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Late Eocene selachians from the Irwinton Sand Member of the Barnwell Formation (Jacksonian), WKA mines, Gordon, Wilkinson County, Georgia

by

Gerard R. CASE* and Paul D. BORODIN**

ABSTRACT

Recent recovery of the teeth of fossil sharks and rays, as well as the rostral spines of sawfishes in the Irwinton Sand Member of the Barnwell Formation at a Kaolin operation in northeast-central Georgia, allows us to compare the faunal assemblage of the present study with that of the Twiggs Clay Member of the Barnwell Formation of Late Eocene age (Jacksonian) (CASE, 1981). At the present time there are no new species to be considered, and we regret that only two species of microteeth *(Heterodontus* cf. *H. pineti* and *Urolophis cruciatus)* have so far been collected. No doubt – with furter collecting, more specimens of the microfauna will come to light.

The fauna of this study consists of the following taxa: *Heterodontus* cf. *H. pineti* CASE; *Carcharocles* sp.; *Isurus praecursor* (LERICHE); *Cretolamna twiggsensis* (CASE); *Carcharias cuspidata* (AGASSIZ); *Nebrius thielensis* (WINKLER); *Hemipristis curvatus* DAMES; *Abdounia enniskilleni* (WHITE); *Galeocerdo latidens* (AGASSIZ); *Negaprion eurybathrodon* (BLAKE); *Pristis* cf. *P. lathami* GALEOTTI; *Propristis schweinfurthi* DAMES; *Urolophis cruciatus* (LACÉPÈDE) and *Hyliobatis* sp. The following teleosts are also present in the fauna: *Cylindracanthus* cf. *C. rectus* (DIXON); *Sphyraena* sp., and *Trichiurides sagittidens* WINKLER.

Introduction

The recent discovery of an assemblage of selachian species, as well as the teeth and vertebrae of bony fishes, snake vertebrae *(Pterosphenus)*, turtle and crocodile remains and the teeth of the shark-toothed whale, *Zeuglodontus*. These latter specimens have been recovered on occassion at the WKA clay pits.

The material in general shows wear and abrasion, and has probably been transported and appears as a large 1 to 2 m sandy lag deposit lying unconformably upon a rich kaolin clay deposit of commercial value (see Text-fig. 1B).

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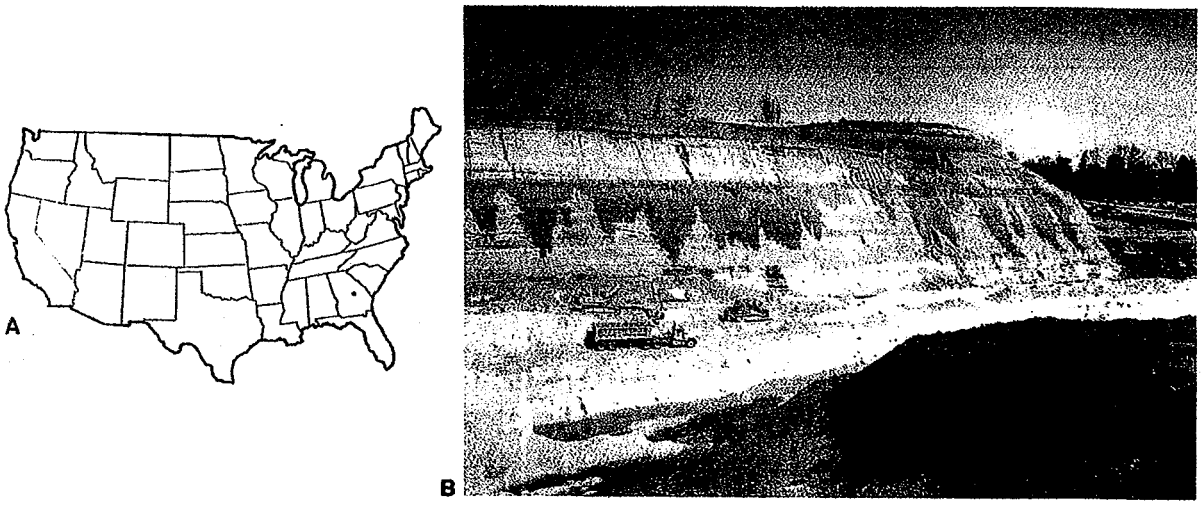


Text-fig. 1. **A.** A map of the United States showing a small black square in the State of Georgia where the specimens of this report were recovered. **B.** A photo taken of the mining operations at WKA. The fossils were recovered above the whitish layer (kaolin) near the bottom of the cliff. Photo was taken in April 1993 by the senior author.

Geology

HUDDLESTON and HETRICK (1985) discuss the Barnwell Formation and its various members and state that these members and formation appear to be of Late Eocene age and in the American marine stage of the Jacksonian.

In a partial paper without title, which we have attributed to an anonymous author. This paper may in fact have been written by R. E. CARVER, and his article was entitled: "Stratigraphy of the Jackson Group in eastern Georgia", and it appeared in Southeastern Geology, volume 14 on pages 153-181. The present authors have only pages 162 through 181 in an "untitled portion of Volume 14 of Southeastern Geology. Nevertheless, we have obtained from "Carver's" article, much knowledge about the Irwinton Member of the Barnwell Formation. This member is younger than the Twiggs Clay Member of the Barnwell and has a larger number of species types, although exactly the same as in the Twiggs Clay unit at Huber (CASE, 1981).

