *Hybodus* sp. 1.

One of the cephalic hook specimens (RBR 4), pl. 2, fig. 11-12, is almost complete, lacking only the recurved barb stalk on the anterior edge of the hook's platform. A very well preserved complete barb stalk of a hybodontid cephalic hook, probably *H. novojerseyensis* nov. sp., was figured by the senior author (Case, 1978, p. 182, fig. C1-3).

The other cephalic hook illustrated in Plate 2, fig. 13-14 (RBR 5) lacks both the posterior spine and the barb stalk. The remaining specimen of the referred series of *H. novojerseyensis* n. sp. is an incomplete mesial section of a dorsal fin spine fragment showing small hemispheric tubercles on its lateral faces. The posterior border has a series of staggered and recurved small barbs. A fragmentary dorsal finspine of the same morphology was figured in Cappetta & Case (1975a, pl. 1, fig. 1-2).

Fragmentary teeth and cephalic hooks, from the Blufftown Formation (Campanian) of Georgia, were figured by Case & Schwimmer (1988, p. 293, fig. 1-4) as *Hybodus* sp. On the basis of the figures, it remains difficult to know if this species is conspecific with *H. novojerseyensis* nov. sp.

This appears to be the first species of *Hybodus* described from the Maastrichtian

of the United States.

Order Heterodontiformes
Family Heterodontidae
Genus ***HETERODONTUS*** BLAINVILLE, 1816

Heterodontus creamridgensis CASE, BORODIN & LEGGETT, 2001
(Plate 3, fig. 1)

Material: one anterior tooth (WBR 95).

Locality: Willow Brook, Colts Neck, Monmouth County, New Jersey.

Age: Early Maastrichtian.

Description:

The tooth comes from the anterior part of the dentition of a probably young specimen. It is almost symmetrical, with a high and rather narrow main cusp with two pairs of lateral cusplets that are inserted high on the crown in labial view. The proximal (i.e. close to the main cusp) cusplets are diverging, broad, and making an angle of about 45° with the base of the main cusp. The outer cusplets are much smaller and narrower. In labial view, there is a clear constriction on each side of the crown, just below the outer cusplets. The basal part of the labial face forms an overhanging apron that is slightly concave medially and rounded at its lateral extremities.

In profile view, The labial face is very oblique and practically straight; the basilar angle is sharp (about 28°).

The root is not very thick. The lobes, both very thin, are U-shaped in basal view. In labial view, the lobes juts out clearly below the lateral parts of the crown apron.

The labial face of the root is very deep; some large foramina open on its lingual part. There is a salient and narrow lingual protuberance with an elliptical foramen opening before its lingual extremity.

Discussion:

Very few species of *Heterodontus* have been noted in Maastrichtian deposits.

Heterodontus creamridgensis has been described from the Late Maastrichtian (New Egypt Fm., Shrewbury Mb.) of Deep Run Creek, about 1,5 km SE of Arneytown, Monmouth Co., New Jersey, U.S.A., on the basis of a single anterior tooth of a probably juvenile specimen. The tooth from Willow Brook is very close morphologically to the Deep Run Creek specimen. Only some small differences can be noted, concerning the lateral cusplets that are broader and more diverging, and the lobes of the root that are longer in labial view; yet, these differences can be related with the fact that the tooth from Willow Brook occupied a slightly less anterior position in the mouth.

Two other Maastrichtian species are known :

Heterodontus granti CASE & CAPPETTA, 1997: p. 135, pl. 1, fig. 1-2, pl. 2, fig. 1.

Kemp Clay Fm.) Late Maastrichtien (Navarroan, South Sulphur River, near Commerce, Hunt Co., Texas, U.S.A. In this species, the main cusp is less high, the apron less transversally developed but more prominent, the labial profile of the crown usually more concave, and the root relatively higher than in *H. creamridgensis*.

Heterodontus rugosus (AGASSIZ, 1839): *Acrodus*; p. 148, pl. 22, fig. 28-29. Maastrichtian, Maastricht, The Netherland. [Type-species of the genus *Pseudoheterodontus* GLÜCKMAN & ZHELEZKO, 1971]. The anterior teeth of this species show the basal face of the crown with a very corrugated enamel; moreover, in labial view, the base of the crown is much broader than in *H. creamridgensis*.

