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ELASMOBRANCH TEETH (VERTEBRATA, PISCES) FROM THE DONGEN FORMATION (EOCENE) IN THE NETHERLANDS

by

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This paper deals with elasmobranch teeth from Eocene deposits in The Netherlands. Over 500 teeth and tooth fragments were collected from the Dongen Formation in NAM-well De Wijk-19, NAM-well Opende-1 and RGM-boring Haaksbergen 34G.2-8, all located in the northeastern part of The Netherlands. About 50% of this material is too incomplete to be identified to generic or specific level, the remaining part is assigned to 37 species of shark and ray.

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Contents:

SAMENVATTING

De Dongen Formatie omvat in Nederland alle afzettingen met een eocene ouderdom. Ze kan een dikte van meer dan 400 m hebben en bestaat hoofdzakelijk uit groengrijze en bruine, weinig kalkhoudende kleien met een ingeschakelde zand- of mergeleenheid. Van onder naar boven worden opeenvolgend de Basis Dongen Tuf Member, Ieper Klei Member, Brussel Zand Member en Asse Klei Member onderscheiden. De Dongen Formatie dagzoomt niet in Nederland, zodat we in ons land het Eoceen alleen uit boringen kunnen bestuderen.

Uit een drietal spoelboringen in Noordoost-Nederland (NAM-boringen De Wijk-19 en Opende-1, en RGM-boring Haaksbergen 34G.2-8) konden in totaal meer dan 500 tanden en tandfragmenten van haaien en roggen uit de Dongen Formatie verzameld worden. Ongeveer de helft van dit materiaal kan tot 37 soorten haaien en roggen gerekend worden, welke hier beschreven en afgebeeld worden. De andere helft van het tandenmateriaal is te fragmentarisch om tot op genus- of soortniveau gedetermineerd te worden.

De Basis Dongen Tuf Member bevatte in de onderzochte boringen erg weinig haaie- en roggetandjes. Tot nu toe zijn slechts twee soorten bekend: *Isistius trituratus* en *Dasyatis* sp. Beide soorten verschijnen in België en Engeland voor het eerst in het Vroeg Eoceen.

De Ieper Klei Member bevatte relatief weinig tanden van haaien en roggen. De meest karakteristieke soorten voor deze afzetting zijn *Xenodolamia eocaena, Squalus* sp. div., *Isistius trituratus, Scyliorhinus casieri, S. pattersoni, Triakis wardi*, twee onbeschreven *Raja* sp., ? *Arechia* sp. en *Burnhamia daviesi*. Deze associatie is indicatief voor een vroeg-eocene ouderdom.

In de Brussel Zand Member, vooral in het bovenste gedeelte, komen erg veel haaie- en roggetanden voor. De associaties uit de NAM-boringen De Wijk-19 en Opende-1 vertonen enkele belangrijke verschillen: in De Wijk-19 zijn op de zeebodem levende roggen dominant, in het bijzonder de adelaarsrog *Myliobatis*. Daarnaast komen de Carcharhinidae *Abdounia minutissima, Physogaleus secundus* en *Scoliodon* sp. algemeen voor. In Opende-1 komen deze groepen veel minder algemeen voor en zien we inplaats daarvan een dominantie van *Isistius trituratus*. Daarnaast komen de orectilobiforme haaien *Eostegostoma angustum* en *Palaeorhincodon wardi*, de pelagische duivelsrog *Burnhamia daviesi* en een aantal kleinere haaien voor, die voorheen alleen uit de Engelse London Clay bekend waren, namelijk *Scyliorhinus casieri, S. pattersoni* en *Triakis wardi*. Dit wijst erop dat in Opende-1 de Brussel Zand Member in dieper water werd afgezet. Het voorkomen van *Heterodontus vincenti, Eostegostoma angustum, Palaeorhincodon wardi* en relatief grote tanden van *Striatolamia macrota* duiden op een midden-eocene ouderdom van de Brussel Zand Member.

In de Asse Klei Member werden weinig tandjes van haaien en roggen aangetroffen. De volgende soorten komen voor: *Squalus* sp., *Isistius trituratus, Physogaleus secundus, Raja cecilae* en *R. heinzelini*. Deze associatie is indicatief voor een laat-eocene ouderdom.

INTRODUCTION

Allochthonous Eocene elasmobranch faunas are well-known from The Netherlands. Beds with reworked phosphoritic concretions at the base of Oligocene deposits in the eastern part of The Netherlands contain many elasmobranch teeth, reworked from Eocene deposits in this area. This material was extensively studied by Leriche (1936), van de Geyn (1937) and van den Bosch (1964). Hitherto teeth of more than 20 Eocene elasmobranch species are known from these deposits (van den Bosch, 1980). A rich allochthonous Eocene fauna is also present in the glacial boulder clay at Losser (Spaink, 1978). The molluscs and microfauna indicate a Late Eocene age. Spaink recorded 18 elasmobranch species from this fauna.

These allochthonous faunas suggest that the extensive Eocene deposits present in the substrata of The Netherlands may be expected to contain very rich elasmobranch faunas in situ. Such autochthonous faunas have remained undescribed for a long time, because deposits of Eocene age do not crop out in The Netherlands and can only be studied from borings. Samples collected for micro-

paleontological investigation from wells by oil companies and the Geological Survey of The Netherlands are usually too small to contain any significant elasmobranch material. Inspection of rather large samples is necessary to obtain a representative elasmobranch fauna.