CASE and CAPPETTA (1990) have studied the teeth of selachians in Egypt and have found similar species types in the Barnwell Formation. Although, the Egyptian material extends from the Middle Eocene (Gar Gehannam Formation (Ravine Beds and the Wadi Rayan Formation) up to the Qasr-el-Sagha Formation and the Birket-el-Qurun Formation of the Late Eocene and on into the Gebel-el-Quatrani (Fluvio-marine series) of the Oligocene. The Irwinton and Twiggs Members of the Barnwell Formation are definitely Late Eocene in age. The similarity of species in the Egyptian material and the Georgia (USA) are as follows:

Species	Egypt	Georgia (USA)
Carcharocles cf. *sokolowi*	×	×
Isurus praecursor	×	×
Cretolamna twiggsensis	×	×
Galeocerdo latidens	×	×
Hemipristis curvatus	×	×
Pristis lathami	×	×
Propristis schweinfurthi	×	×

Plate 1

Fig. 1-2 ***Nebrius thielensis* (WINKLER)**

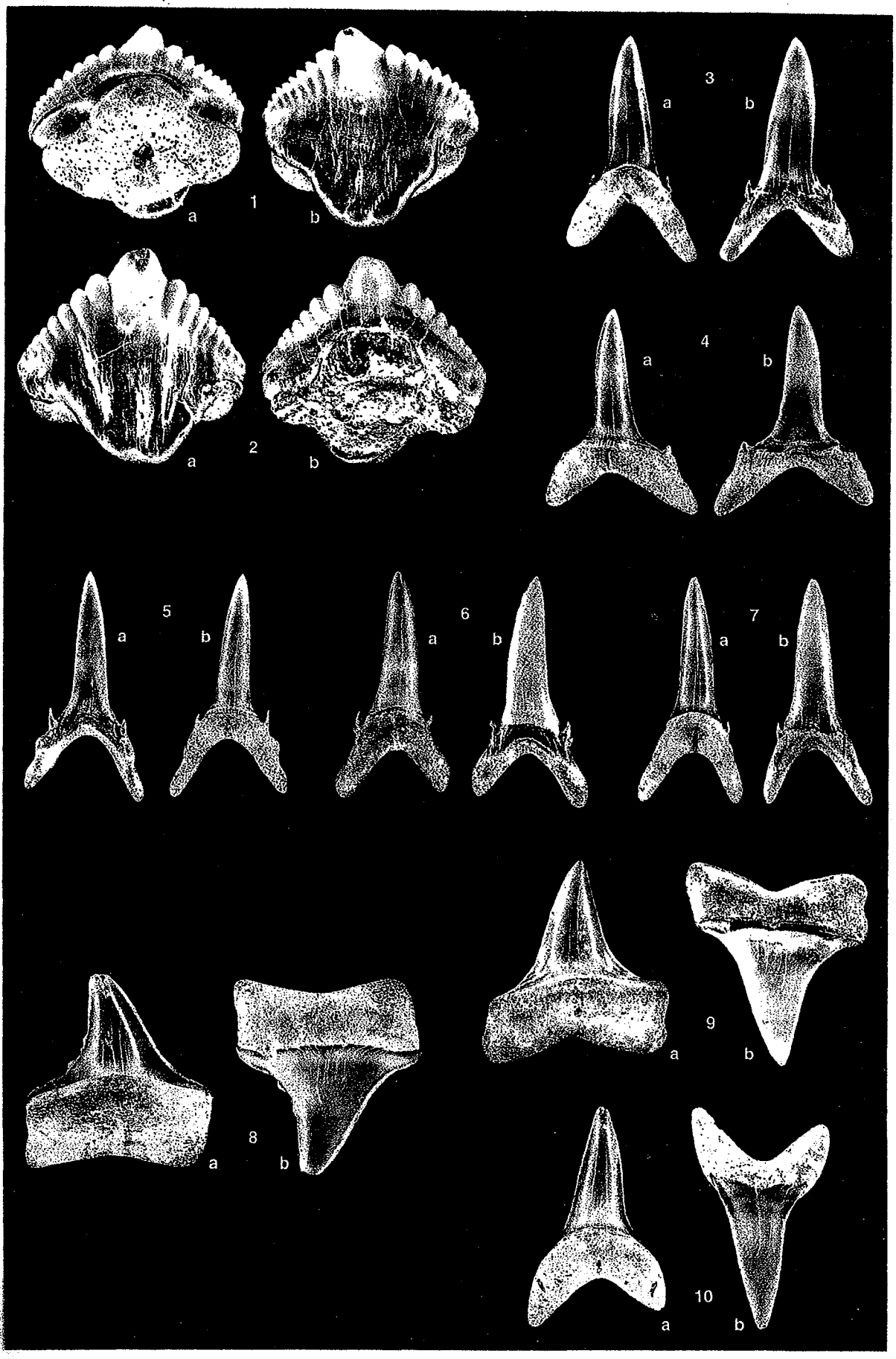
Fig. 1 lateral tooth (AMNH19744), ×4. **a.** basal lingual view. **b.** labial view.
Fig. 2 (AMNH19745), ×4. **a.** lateral tooth, labial view. **b.** antero-lateral tooth, basal lingual view.

Fig. 3-7 ***Carcharias cuspidata* (AGASSIZ)**

Fig. 3 anterior tooth (AMNH19746), ×1. **a.** lingual view. **b.** labial view.
Fig. 4 antero-lateral tooth (AMNH19747), ×2. **a.** lingual view, **b.** labial view.
Fig. 5 anterior tooth (AMNH19748), ×1.5. **a.** labial view, **b.** lingual view.
Fig. 6 anterior tooth (AMNH19749), ×1. **a.** lingual view, **b.** labial view.
Fig. 7 anterior tooth (AMNH19750), ×1. **a.** lingual view, **b.** labial view.

Fig. 8-10 ***Isurus praecursor* (LERICHE)**

Fig. 8 lateral tooth (AMNH19751), ×2. **a.** lingual view, **b.** labial view.
Fig. 9 antero-lateral tooth (AMNH19752), ×1.5. **a.** lingual view, **b.** labial view.
Fig. 10 anterior tooth (AMNH19753), ×1. **a.** lingual view, **b** labial view.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Systematics

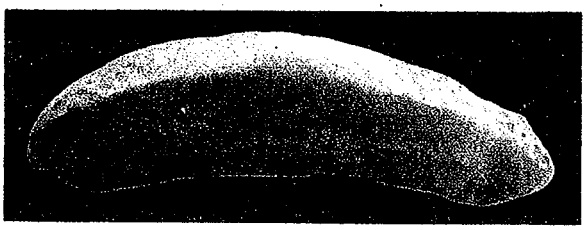
In this part, the classification followed is that of CAPPETTA, 1987.