Order Lamniformes
Family Anacoracidae

Genus ***PEUDOCORAX*** PRIEM, 1897

Pseudocorax aff. *affinis* MÜNSTER *in* AGASSIZ, 1843
(Plate 3, fig. 3)

1843 - *Corax affinis* AGASSIZ, p. 227, pl. 26, fig. 2, pl. 26a, fig. 21-24.

1843 - *Corax planus* AGASSIZ, p. 229, pl. 26a, fig. 56-57.

1897 - *Pseudocorax affinis* (AG.); Priem, p. 47, pl. 1, fig. 20-27.

1952 - *Pseudocorax affinis* (AG.); Arambourg, p. 116, pl. 21, fig. 1-3.

1964 - *Pseudocorax affinis* (AG.); Albers & Weiler, p. 13, fig. 48-50 in texte.

1977 - *Pseudocorax affinis* (AG.); Herman, p. 116, pl. 4, fig. 5.

Material: two lateral teeth, one of which is complete (BBR 15).

Locality: Big Brook, Marlboro, Monmouth County, New Jersey.

Age: Early Maastrichtian, Navesink Formation.

Description:

The better preserved tooth is broader than high and is an element of an antero-lateral file. The main cusp is broad and tilted distally at an angle of 45°. The mesial cutting edge shows at its base a hardly differentiated and low heel, slightly separated from the cutting edge of the cusp by a weak concavity; the cutting edge of the cusp is slightly convex. The distal cutting edge of the cusp is straight. The low distal heel is clearly separated from the cusp by a sharp angle. In labial view (pl. 3, fig. 3a), the base of the labial face forms a clear bulge, concave medially, and ascending in its marginal parts. The serration is very weak on the cutting edges.

The root is very high lingually (pl. 3, fig. 3b), with a flat basal face. The groove is vertical and well developed. The basal notch is rather narrow and sharp. The marginal

parts of the root show a clear constriction.

Discussion:

The genus is well represented in the Campanian deposits of Texas by the species *P. granti* CAPPETTA & CASE, 1997. Compared to this last species, the teeth of *P. affinis* are larger, with a broader cusp, and show serrated cutting edges. Another species, *P. laevis*, shows a dental morphology close to that of *P. affinis* but is characterized by smooth cutting edges.

It seems that the occurrence of *Pseudocorax affinis* is indicated for the first time in the Early Maastrichtian deposits of U.S.A. The species has been cited by Applegate 1970) from the Selma Formation of Alabama; yet according to the tooth morphology, particularly the complete lack of serrations on the cutting-edges, this species seems to correspond to *P. granti* and not to *P. affinis*.

The species *affinis* is known from the Campanian of Europe (France: Cappetta & Odin, 2001; Belgium: Leriche, 1929; Herman, 1977; Great Britain: Woodward, 1911) and from the Maastrichtian of Morocco (Arambourg, 1952; Noubhani & Cappetta, 1997) and Belgium (Leriche, 1929; Albers & Weiler, 1964; Herman, 1977). In Israel, Lewy & Cappetta (1989) have noted the occurrence of this species in the lowermost Maastrichtian of the Oron syncline, Negev desert. Yet, it must be noted that the teeth from this last area show a much more slight and irregular serration than *P. affinis*. By this feature, the teeth from New Jersey seem closer to the teeth from Negev than to the teeth of *P. affinis*, that is in agreement with the early Maastrichtian age of the fossils.

Genus ***SQUALICORAX*** WHITLEY, 1939

Squalicorax sp.

(Plate 3, fig. 2)

Material: one incomplete lateral teeth.

Locality: Big Brook, Marlboro, Monmouth County, New Jersey (BBR 16).

Age: Early Maastrichtian, Navesink Formation (probably derived).

Description:

This tooth looks like a lateral tooth of *S. kaupi*, except its very peculiar serration. The cusp is clearly directed distally; the beginning of the mesial cutting edge is very convex and bears irregular serrations, small at its base, larger in its median region and again small towards the cusp apex. The large serrations are directed mesially and are secondarily serrated (pl. 3, fig. 2b). The distal cutting edge of the cusp is straight and almost vertical; it bears small and regular serrations. The distal heel is short, oblique, practically unserrated and separated from the distal cutting edge of the cusp but an obtuse angle. The root is damaged but still shows a rather high lingual face.