Van de Geyn (1937) recorded a tooth of *Odontaspis winkleri* Leriche and one of *Galeocerdo* sp. from Late Eocene sediments in a well near Boekelo. Extensive autochthonous elasmobranch material from the Eocene of The Netherlands was recorded for the first time by van den Bosch (1980). He mentioned over thirty elasmobranch species from the Dongen Formation (Eocene) of NAM-boring De Wijk--19 in SW Drente. Unfortunately he did not describe or illustrate this material. Van den Bosch stated that it is possible to characterize the various Eocene deposits in The Netherlands by means of elasmobranch teeth.

In the present paper the autochthonous Eocene elasmobranch material now available from The Netherlands is described. The material from NAM-well De Wijk-19 is revised and new material from NAM-well Opende-1 and RGM-boring Haaksbergen 34G.2-8 is studied.

STRATIGRAPHY

Lithostratigraphy

The lithostratigraphical subdivision of the Eocene in The Netherlands used here is according to van Staalduinen et al. (1979) and Nederlandse Aardolie Maatschappij B.V. & Rijks Geologische Dienst (1980). This subdivision is not satisfactory, because the definitions of the units are vague and the subdivision could be more detailed. Furthermore topographic names used as the geographic component of formation or member names are repeated, which is against the recommendations of the International Stratigraphic Guide (Hedberg, 1976). In addition several names were borrowed or translated from Belgian stratigraphic nomenclature without the cerrtainty that the same lithostratigraphical units are involved. It is, however, the best existing lithostratigraphical classification for the Eocene in The Netherlands.

The Dongen Formation forms the upper part of the Lower North Sea Group. It includes all beds considered to be of Eocene age. It may reach a thickness of 400 metres and consists mainly of greenish-grey and brown, slightly calcareous clays, with an intercalated sand or marl unit. It overlies the marls and clays of the Landen Formation (Paleocene) or the chalks of the Ommelanden Chalk Formation (Turonian-Early Paleocene). The top of the Dongen Formation is marked by the unconformable contact with sands or clays of the Rupel Formation (Oligocene). In general a fourfold subdivision of the Dongen Formation can be recognized.

The Basal Dongen Sand Member is present in the southern part of The Netherlands and consists of a thin basal glauconitic sandstone bed. Northwards the Basal Dongen Tuffite Member represents a lateral equivalent of the Basal Dongen Sand Member. It consists of tuffaceous clays alternating with dark grey and reddish-brown clays, generally rich in pyritised frustules of *Coscinodiscus*-type diatoms. The deposition of this tuffaceous sequence is related to Early Eocene vulcanism occurring in the Rockall-Faeroe Trough and the present-day Skagerak area. It has a markedly widespread distribution throughout almost the entire North Sea Basin (Jacqué & Thouvenin, 1975). Therefore, and because it is considered to be essentially synchronous, it is a good marker horizon (Subgroup Lithostratigraphy and Maps, 1980).

The Ieper Clay Member is a sequence of dark grey and greenish grey, often slightly calcareous, commonly glauconitic clays.

The Brussels Sand Member consists of calcareous glauconitic sandstones with *Nummulites*. In a NW direction the grain sizes gradually diminish and the member is replaced by the Brussels Marl Member, consisting of greenish grey to brownish grey, silty, calcareous clays and marls.

The Asse Clay Member is a dark greenish grey, slightly calcareous clay sequence. It represents a Late Eocene southward penetration of the sea.

Two depocenters with maximal rates of subsidence are present. The northern one of these forms part of the N.-German-Danish Basin, while the southern depocentre was connected with the coeval marine depositional domain covering northern France, Belgium and southern England. These two depocentres are separated by a NW-SE trending high, located across the central Netherlands. Uplift and deep-cutting erosion in the central part of The Netherlands around the Eocene/Oligocene transition removed all Eocene deposits once present on this high (van Staalduinen et al., 1979).

Biostratigraphy

The microfossil biostratigraphy of the Dutch Eocene is based mainly on benthonic Foraminifera. Doppert (1975) established a biozonation for the Tertiary and lower Quaternary deposits of The Netherlands, based on changes in the composition of foraminiferal faunas. According to van Staalduinen et al. (1979), the basal beds of the Dongen Formation and the major part of the Ieper Clay Member are characterized by a foraminiferal assemblage diagnostic of the FI zone, which is considered to be of Early Eocene age. The uppermost layers of the Ieper Clay Member and the greater part of the Brussels Sand or Brussels Marl Member contain a foraminiferal assemblage indicative of the FH2 subzone. This subzone is considered to be of Middle Eocene age. The uppermost part of the Brussels Sand or Brussels Marl Member and the overlying Asse Clay Member contain a foraminiferal assemblage diagnostic of the FH1 subzone, which is considered to be of Late Eocene age Correlations of these foraminiferal zones with the standard chronostratigraphic scale are tentative, as they need confirmation by means of other fossil groups, e.g. calcareous nannofossils.

The foraminiferal biostratigraphy of the Dutch Tertiary was reviewed by Letsch & Sissingh (1983). They introduced a new unifying system of zonal Foraminifera Tertiary (FT) codes applicable to the onshore Tertiary of The Netherlands and northern Belgium. The FI zone, and FH2 and FH1 subzones of Doppert (1975) correspond respectively with the FT2, FT3 and FT4 zones of Letsch & Sissingh (1983).

LOCALITIES

NAM-Well De Wijk-19

Well De Wijk-19 of the Nederlandse Aardolie Maatschappij B.V.
Location: x = 216.898 y = 527.449 (fig. 1).
Boring method: flush drilling.
Date: September 1978.
Depths measured from RT, 7.29 m above surface level. Surface level at 2.22 m + NAP. Casing to 266.30 m-RT. Sampling by Mr M. van den Bosch. Samples are kept in the collection of the Rijksmuseum van Geologie en Mineralogie in Leiden, The Netherlands (RGM).