Class Chondrichthyes HUXLEY 1880
Subclass Elasmobranchii BONAPARTE 1838
Subcohort Neoselachii COMPAGNO 1977
Superorder Galeomorphii COMPAGNO 1973
Order Heterodontiformes BERG 1937
Family Heterodontidae GRAY 1831
Genus *Heterodontus* BLAINVILLE 1816

***Heterodontus* cf. *H. pineti* CASE**
(Text-fig. 2)

1981 *Heterodontus pineti* CASE-CASE, pp. 55-56 and pl. 1, fig. 1-2.

Material: 1 isolated battery tooth (lateral).
Description: See CASE, 1981, pp. 55-56.
Discussion: See above.



Text-fig. 2. *Heterodontus* cf. *H. pineti* CASE, an isolated battery tooth (AMNH19744a) in occlusal aspect. The specimen is badly worn, but shows enough diagnostic features to be assigned to *H. pineti* (SEM photo x13).

Order Orectolobiformes APPLEGATE 1972
Family Ginglymostomatidae GILL 1862
Genus *Nebrius* RÜPPELL 1837

***Nebrius thielensis* (WINKLER)**
(Plate 1, fig. 1-2)

Material: 2 lateral teeth.
Description: See CASE, 1994a, p. 105.
Discussion: See above.

Order Lamniformes BERG 1958
Family Odontaspididae MÜLLER & HENLE 1839
Genus Carcharias RAFINESQUE 1810

***Carcharias cuspidata* (AGASSIZ)**
(Plate 1, fig. 3-7)

Material: 5 specimens, 4 anterior and 1 antero-lateral tooth.
Description: Teeth ranging in size from 2 to 4 cm, averaging 3.5 cm. Teeth with a slender central blade with two lateral (and sometimes an additional, smaller aberrant denticle) denticles, one on either side of the central blade (cf. pl. 1, fig. 6a). The lateral denticles are strongly sigmoidal. The root boss (in lingual view) contains a slight groove or furrow (cf. pl. 1, fig. 4a). The teeth do not contain any apparent ornamentation (striae).
Discussion: The teeth of *C. cuspidata* extend into the Miocene and are quite common in most Miocenic formations. The tooth was formally named *Synodontaspis* by CAPPETTA (1987: 91).

Family Lamnidae MÜLLER & HENLE 1838
Genus *Isurus* RAFINESQUE 1810

***Isurus praecursor* (LERICHE)**
(Plate 1, fig. 8-10)

Material: 3 specimens, 1 anterior, 1 antero-lateral and 1 lateral tooth.
Description: See CASE, et al, 1996, pp. 106-107 and CASE and CAPPETTA, 1990, p. 8.
Discussion: See above.

Family Otodontidae GLIKMAN 1964
Genus *Carcharocles* JORDAN & HANNIBAL 1923

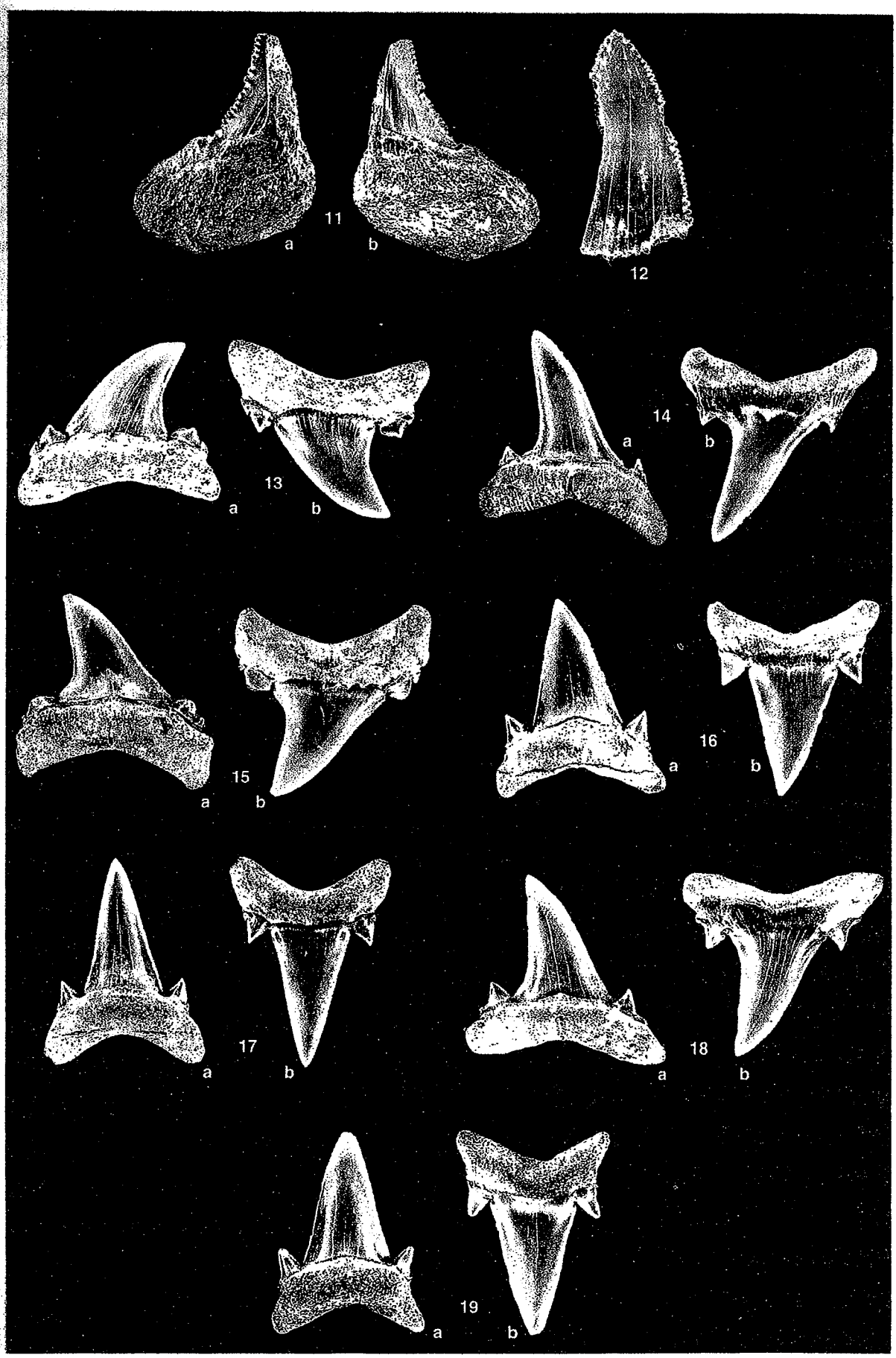
***Carcharocles* sp.**
(Plate 2, fig. 11-12)