Discussion:

This tooth is interesting because it shows different serration features on the distal

and on the mesial cutting edges of the cusp. The mesial one, with its rather large serrations secondarily serrated is typical of the design occurring in *S. yangaensis*. The distal cutting edge shows simple, minute and regular serrations, as can be seen in *S. kaupi* for instance.

This tooth shows a general morphology corresponding to *S. kaupi*; in particular, the base of the labial face of the crown does not overhang the root. Yet it differs by its secondarily serrated cutting edges.

Squalicorax yangaensis, which shows also secondarily serrated cutting edges, was first described from the Senonian (probably Campanian) of the Enclave of Cabinda, western Africa (Dartevelle & Casier, 1943); this species occurs also in Santonian to Campanian deposits of Angola (Antunes & Cappetta, 2002). A Moroccan species also showing secondarily serrated cutting edges was attributed by Arambourg (1952) to *S. yangaensis*; yet, the Moroccan specimens have a much more derived morphology and belong in fact to a new species (HC, forthcoming).

RESULTS AND CONCLUSIONS

The fossil collecting in the Maastrichtian of New Jersey has allowed us to expand the elasmobranch fauna previously published (Cappetta and Case, 1975a). At this moment, 28 species were identified in the Early Maastrichtian deposits of New Jersey; it is important to note that the age was then considered as Late Campanian.

Three previously undescribed species can be now added to the list: *Heterodontus creamridgensis* CASE, BORODIN & LEGGETT, 2001, *Pseudocorax affinis*, and *Squalicorax* sp.

It seems that *Pseudocorax affinis* is identified for the first time in the Maastrichtian of North America.

Concerning the previously published taxa, the increase of knowledge and the progress in the systematics of elasmobranchs during the three last decades allow now to correct several specific and generic assignements :

- the species *serrata* is now attributed to the genus *Serratolamna* LANDEMAINE, 1991;
- the species *borodini* is now attributed to the genus *Protolamna* CAPPETTA, 1980;
- the species *arcuata* is now named *kopingensis* and attributed to the genus *Archaeolamna* SIVERSON, 1992, following Siverson, 1992;
- the species *aculeatus* is now attributed to the genus *Odontaspis* AGASSIZ, 1838;
- the species *holmdelensis*, *hardingi* and *samhammeri* must be attributed to the genus *Carcharias* RAFINESQUE, 1810.
- the species *globidens* can be assigned to the genus *Plicatoscyllium* CASE & CAPPETTA, 1997.

At the specific level, the teeth assigned previously to *Ptychotrygon triangularis* REUSS, 1845 have been described by the junior author as a new species, *P. vermiculata*, in 1975.

The associated fauna is as follows (updated from Cappetta and Case, 1975a) :

Cappetta & Case, 1975a	This publication
Hybodus sp. 1	*Hybodus novojerseyensis* nov. sp.
Hybodus sp. 2	*Hybodus* sp. 2
Lonchidion babulskii	*Lonchidion babulskii*
Squalicorax kaupi	*Squalicorax kaupi*
Squalicorax pristodontus	*Squalicorax pristodontus*
	Squalicorax sp.
	Pseudocorax affinis
Squatina hassei	*Squatina hassei*
	Heterodontus creamridgensis
Cretolamna appendiculata lata	*Cretolamna appendiculata lata*
Cretolamna serrata	*Serratolamna serrata*
Cretoxyrhina mantelli	*Cretoxyrhina mantelli*
Plicatolamna borodini	*Protolamna borodini*
Plicatolamna arcuata	*Archaeolamna kopingensis*
Paranomotodon cf. *angustidens*	*Paranomotodon* cf. *angustidens*
Scapanorhynchus texanus	*Scapanorhynchus texanus*
Hypotodus aculeatus	*Odontaspis aculeatus*
Odontaspis holmdelensis	*Carcharias holmdelensis*
Odontaspis hardingi	*Carcharias hardingi*
Odontaspis samhammeri	*Carcharias samhammeri*
Brachaelurus sp. 1	*Brachaelurus* sp. 1
Brachaelurus sp. 2	*Brachaelurus* sp. 2
Ginglymostoma globidens	*Plicatoscyllium globidens*
Rhinobatos casieri	*"Rhinobatos " casieri*
Ischyrhiza cf. *avonicola*	*Ischyrhiza* cf. *avonicola*
Ischyrhiza mira mira	*Ischyrhiza mira mira*
Ankystrorhynchus major	*Ankystrorhynchus major*
Ptychotrygon triangularis	*Ptychotrygon vermiculata*
Ptychotrygon cuspidata	*Ptychotrygon cuspidata*
Brachyrhizodus wichitaensis	*Brachyrhizodus wichitaensis*
Rhombodus levis	*Rhombodus levis*

Table 1.— Up-dated faunal list of the elasmobranchs from the early Maastrichtian of New Jersey.