In this well, the Dongen Formation is present from 290 to 573 m-RT, which means a thickness of 283 m. It is underlain by limestones of the Ommelanden Chalk Formation and overlain by sands and clays of the Rupel Formation. For well section see fig. 2.

Description of the Dongen Formation

Asse Clay Member:

290-318 m Greenish-grey clay with intercalations of fine-grained sand. Locally rather much fine-grained glauconite is present. Scattered pyrite concretions and stems.

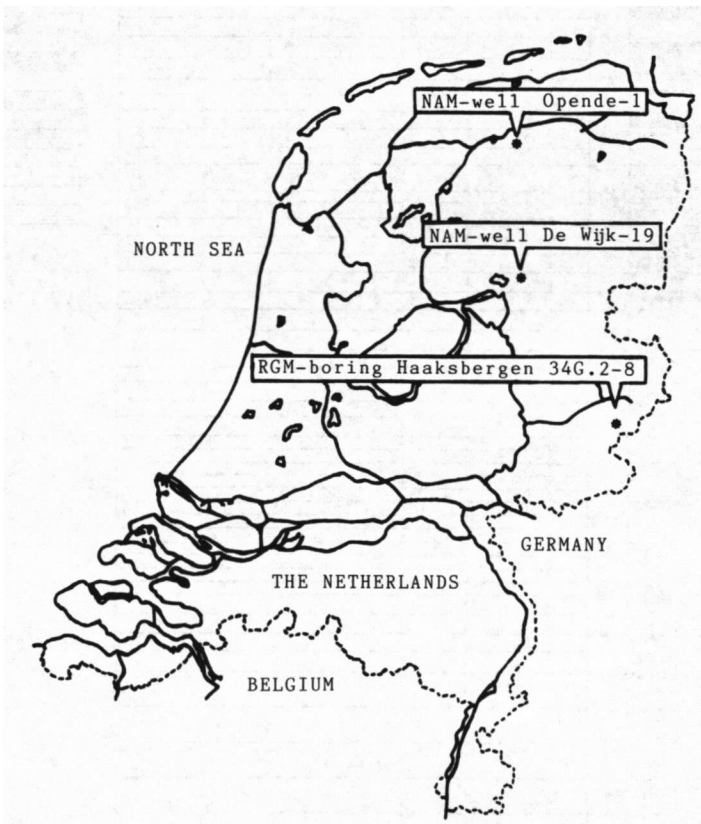


Fig. 1. Location of NAM-wells De Wijk-19 and Opende-1 and RGM-boring Haaksbergen 34G.2-8 in the NE part of The Netherlands.

Brussels Sand Member:

318-332 m Greenish-grey, sandy clay with rather much glauconite, some mica and some pyrite concretions. Many Foraminifera and molluscan shells are present. In the lower part light grey calcareous sandstone occurs with many Foraminifera and molluscan shells. At the base there is a layer with reworked shells, black elasmobranch teeth and phosphoritic concretions.

332-364 m Light grey calcareous sandstone with clayey and sandy intercalations. Locally rather much fine-grained glauconite and pyrite grains are present. Foraminifera and molluscan shells are common. Olive-grey phosphoritic concretions occur very frequently.