Material: 2 tooth fragments, possibly a lateral (fig. 11a) and an anterior (fig. 12) tooth. They may possibly be *C. sokolowi*, but are just too fragmentary for a description.
Description: See CASE and CAPPETTA, 1990, pp. 6-7

Plate 2

Fig. 11-12 ***Carcharocles* sp.**
Fig. 11 (fragment) lateral tooth? (AMNH19754), x1.5. **a.** lingual view. **b.** labial view.
Fig. 12 (fragment) anterior tooth? (AMNH19755), x1, labial view.

Fig. 13-19 ***Cretolamna twiggsensis* (CASE)**
Fig. 13 lateral tooth (AMNH19756), x2. **a.** lingual view, **b.** labial view.
Fig. 14 antero-lateral tooth (AMNH19757), x2. **a.** lingual view, **b.** labial view.
Fig. 15 lateral tooth (AMNH19758), x2. **a.** lingual view, **b.** Labial view.
Fig. 16 anterior tooth (AMNH19759), x2. **a.** lingual view, **b.** labial view.
Fig. 17 anterior tooth (AMNH19760), x2. **a.** lingual view, **b.** labial view.
Fig. 18 lateral tooth (AMNH19761), x1.5. **a.** lingual view, **b.** labial view.
Fig. 19 anterior tooth (AMNH19762), x2. **a.** lingual view, **b.** labial view.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for a description of *C. sokolowi*.
Discussion: See above.

Family Cretoxyrhinidae GLIKMAN 1958
Genus *Cretolamna* GLIKMAN 1958

***Cretolamna twiggsensis* (CASE)**
(Plate 2, fig. 13-19)

1981 *Lamna twiggsensis* CASE-CASE, pp. 58-59 and pl. 3, fig. 4-8

Material: 7 specimens, 3 anterior, 1 antero-lateral and 3 lateral teeth.
Description: See CASE, 1981, p. 58-59 and CASE and CAPPETTA, 1990, pp. 9-10.
Discussion: See above.

Order Carcharhiniformes COMPAGNO 1973
Family Hemigaleidae HAASE 1879 (1995)
Genus *Hemipristis* AGASSIZ 1843

***Hemipristis curvatus* DAMES**
(Plate 3, fig. 20-23)

Material: 4 specimens, 2 anterior, 1 antero-lateral, and 1 lateral tooth.
Description: See CASE and CAPPETTA, 1990, pp. 16-17.
Discussion: See above.

Family Carcharhinidae JORDAN & EVERMANN 1896
Genus *Abdounia* CAPPETTA 1980

***Abdounia enniskilleni* (WHITE)**
(Plate 4, fig. 31-34)

Material: 4 specimens, 1 anterior, 2 antero-lateral & 1 lateral tooth.
Description: See CASE, 1981, p. 62 & CASE and CAPPETTA, 1990, p. 11.
Discussion: see above. Note: This species was originally named *Scyliorhinus* (see CASE, 1981, p. 62).

Genus *Galeocerdo* MÜLLER & HENLE 1838

***Galeocerdo latidens* (AGASSIZ)**
(Plate 4, fig. 35-38)

Material: 4 specimens, 2 antero-lateral and 2 lateral teeth.
Description: See CASE and CAPPETTA, 1990, pp. 13-14.
Discussion: See above

Genus *Negaprion* WHITLEY 1940

***Negaprion eurybathrodon* (BLAKE)**
(Plate 3, fig. 24-30)

Material: 7 specimens, 1 antero-lateral and 6 lateral teeth.
Description: See CASE, 1981, p. 64.
Discussion: See above.

Suborder Pristiodei CAPPETTA 1980
Family Pristidae BONAPARTE 1838
Genus *Propristis* DAMES 1883

***Propristis schweinfurthi* DAMES**
(Plate 5, fig. 43-50)

Material: 3 rostral fragments, showing tooth notches and 5 isolated rostral spines (that fit the notches on the rostrum).
Description: See CASE, 1981, p. 71 & CASE and CAPPETTA, 1990, pp. 19-20.
Discussion: See above.

***Pristis* cf. *P. lathami* GALEOTTI**
(Plate 4, fig. 39-42)

Material: 3 rostral spines, 2 complete and 1 fragment.
Description: See CASE, 1981, p. 70 & CASE and CAPPETTA, 1990, pp. 18-19.