ACKNOWLEDGEMENTS

The authors appreciate the collecting efforts over the past 35 years at both Willow Brook and Ramanessin Brook sites of the following persons: David Samhammer, Emil Babulski, Paul D. Borodin, Charlis Borodin, Vladimir Borodin, James J. Leggett and William Platt. The two referees, D. Ward (Great-Britain) and M. Siverson (Australia), are thanked for their helpfull comments and suggestions.

Some of the photography of the specimens in this report was the work of Mr. Richard E. Grant, Dallas, Texas. The scanning electron microscopy (SEM) work for this paper was done at the University of Montpellier II.

The specimens (holotype, paratypes, and figured teeth) are housed in the paleontological collections of the University of Montpellier II, France.

Contribution ISEM N 2004-074.

REFERENCES

AGASSIZ, L., 1843b (1833-44). — Recherches sur les poissons fossiles. **3** : 390 + 32 p., 47 pl.

ALBERS, H. & WEILER, W., 1964. — Eine Fischfauna aus der oberen kreide von Aachen und neuere funde von Fischresten aus dem Maestricht des angrenzenden belgish-holländischen Raumes. *N. Jb. Geol. Paläont., Abh.*, **120** : 1-33, 51 fig.

ANTUNES, M. T. & CAPPETTA, H., 2002. — Sélaciens du Crétacé (Albien-Maastrichtien) d'Angola. *Palaeontographica, Abt. A*, **264** (5-6) : 85-146, 3 fig., pl. 1-12.

APPLEGATE, S. P., 1970. — The vertebrate fauna of the Selma Formation of Alabama. VIII : The fishes. *Fieldiana, Geol. Mem.*, **3** (8) : 383-433, 31 fig.

ARAMBOURG, C., 1952d. — Les vertébrés fossiles des gisements de phosphates (Maroc-Algérie-Tunisie). *Notes et Mém. Serv. géol. Maroc*, **92** : 1-372, 62 fig., 44 pl.

BECKER, M. A., SLATERRY, W. & CHAMBERLAIN, J. A., 1996. — Reworked Campanian and Maastrichtian macrofossils in a sequence bounding, transgressive lag deposit, Monmouth County, New Jersey. *Northeast. Geol. Envir. Sci.*, **18** (3) : 243-252, 7 fig.

BROUWERS, E. M. & HAZEL, J. E., 1978. — Ostracoda and correlation of the Severn Formation (Navarroan; Maestrichtian) of Maryland. *J. Paleont., Paleont. Monogr. N 1*, **52** (6) : 1-52.

BURNETT, J. A., HANCOCK, J. M., KENNEDY, W. J. & LORD, A. R., 1992. — Macrofossil, planktonic foraminiferal and nannofossil zonation at the Campanian/Maastrichtian boundary. *Newsl. Stratigr.*, **27** : 157-172, 4 fig.

CAPPETTA, H., 1975. — *Ptychotrygon vermiculata* nov. sp., sélacien nouveau du Campanien du New Jersey (U.S.A.). *C.R. somm. Soc. géol. France*, (5) : 164-166, 1 fig.

CAPPETTA, H., 1980. — Modification du statut générique de quelques espèces de sélaciens crétacés et tertiaires. *Palaeovertebrata*, **10** (1) : 29-42, 6 fig.

CAPPETTA, H., 1987. — Mesozoic and Cenozoic Elasmobranchii, Chondrichthyes II. 3B : 193 p., 148 fig.,

CAPPETTA, H. & CASE, G. R., 1975a. — Contribution à l'étude des Sélaciens du groupe Monmouth (Campanien-Maestrichtien) du New Jersey. *Palaeontographica , Abt. A*, **151** (1-3) : 1-46, 11 fig., 9 pl.

CAPPETTA, H. & CASE, G. R., 1975b. — Sélaciens nouveaux du Crétacé du Texas. *Geobios*, **8** (4) : 303-307, 6 fig.