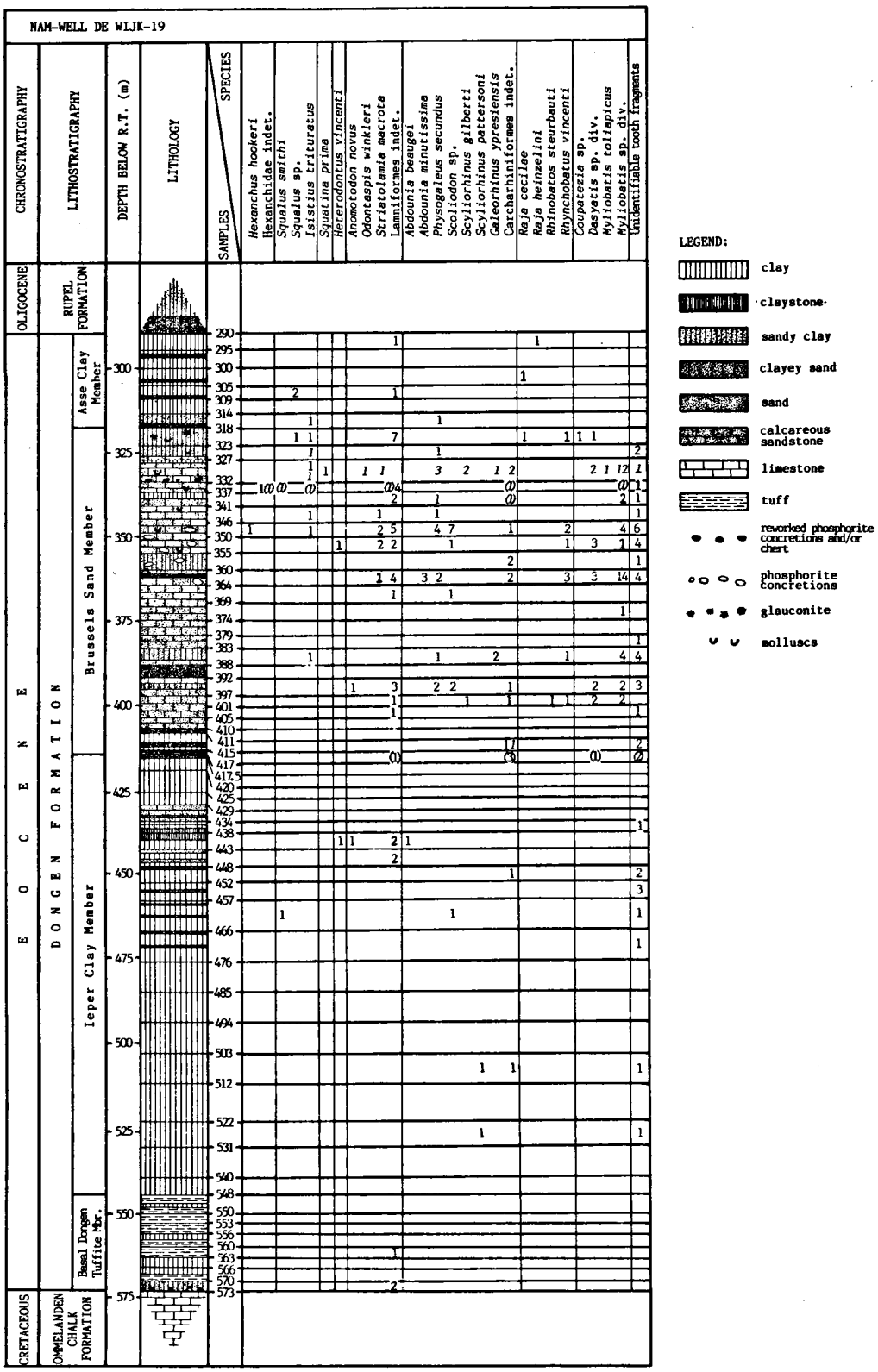


Fig. 2. Lithological section of the Dongen Formation (Eocene) and range chart of elasmobranch teeth in NAM-well De Wijk-19, The Netherlands. Reworked specimens in italics, caved specimens are placed in brackets.

364-415 m Light grey calcareous sandstone with sandy and clayey intervals. Some fine-grained glauconite and pyrite. Few molluscan shells and Foraminifera. A blackish basal gravel is present.

Ieper Clay Member:
415-494 m Grey to dark grey, sometimes calcareous clays. Locally thin intercalated claystone layers. From 429 to 448 m fine-grained calcareous sandstones and sandy intercalations occur.
494-548 m Almost non-calcareous, olive-grey clay.

Basal Dongen Tuffite Member:
548-573 m Dark grey to olive-grey clay with intercalations of olive-grey volcanic ash layers and tuffs. Some pyrite present. Slightly or non-calcareous. A slightly sandy, blackish basal gravel is present.

NAM-Well Opende-1

Well Opende-1 of the Nederlandse Aardolie Maatschappij B.V.
Location: x = 210.719 y = 575.281 (fig. 1).
Boring method: flush drilling.
Date: September 1979.

Depths measured from RT, 8.20 m above surface level. Surface level at 1.99 m + NAP. Casing to 506,70 m-RT. Sampling by Messrs M. van den Bosch and P.A.M. Gaemers. Samples are kept in the RGM-collection.

The Dongen Formation is present from 558 to 945 m-RT, so its thickness is 387 m. In this well, the Asse Clay Member is absent. The Dongen Formation is underlain by the Ommelanden Chalk Formation and overlain by the Rupel Formation. For well section see fig. 3.

Description of the Dongen Formation

Brussels Sand Member:
558-573 m Light bluish-grey calcareous clay with fine sand, some molluscan shells and Foraminifera.
573-626 m Light grey calcareous clay, clayey marl and light bluish grey, very fine-grained calcareous sandstone with rather little very fine glauconite. Molluscan shells and Foraminifera are present. Locally some pyrite and small, black non-reworked phosphorite concretions occur.
626-700 m Light grey calcareous clay and light bluish grey, very fine-grained calcareous sandstone with some very fine glauconite. The lower part is not calcareous.

Ieper Clay Member:
700-915 m Grey, heavy, laminated, slightly or not calcareous clay. Locally some thin claystone layers occur. The lower half shows a somewhat reddish shade and the clay is still heavier.

Basal Dongen Tuffite Member:
915-945 m Dark grey, very heavy, not or only slightly calcareous clay with many tuffite layers, especially in the uper part. Locally thin claystone layers are present.