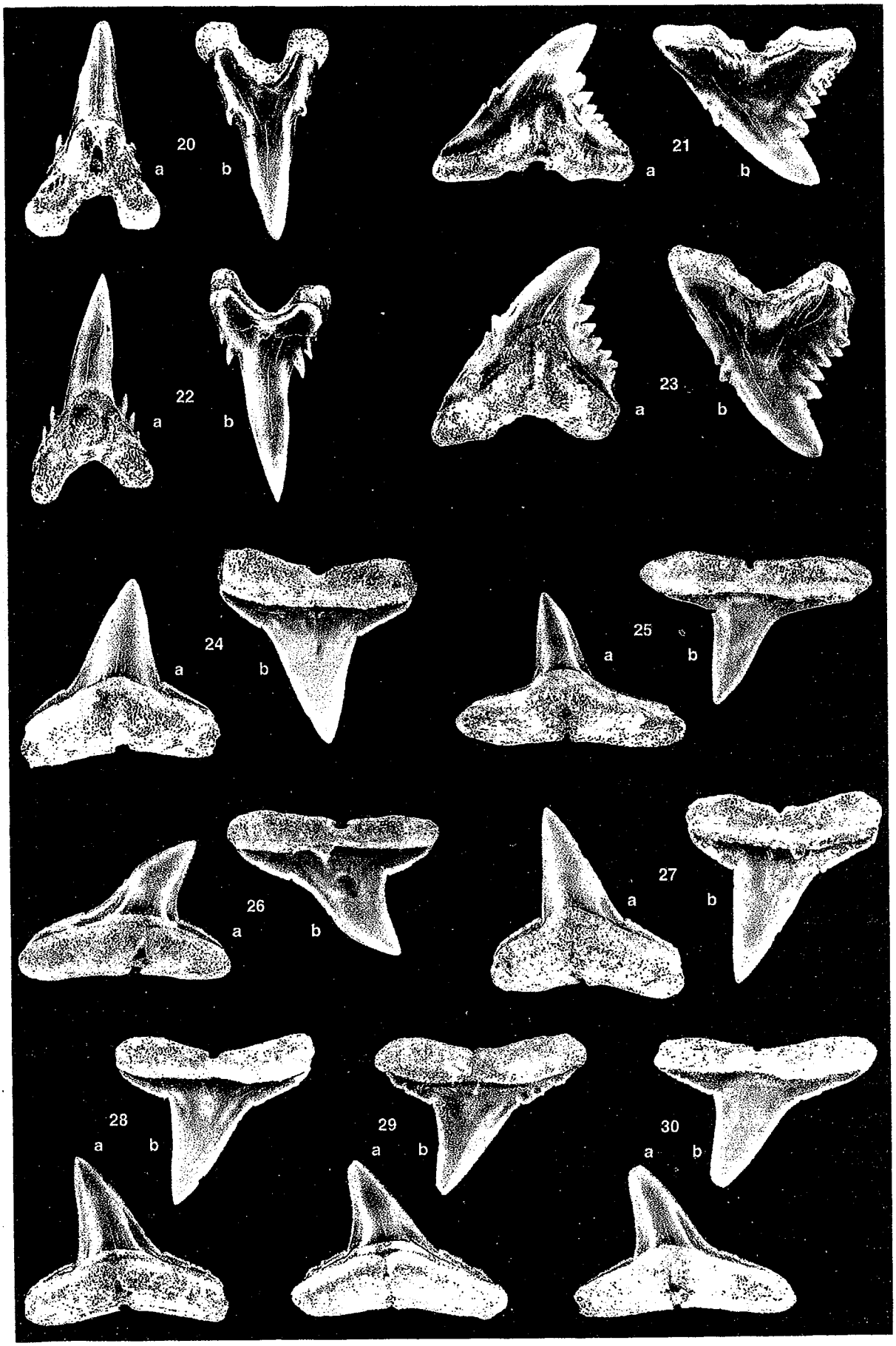
Plate 3

Fig. 20-23 ***Hemipristis curvatus* DAMES**

Fig. 20 anterior tooth (AMNH19763), ×4. **a.** lingual view, **b.** labial view.
Fig. 21 lateral tooth (AMNH19764), ×3. **a.** lingual view, **b.** labial view.
Fig. 22 anterior tooth (AMNH19765), ×4. **a.** lingual view, **b.** labial view.
Fig. 23 antero-lateral tooth (AMNH19766), ×3.5. **a.** lingual view, **b.** labial view.

Fig. 24-30 ***Negaprion eurybathrodon* (BLAKE)**

Fig. 24 lateral tooth (AMNH19767), ×3. **a.** lingual view, **b.** labial view.
Fig. 25 antero-lateral tooth (AMNH19768), ×3. **a.** lingual view, **b.** labial view.
Fig. 26 lateral tooth (AMNH19769), ×3. **a.** lingual view, **b.** labial view.
Fig. 27 lateral tooth (AMNH19770), ×3. **a.** lingual view, **b.** labial view.
Fig. 28 lateral tooth (AMNH19771), ×3. **a.** lingual view, **b.** labial view.
Fig. 29 lateral tooth (AMNH19772), ×3. **a.** lingual view, **b.** labial view.
Fig. 30 lateral tooth (AMNH19773), ×3. **a.** lingual view, **b.** labial view.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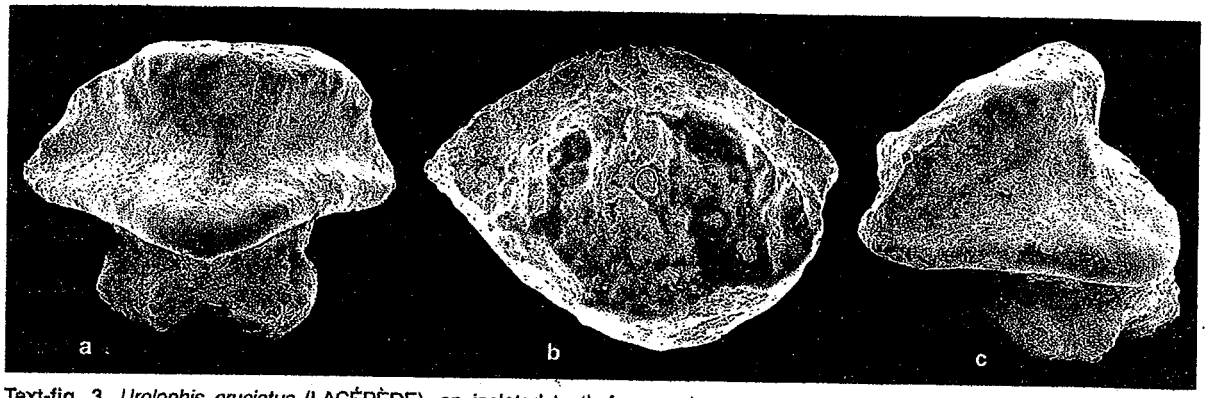


Text-fig. 3. *Urolophis cruciatus* (LACÉPÈDE), an isolated tooth from a clear-nose skate (AMNH19794a). **a.** Lingual view x34; **b.** Occlusal view x34; and **c.** Profile view x32 (SEM photos).