CAPPETTA, H. & ODIN, G. S., 2001. — Les sélaciens du Campanien-Maastrichtien de Tercis-les-Bains (SO France) *in The Campanian - Maastrichtian Boundary: characterisation and correlation from Tercis (Landes, SW France) to Europe and other continents*, ODIN G. S. (ed.), IUGS Special Publication (monograph) series, 36 and Developments in Palaeontology and Stratigraphy, Elsevier Sciences Publ., (D8)**:** 679-685, 1 pl.

CASE, G. R., 1978. — A new selachian fauna from the Judith River Formation (Campanian) of Montana.

Palaeontographica, Abt.A, **160** (1-6) : 176-205, 16 fig., 6 pl.

CASE, G. R., 1987. — A new selachian fauna from the Late Campanian of Wyoming (Teapot Sandstone Member, Mesaverde Formation, Big Horn Basin). *Palaeontographica, Abt. A*, **197** (1-3) : 1-37,12 fig., 15 pl.

CASE, G. R., 2001. — A New selachian fauna from the Coleraine Formation (Upper Cretaceous/ Cenomanian) of Minnesota. *Palaeontographica , Abt. A*, **261** (4-6) : 103-112, 2 pl.

CASE, G. R. & CAPPETTA, H., 1997. — A new selachian fauna from the Late Maastrichtian of Texas (Upper Cretaceous/Navarroan; Kemp Formation). *Münchner Geowiss. Abh., (A: Geol. und Paläont.)*, **34** : 131-189, 10 fig., 15 pl.

CASE, G. R. & SCHWIMMER, D. R., 1988. — Late Cretaceous fish from the Blufftown Formation (Campanian) in Western Georgia. *J. Paleont.*, **62** (2) : 290-301, fig. 1-6.

CASE, G. R., BORODIN, P. D. & LEGGETT, J. J., 2001. — Fossil selachians from the New Egypt Formation (Upper Cretaceous, Late Maastrichtian) of Arneytown, Monmouth County, New Jersey. *Palaeontographica , Abt. A*, **261** (4-6) : 113-124, 1 fig., 5 pl.

DARTEVELLE, E. & CASIER, E., 1943. — Les poissons fossiles du Bas-Congo et des régions voisines. *Ann. Mus. Congo Belge, Sér. A (Minér., Géol., Paléont.)*, **3, 2** (1) : 1-200, fig. 1-60, pl. 1-16.

GALLAGHER, W. B., PARRIS, D. C. & SPAMER, E. E., 1986. — Paleontology, biostratigraphy, and depositional environments of the Cretaceous-Tertiary transition in the New Jersey Coastal Plain. *Mosasaur*, **3** : 1-35, 4 fig.

LANDEMAINE, O., 1991. — Sélaciens nouveaux du Crétacé supérieur du Sud-Ouest de la France. Quelques apports à la systématique des élasmobranches. *Saga*, **1** : 1-45,11 fig.,16 pl.

LAUGINIGER, E. M., 1984. — An Upper Campanian vertebrate fauna from the Chesapeake and Delaware Canal. *Mosasaur*, **2** : 141-149, 2 pl.

LAUGINIGER, E. M., 1986. — An upper Cretaceous vertebrate assemblage from Big Brook, New Jersey. *Mosasaur*, **3** : 53-61, pl. 1-2.

MANNING, E. M. & DOCKERY III, D. T., 1992. — A guide to the Frankstown vertebrate fossil locality (Upper Cretaceous), Prentiss County, Mississippi. *Mississippi Depart. Environm. Qual., Off. Geol.*, **4** : 1-43, 7 fig., pl. 1-12.

OLSSON, R. K., 1964. — Late Cretaceous planktonic Foraminifera from New Jersey and Delaware. *Micropal.*, **10** (2) : 157-188, 3 fig., pl. 1-7.

OLSSON, R. K. & WISE, S. W. J., 1987. — Upper Maestrichtian to middle Eocene stratigraphy of the New Jersey slope and coastal plain. *Init. Rep. D.S.D.P.*, **93** : 1343-1365.