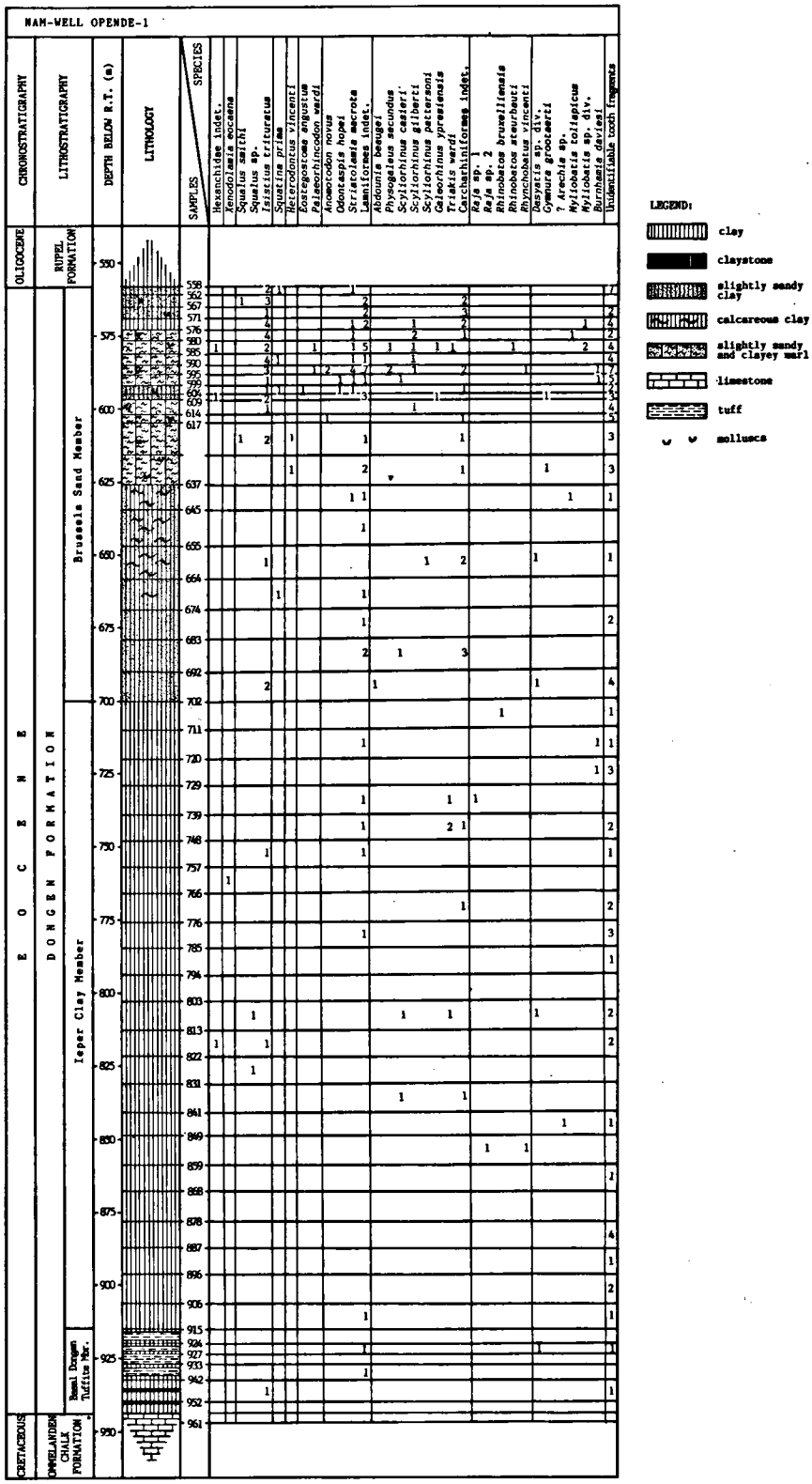


Fig. 3. Lithological section of the Dongen Formation (Eocene) and range chart of elasmobranch teeth in NAM-well Opende-1, The Netherlands.

RGM-Boring Haaksbergen 34G.2-8

Boring Haaksbergen 34G.2-8 of the Rijksmuseum van Geologie en Mineralogie.
Location: near the canteen of the shooting-range at Haaksbergen (fig. 1).
Boring-method: flush drilling.
Date: July-August 1982.

Depths measured from surface level. Casing to 10.15 m below surface level. Sampling by Mr M van den Bosch. Samples are kept in the RGM-collection.

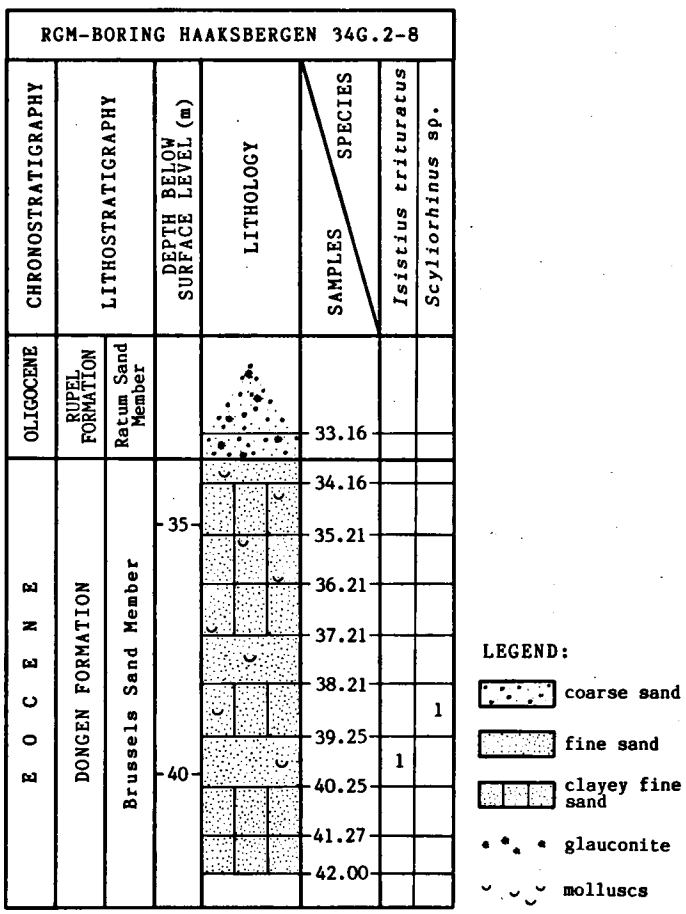


Fig. 4. Lithological section of the Dongen Formation (Eocene) and range chart of elasmobranch teeth in RGM-boring Haaksbergen 34G.2-8, The Netherlands.

In this boring, the Dongen Formation is present from 33.70 to 42.00 m. Unfortunately the base of the formation was not reached. The Dongen Formation is overlain subsequently by the Ratum and Brinkheurne Members of the Rupel Formation. For boring section see fig. 4.

Description of the Dongen Formation

Brussels Sand Member:

33.70-42.00 m Light greenish-grey, fine-grained, calcareous, clayey sand with many Foraminifera and Ostracoda. Some molluscan shells are present. Some mica and locally much glauconite is present.