Order Myliobatiformes COMPAGNO 1973
Subfamily Dasyatoidea WHITLEY 1940
Family Urolophidae GRAY 1851
Genus *Urolophis* MÜLLER & HENLE 1837

***Urolophis cruciatus* (LACÉPÈDE)**
(Text-fig. 3)

Material: specimen, a lateral tooth.
Description: A minute lateral tooth measuring less than 1 mm, with a hood-like condition of the occlusal aspect overhanging the root boss (cf. Text-fig. 3a and c). The occlusal aspect (cf. Text-fig. 3b) (although quite worn and abraded) has a pitted surface as an ornamentation and its apron (cf. Text-fig. 3c) overhangs the root in labial aspect. There appears a foramina, one on either side of the root in lingual aspect (cf. Text-fig. 3a).
Discussion: CAPPETTA (1987:165) states that *Urolophis* is known by a complete skeleton from the Lower Eocene of Monte Bolca, Italy. He further states that the range for *Urolophis* is from the Lower Eocene to recent. The present species can be confused with *Dasyatis*, but *Urolophis* differs from *Dasyatis* by its minute size (teeth).

Superfamily Myliobatoidea COMPAGNO 1973
Family Myliobatidae BONAPARTE 1838
Genus *Myliobatis* CUVIER 1817

***Myliobatis* sp.**
(Plate 5, fig. 51-55)

Material: 3 mouth plates and 2 fragmentary tail barbs.
Description: See CASE, 1981, p. 72.
Discussion: See above.

Class Osteichthyes
Subclass Actinopterygii
Order Teleostei
Family Sphyraenidae SCHNEIDER 1801
Genus *Sphyraena* SCHNEIDER 1801

***Sphyraena* sp.**
(Plate 5, fig. 58-59)

Material: 2 specimens, 1 maxillary and 1 incisor tooth.
Description: See CASE and WEST, 1991, p. 115.
Discussion: See above.

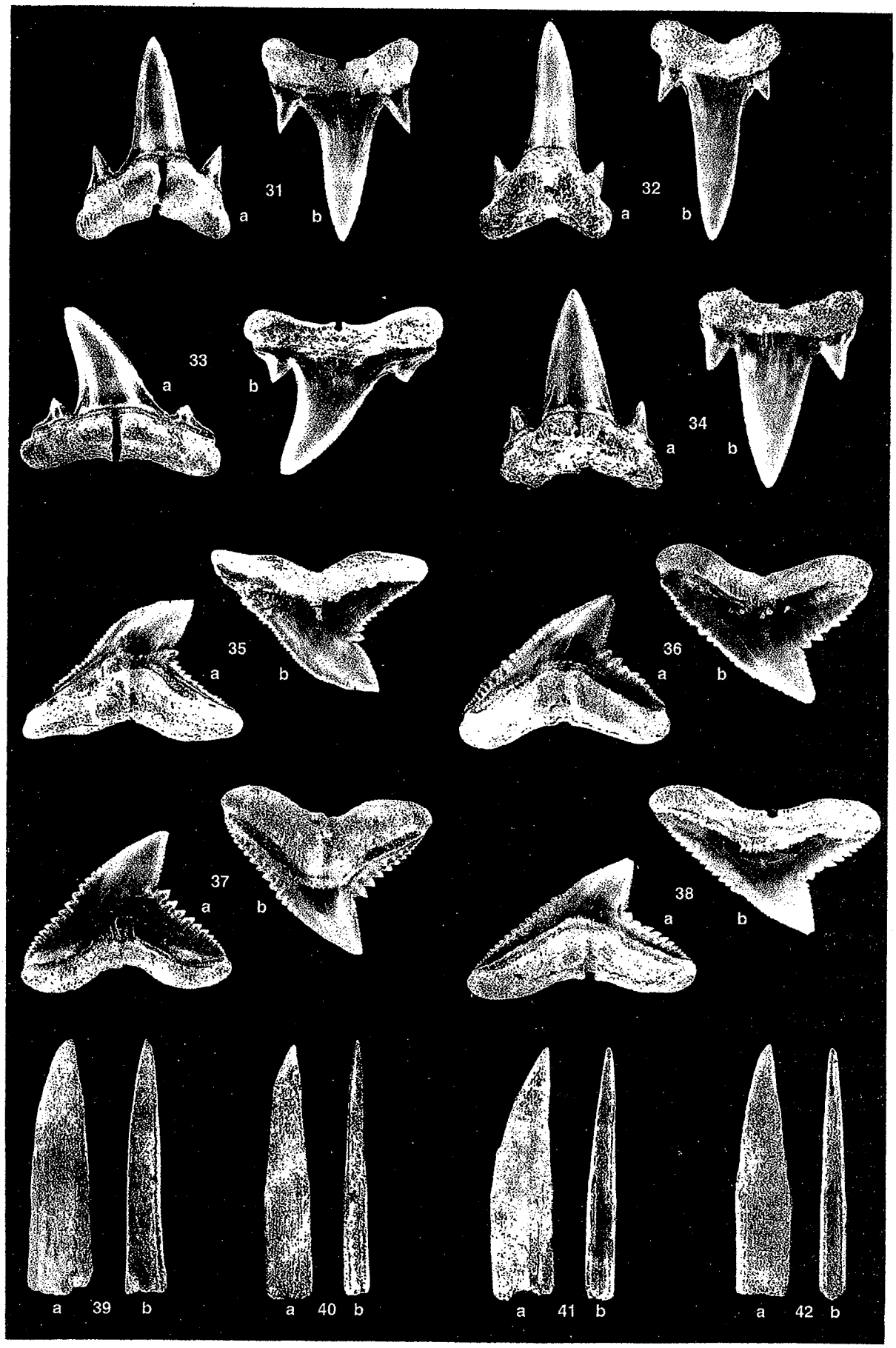
Plate 4

Fig. 31 ***Abdounia enniskilleni* (WHITE)**
antero-lateral tooth (AMNH19774), x3.5. **a.** lingual view, **b.** labial view.