OWENS, J. P. & GOHN, G. S., 1985. — Depositional history of the Cretaceous series in the U.S. Atlantic Coastal Plain: stratigraphy, paleoenvironments, and tectonic control of sedimentation, in *Geological evolution of the United States Atlantic margin*, POAG, C. W. edit., 2 : 25-86, 22 fig.,

OWENS, J. P., MINARD, J. P., SOHL, N. F. & MELLO, J. F., 1970. — Stratigraphy of the outcropping post-Magothy Upper Cretaceous formations in southern New Jersey and northern Delmarva Peninsula, Delaware and Maryland. *U.S. Geol. Surv. Prof. Pap.*, **674** : 33-49, 24 fig., 9 tabl.

PETTERS, S. W., 1976. — Upper Cretaceous subsurface stratigraphy of Atlantic Coastal Plain of New Jersey. *AAPG Bull.*, **60** (1) : 87-107, 7 fig.

PRIEM, F., 1897. — Sur des dents d'élasmobranches de divers gisements sénoniens (Villedieu, Meudon, Folx-les-Caves). *Bull. Soc. géol. France*, 25 (3) : 40-56, 1 pl.

RAFINESQUE, C. S., 1810. — Caratteri di alcuni nuovi generi e nuove specie di animali e pinate della Sicilia, con varie osservazioni sopra i medisimi. : [i-iv] 3-69.

REES, J., 1999. — Late Cretaceous hybodont sharks from the Kristianstad Basin, southern Sweden. *N. Jb. Geol. Paläont. Mh.*, **5** : 257-270, 6 fig.

REUSS, A. E., 1845. — Die Versteinerungen der böhmischen Kreideformation. Erste Abteilung. *Versteiner. böhmisch. Kreideform. Erste Abt.*, : 58 p., 13 pl.

SIVERSON, M., 1992. — Biology, dental morphology and taxonomy of Lamniform sharks from the Campanian of the Kristianstad basin, Sweden. *Palaeontology*, **35** (3) : 519-554, 2 fig., 5 pl.

SPANGLER, W. B. & PETERSON, J. J., 1950. — Geology of Atlantic Coastal Plain in New Jersey, Delaware, Maryland, and Virginia. *AAPG Bull.*, **34** (1) : 1-99, 11 fig.

STEPHENSON, L. W., KING, P. B., MONROE, W. H. & IMLAY, R. W., 1942. — Correlation of the outcropping Cretaceous Formations of the Atlantic and Gulf Coastal Plain and Trans-Pecos Texas. *Bull. Geol. Soc. Amer.*, **53** (3) : 435-448, 1 pl.

SUGARMAN, P. J., MILLER, K. G., BUKRY, D. & FEIGENSON, M. D., 1995. — Uppermost Campanian-Maestrichtian strontium isotopic, biostratigraphic, and sequence stratigraphic framework of the New Jersey Coastal Plain. *Geol. Soc. Amer. Bull.*, **107** : 19-37.

WARD, P. & ORR, W. N., 1997. — Campanian-Maastrichtian ammonite and planktonic foraminiferal biostratigraphy from Tercis, France: implications for defining the stage boundary. *J. Paleont.*, **71** (3) : 407-418, 6 fig., 1 tabl.

WHITLEY, G. P., 1939. — Taxonomic notes on sharks and rays. *Austral. Zool.*, **9** (3) : 227-262, fig. 18, pl. 20-22.

WOODWARD, A. S., 1911. — The fishes of the English Chalk. VI. *Palaeontogr. Soc. London*, **64** : 185-224, fig. 56-68, pl. 39-46.

CAPTIONS OF THE PLATES

PLATE 1

Except for the specimens of the plate 3, fig. 2, the figured material is housed in the paleontologic collections of the University of Montpellier II.

Figures 1-3. *Hybodus novojerseyensis* n. sp.

Fig. 1a-e (RBR 1): lower lateral tooth. Holotype. 1a: labial view; 1b: profile; 1c: lingual view; 1d: occlusal view; 1e: basal view.

Fig. 2a-c (RBR 2): lower lateral tooth. Paratype. 2a: labial view; 2b: profile; 2c: lingual view.

Fig. 3a-b (RBR 3): upper lateral tooth. Paratype. 3a: labial view; 3b: lingual view.

PLATE 2

Figures 1-5. *Hybodus novojerseyensis* n. sp.

Fig. 1-2: Referred cephalic spines.

1a (AMNH 6642): incomplete cephalic hook, lateral view; 1b (idem): anterior

view; 1c (idem): posterior view.

2 (BMNH P4919): almost complete cephalic hook, lateral view.

Fig. 3-4: Referred cephalic spines (base).