COLLECTING TECHNIQUES

All borings from which samples were studied were drilled by means of flush drilling. The Tertiary intervals were drilled very carefully with a relatively low drilling rate to prevent caving and to assure the highest possible quality of the samples. From each sampled interval 10-15 kgs of drilling debris were collected. All the raw samples were frozen to speed up sediment desintegration, before being washed over a 150 μm mesh. The fractions coarser than 400 μm were investigated for elasmobranch teeth.

SYSTEMATIC PALEONTOLOGY

All material is housed in the RGM-collections. Specimens marked with an asterisk are most likely down-hole contamination by caving.

Order Hexanchiformes
Family Hexanchidae Gray, 1851
Genus *Hexanchus* Rafinesque, 1810

Hexanchus hookeri Ward, 1979
Pl. 1, fig. 1

1979 *Hexanchus hookeri* Ward, p. 115, pl. 1, figs 5-8.

Material — De Wijk-19, 346-350 m: 1 tooth (RGM 176 864).

Description — One small right upper-lateral tooth is present. The principal cusp is distinctly larger than the first distal cusplet and shows rather coarse serrations at the base of the mesial cutting edge. Three distal cusplets are present. The root is labio-lingually flattened and has a subrectangular outline.

Remarks — At present three *Hexanchus* species are known from the Eocene of NW Europe, viz. *H. agassizi* Cappetta, 1976, *H. collinsonae* Ward, 1979 and *H. hookeri* Ward, 1979. The distinction of these species is primarily based on differences in the lower antero-lateral teeth. The dentition of the former two species resembles the teeth of the extant species *H. griseus* (Bonnaterre, 1788), while *H. hookeri* more closely resembles the living species *H. vitulus* Springer & Waller, 1969. The present tooth resembles the upper-lateral teeth of *H. vitulus* in general morphology and is therefore assigned to the only "vituliform" *Hexanchus* species currently known from the Eocene of NW Europe, viz. *H. hookeri*.

Stratigraphic range — *Hexanchus hookeri* was recorded from the London Clay (Early Eocene) in England (Ward, 1979; 1980), where it is a rare species. The specimen described here obviously is much younger.

Hexanchidae indet.
Pl. 1, figs 2-3

Material — De Wijk-19, 332-337 m: 1 tooth (RGM 176 865) and 1 reworked tooth (RGM 176 866)*. Opende-1, 580-585 m: 1 tooth (RGM 176 867); 604-609 m: 1 tooth (RGM 176 868); 813-822 m: 1 tooth (RGM 176 869).

Description — Five tooth fragments have been recovered, showing one pair of more or less equally sized cusps, which are typical of the lower-lateral teeth of hexanchoid sharks. Two tooth fragments (RGM 176 865 and 176 867) show a principal cusp and one distal cusp. The principal cusp is barely larger than the first distal cusplet. In one specimen (RGM 176 865) the base of the mesial cutting edge shows a rather coarse serration, the mesial cutting edge of the other specimen (RGM 176 867) has an indistinct serration. The other three tooth fragments show only distal cusplets.

Remarks — The present material is too fragmentary for generic or specific identification. It probably belongs to one or more of the hexanchoid species known from the Eocene of England and Belgium: *Hexanchus agassizi* Cappetta, 1976, *H. collinsonae* Ward, 1979, *H. hookeri* Ward, 1979, *Weltonia burnhamensis* Ward, 1979, *Notorynchus serratissimus* (Agassiz, 1844) and *N. kempi* Ward, 1979.

Family uncertain
Genus *Xenodolamia* Leidy, 1877

Xenodolamia eocaena (Woodward, 1889)
Pl. 1, fig. 4

1889 *Carcharias* (*Scoliodon*) *eocaenus* Woodward, p. 436.
1905 *Xenodolamia eocaena* Woodward, 1889 - Leriche, p. 185, figs 54-60
1966 *Xenodolamia eocaena* (Woodward) - Casier, p. 48, pl. 1, figs 13-22.

Material — Opende-1, 757-766 m: 1 tooth (RGM 176 870).

Description — The crown is subtriangular in outline and lacks lateral cusplets. The apex is broken. The crown is flattened labio-lingually. Both lingual and labial faces are slightly convex, forming sharp cutting edges. The enamel is smooth. The root is subrectangular in outline, flattened labio-lingually and it shows a partially developed median groove (hemiaulacorhizoid).

Stratigraphical range — In England, this species is well-known from the London Clay (Early Eocene) (Casier, 1966; Ward, 1980). In Belgium, the species is recorded from the Ghlin Clay, Mons-en-Pévèle Sands (Early Eocene) and Wemmel Sands (Late Eocene) (Herman, 1979 and 1980). Locally it may be rather common in these deposits.

Order Squaliformes
Family Squalidae Bonaparte, 1834
Genus *Squalus* Linnaeus, 1758

Squalus smithi Herman, 1982
Pl. 1, figs 5-6

1982 *Squalus smithi* Herman, p. 3, pl. 1, figs 4-5

Material — De Wijk-19, 332-337 m: 1 reworked tooth (RGM 176 871)*; 457-466 m: 1 tooth (RGM 176 872). Opende-1, 562-567 m: 1 tooth (RGM 176 873); 617-627 m: 1 tooth (RGM 176 874).

Description — The mesial part of the teeth, which is located in front of the apron, is poorly developed. The apron is rather long and broad. The external face of the crown has a slightly lobulate base. Crenulations or serrations are absent. The root shape is quite regular.

Remarks — *Squalus minor* (Leriche, 1902) can be distinguished from *S. smithi* Herman, 1982 by the more elongated anterior part of the crown, a much more slender apron and a more lobulate labial base of the crown.