Fig. 32-34 ***Abdounia enniskilleni* (WHITE)**
Fig. 32 anterior tooth (AMNH19775), x3.5. **a.** lingual view, **b.** labial view.
Fig. 33 lateral tooth (AMNH19776), x4. **a.** lingual view, **b.** labial view.
Fig. 34 antero-lateral tooth (AMNH19777), x3.5. **a.** lingual view, **b.** labial view.

Fig. 35-38 ***Galeocerdo latidens* (AGASSIZ)**
Fig. 35 antero-lateral tooth (AMNH19778), x2. **a.** lingual view, **b** labial view.
Fig. 36 lateral tooth (AMNH19779), x2. **a.** lingual view, **b.** labial view.
Fig. 37 antero-lateral tooth (AMNH19780), x2. **a.** labial view, **b.** lingual view.
Fig. 38 (AMNH19781), x2. **a.** lingual view, **b.** labial view, same specimen, lateral tooth.

Fig. 39-42 ***Pristis lathami* GALEOTTI**
Fig. 39 rostral spine fragment (AMNH19782), x1. **a.** right profile view, **b.** Posterior view.
Fig. 40 complete rostral spine (AMNH19783), x.5. **a.** right profile view, **b.** Posterior view.
Fig. 41 rostral spine fragment (AMNH19784), x1. **a.** right profile view, **b.** Posterior view.
Fig. 42 rostral spine fragment (AMNH19785), x1. **a.** right profile view, **b.** Posterior view.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Order Anacanthini
Suborder Gadoidea
Family Merluccidae?
Genus *Trichiurides* WINKLER 1874

***Trichiurides sagittidens* WINKLER**
(Plate 5, fig. 60)

Material: 1 incisor tooth.
Description: See CASE, 1994b, pp. 146-147.
Discussion: See above.

Family Xiphiidae LEIDY 1857
= Blochidae CASIER 1966
Genus *Cylindracanthus* LEIDY 1857

***Cylindracanthus rectus* (DIXON)**
(Plate 5, fig. 56-57)

Material: 2 fragments of rostrums (bills).
Description: See CASE, 1994b, p. 147.
Discussion: See above.

The authors felt that it was not necessary to rewrite the descriptions and discussions on many of the species in this report. The reader can find these descriptions and discussions in previous literature.

Results and conclusions

The selachians recovered at Wilkinson Kaolin Associates clay pits represent an offshore or littoral marine incursion and the species are listed below in their commoness to their rarity:

Abdounia	Abundant
Galeocerdo	Abundant
Propristis	Abundant
Sphyraena	Abundant
Carcharias	Common
Cretolamna	Common
Hemipristis	Common
Negaprion	Common
Pristis	Common
Myliobatis	Common
Isurus	Uncommon
Carcharocles	Uncommon
Trichiurides	Uncommon
Cylindracanthus	Uncommon
Nebrius	Rare
Heterodontus	Extremely rare
Urolophis	Extremely rare

Plate 5

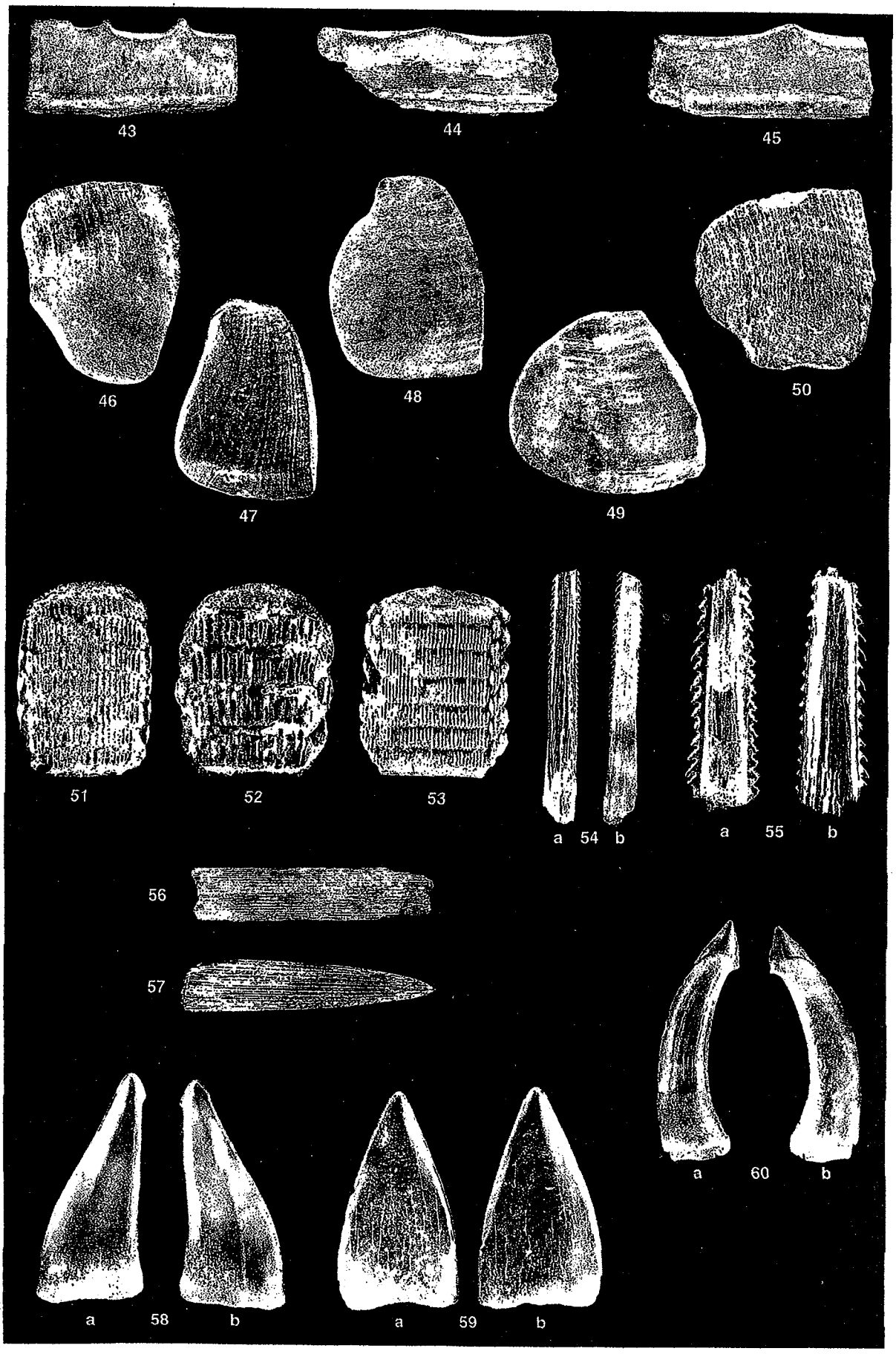
Fig. 43-50 ***Propristis schweinfurthi* DAMES**
- **Fig. 43** rostral fragment with notches at top, indicating location of the spine (tooth) (AMNH19786).
- **Fig. 44** rostral fragment with two spine notches (AMNH19787), ×1.
- **Fig. 45** rostral fragment with two notches (AMNH19788), ×1.5.
- **Fig. 46** left view of an isolated spine (tooth) (AMNH19789), ×2.
- **Fig. 47** left view of an isolated spine (tooth) (AMNH19790), ×3.
- **Fig. 48** left view of an isolated spine (tooth) (AMNH19791), ×2.
- **Fig. 49** left view of an isolated spine (tooth) (AMNH19792), ×2.
- **Fig. 50** left view of an isolated spine (tooth) (AMNH19793), ×2.