Fig. 3a (RBR 4): dorsal view; 3b: ventral view.

Fig. 4a (RBR 5): dorsal view; 4b: ventral view.

Fig. 5a-d (RBR 6). Referred incomplete dorsal fin spine. 5a: right lateral view; 5b: anterior view; 5c:posterior view; 5d: left lateral view.

PLATE 3

Figures 1: *Heterodontus creamridgensis*

Fig. 1a (WBR 95): anterior tooth of a young specimen; b (idem): profile; c (idem): lingual view; d (idem): basal view.

Figure 2: *Squalicorax* sp.

Fig. 2a (BBR 16): lateral tooth, lingual view; 2b (idem): detail of the serration of the mesial cutting edge, labial view.

Figure 3: *Pseudocorax* cf. *affinis*

Fig. 3a (BBR 15): lateral tooth, labial view; 3b (idem): lingual view.

PLATE 1

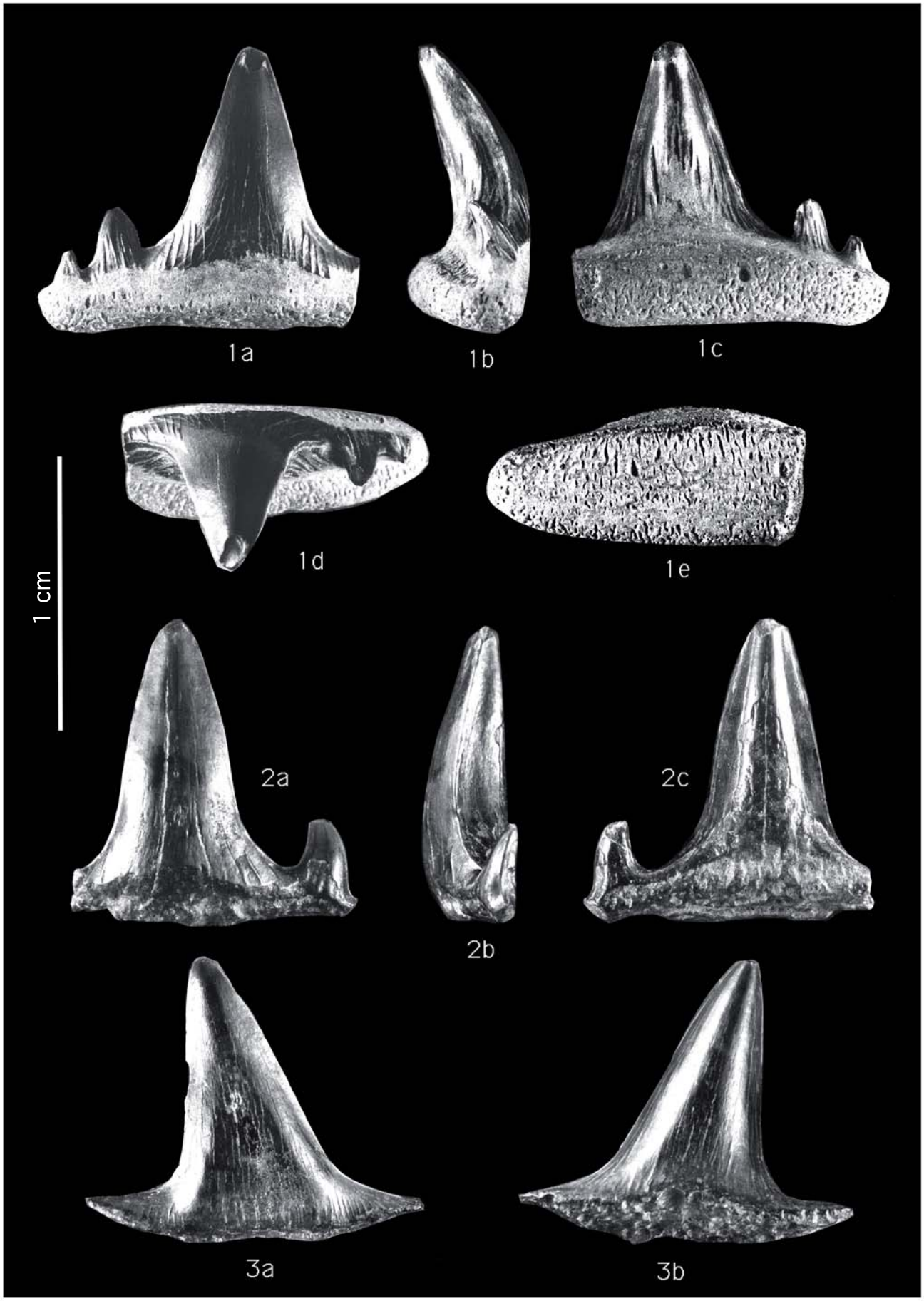

PLATE 2

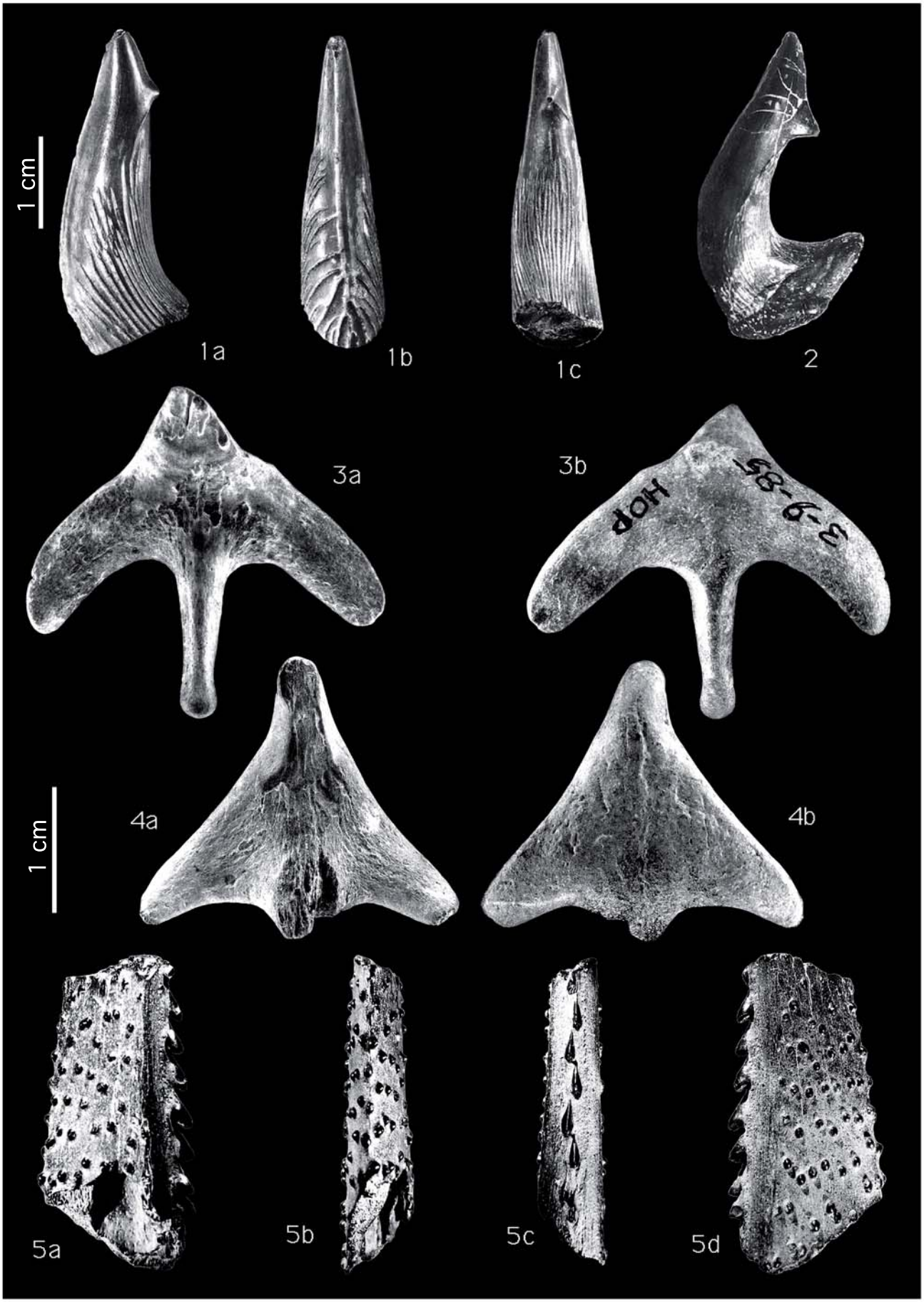

PLATE 3