Stratigraphic range — In Belgium, *Squalus smithi* is known from the Forest Sands and Mons-en-Pévèle Sands (Early Eocene) where it is extremely rare. Locally it may be abundant in the Brussels Sands (Middle Eocene) (Herman, 1982). In Great Britain, the species is common in some horizons of the Early Eocene London Clay (Herman, 1982).

Squalus sp.
Pl. 1, figs 7-8

Material — De Wijk-19, 305-309 m: 2 teeth (RGM 176 875-176 876); 318-323 m: 1 tooth (RGM 176 877). Opende-1, 803-813 m: 1 tooth (RGM 176 878); 822-831 m: 1 tooth (TGM 176 879).

Description — Teeth characterized by a rather slender apron with a subrectangular outline. In other aspects they resemble *Squalus smithi* Herman, 1982.

PLATE 1

Fig. 1. *Hexanchus hookeri* Ward, 1979
Right upper-lateral tooth; labial view; × 6.
De Wijk-19, 346-350 m-RT, RGM 176 864.

Figs 2-3. Hexanchidae indet.
Lower-lateral teeth; labial views; × 6.
2. De Wijk-19, 332-337 m-RT, RGM 176 865. 3. Opende-1, 580-585 m-RT, RGM 176 867.

Fig. 4. *Xenodolamia eocaena* (Woodward, 1889)
4a labial, 4b lateral, 4c lingual views; × 6.
Opende-1, 757-766 m-RT, RGM 176 870.

Figs 5-6. *Squalus smithi* Herman, 1982
5a and 6 labial views, 5b lingual view; × 11.
5. De Wijk-19, 457-466 m-RT, RGM 176 872; 6. Opende-1, 562-567 m-RT, RGM 176 873.

Figs 7-8. *Squalus* sp.
Labial views; × 11.
7. De Wijk-19, 305-309 m-RT, RGM 176 875; 8. Opende-1, 822-831 m-RT, RGM 176 879.

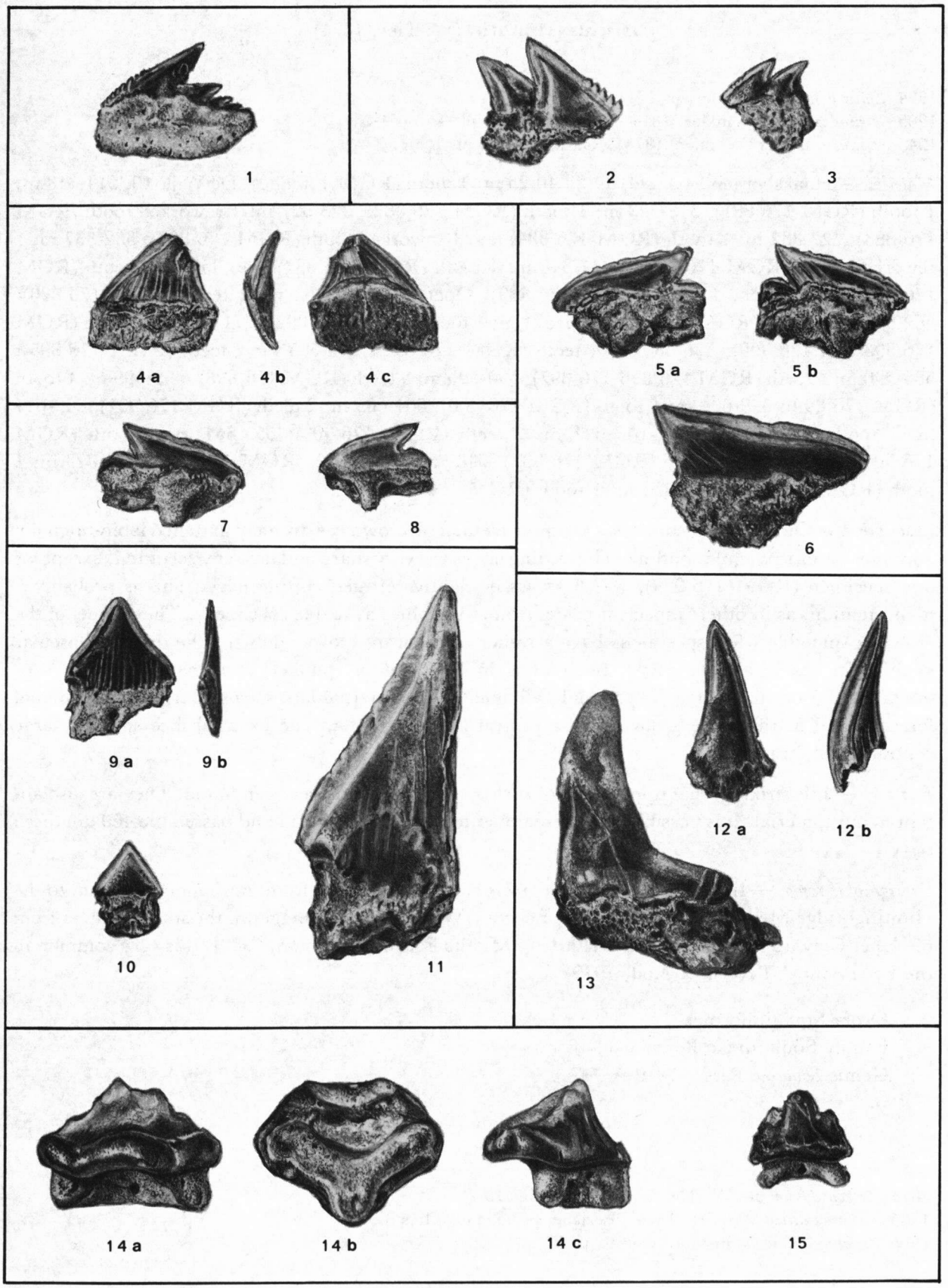
Figs 9-11. *Isistius trituratus* (Winkler, 1874)
Lower teeth; 9a, 10 and 11 labial, 9b lateral views; 9-10 × 6, 11 × 23.
9. De Wijk-19, 341-346 m-RT, RGM 176 887; 10. Opende-1, 585-590 m-RT, RGM 176 896; 11. Opende-1, 571-576 m-RT, RGM 176 909.
Note the slightly serrated cutting edge of the specimen in fig. 11.