Fig. 51-55 ***Myliobatis* sp.**
- **Fig. 51** dorsal view of an entire mouth plate, with 7 chevrons (AMNH19794), ×2.
- **Fig. 52** dorsal view of an entire mouth plate, with 4 chevrons (AMNH19795), ×1.5.
- **Fig. 53** dorsal view of an entire mouth plate, with 7 chevrons (AMNH19796), ×.5.
- **Fig. 54** posterior portion of a sting-ray barb (AMNH19797), ×.5. **a.** dorsal view, **b.** ventral view.
- **Fig. 55** mesial portion of a sting-ray barb (AMNH19798), ×1.5. **a.** ventral view, **b.** dorsal view.

Fig. 56-57 ***Cylindracanthus* cf. *C. rectus* (DIXON)**
- **Fig. 56** fragment of a rostrum (bill) (AMNH19799), ×1.5.
- **Fig. 57** fragment of a rostrum (bill) (AMNH19800), ×1.

Fig. 58-59 ***Sphyraena* sp.**
- **Fig. 58** incisor tooth (AMNH19801), ×2. **a.** left profile, **b.** right profile.
- **Fig. 59** isolated maxillary tooth (AMNH19802), ×3.5. **a.** reverse view, **b.** obverse view.

Fig. 60 ***Trichiurides sagittidens* WINKLER**
incisor tooth (AMNH19803), ×3. **a.** right profile, **b.** left profile.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There are many otoliths present in the Irwinton and as these fish earbones are quite difficult to identify to their teleostean species, it will remain for an expert such as Dirk Nolf to study them. His work in Belgium (NOLF, 1988) on the otoliths is legendary.

As far as the remains of reptiles (turtles, snakes and crocodiles) and mammals, such as the whale Zeuglodont, this will remain for others to study.

In conclusion, the species recovered in the Irwinton Member of the Barnwell Formation are quite similar to those recovered in the Twiggs Clay Member at Huber, Georgia. The following species are from Huber in the Twiggs Clay Member and have not been recovered so far at WKA: *Scyliorhinus, Scoliodon, Rhizoprionodon, Galeorhinus, Sphyrna, Squatina, Rhinobatos, Rhinoptera* and *Aetobatis.*

This does not mean that they do not exist in the entire taxa at WKA, just that they are quite small and have not been recovered yet.

Table 1. Geographic range of Ocala Limestone and Barnwell species with those of the Fayum in Egypt.

Fayum Depression of Egypt	Barnwell Formation**	Ocala Limestone*
Carcharocles cf. *sokolowi*		×
Isurus praecursor		×
Cretolamna twiggsensis	×	×
Alopias aff. *alabamensis*		
Abdounia sp. *(enniskilleni)*	×	×
Galeocerdo latidens	×	×
Rhizoprionodon sp.	×	
Hemipristis curvatus	×	×
Pristis lathami	×	
Propristis schweinfurthi	×	×
Myliobatis sp.	×	×
Aetobatus sp.	×	

* Faunal assemblage is not completely known at this site (WKA Quarry, Gordon, Georgia). A microfauna is missing, and several species of larger species have not been recovered.

** An older formation (Twiggs Clay Member) from the Huber Kaolin Mines, Huber, Georgia. A microfauna is known from this latter site (CASE, G. R. 1981. Palaeontographica A (176): 52-79.

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The specimens are to be housed in the Vertebrate Paleontology Collections at the American Museum of Natural History in New York City, New York. Acronym AMNH. The Scanning Electron photographs of Text figures 2 and 3, were made by Ms. Angela V. Klaus, the Laboratory Manager of the Interdepartmental Laboratories at the American Museum of Natural History in New York City, New York.

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