Figs 12-13. *Squatina prima* Winkler, 1873)
12a and 13 labial, 12 b lateral views; 12 × 6, 13 × 24.
12. Opende-1, 558-562 m-RT, RGM 176 911; 13. Opende-1, 585-590 m-RT, RGM 176 912.

Figs 14-15. *Heterodontus vincenti* Leriche, 1905)
14 symphyseal tooth, 15 anterior tooth; 14a and 15 labial view, 14b basal, 14c lateral views; × 11.
14. Opende-1, 617-627 m-RT, RGM 176 915; 15. De Wijk-19, 350-355 m-RT, RGM 176 916.

All specimens from the Eocene Dongen Formation in the northeastern part of The Netherlands.

Plate 1



Genus *Isistius* Gill, 1864

Isistius trituratus (Winkler, 1874)
Pl. 1, figs 9-11

1874 *Corax trituratus* Winkler, p. 12, pl. 2, fig. 13.
1905 *Isistius trituratus* Winkler, 1874 - Leriche, p. 94, pl. 4, figs 1-2.
1946 *Isistius trituratus* (Winkler, 1874) - Casier, p. 50, pl. 1, fig. 7.

Material — Haaksbergen 34G.2-8, 39.25-40.25 m: 1 tooth (RGM 176 880). De Wijk-19, 314-318 m: 1 tooth (RGM 176 881); 318-323 m: 1 tooth (RGM 176 882); 323-327 m: 1 reworked tooth (RGM 176 883); 327-332 m: 1 tooth (RGM 176 884) and 1 reworked tooth (RGM 176 885); 332-337 m: 1 reworked tooth (RGM 176 886)*; 341-346 m: 1 tooth (RGM 176 887); 346-350 m: 1 tooth (RGM 176 888); 383-388 m: 1 tooth (RGM 176 889). Opende-1, 558-562 m: 2 teeth (RGM 176 890); 562-567 m: 3 teeth (RGM 176 891); 567-571 m: 1 tooth (RGM 176 892); 571-576 m: 4 teeth (RGM 176 893 and 176 909); 576-580 m: 4 teeth (RGM 176 894); 580-585 m: 2 teeth (RGM 176 895); 585-590 m: 4 teeth (RGM 176 896-176 897); 590-595 m: 3 teeth (RGM 176 898); 595-599 m: 1 tooth (RGM 176 899); 599-604 m: 1 tooth (RGM 176 900); 604-609 m: 2 teeth (RGM 176 901); 609-614 m: 1 tooth (RGM 176 902); 617-627 m: 2 teeth (RGM 176 903); 655-664 m: 1 tooth (RGM 176 904); 692-702 m: 2 teeth (RGM 176 905); 748-757 m: 1 tooth (RGM 176 906); 813-823 m: 1 tooth (RGM 176 907); 942-952 m: 1 tooth (RGM 176 908).

Description — Our material comprises 46 lower teeth. The crown is extremely flattened labio-lingually and shows a subtriangular outline. The cutting edges are very sharp and lack any serration, except for one specimen (RGM 176 909), which shows a slightly serrated cutting edge. This is probably a malformation, as in other respects it is identical to the other available specimens. The enamel of the crown is smooth. A few specimens have a rather transparant crown, showing the internal vascular system. In nearly all specimens, the root is broken, but in complete specimens, it has a subquadrangular outline and is flattened labio-lingually. The internal face shows a large central lingual foramen and a transverse groove with a central labial foramen. The external face shows a large central labial foramen.

Remarks — It is striking, that upper teeth of *Isistius trituratus* have never been found. They are also absent in our material. It is possible that these upper teeth were very small and passed the 400 µm mesh sieve.

Stratigraphic range — In England, *Isistius trituratus* has been recorded from the London Clay up to the Huntingbridge Member (Early to Middle Eocene) (Ward, 1980). In Belgium, the species ranges from the Ieper Clay up to the Lede Sands (Early to Middle Eocene) (Herman, 1980). It is very common in the Lede Sands (Taverne & Nolf, 1979).

Order Squatiniformes
Family Squatinidae Bonaparte, 1838
Genus *Squatina* Risso, 1810

Squatina prima (Winkler, 1873)
Pl. 1, figs 12-13

1873 *Trigonodus primus* Winkler, p. 13, pl. 1, figs 18-21.
1905 *Squatina prima* Winkler, 1874 - Leriche, p. 96, pl. 4, figs 3-5.
1966 *Squatina prima* (Winkler) - Casier, p. 57, pl. 2, figs 1-7.

Material — De Wijk-19, 327-332 m: 1 tooth (RGM 176 910). Opende-1, 558-562 m: 1 tooth (RGM 176 911); 585-590 m: 1 tooth (RGM 176 912); 599-604 m: 1 tooth (RGM 176 913); 664-674 m: 1 tooth (RGM 176 914).

Description — Five incomplete teeth are present. The root is broken in all specimens, but two of them still show a part of the roof-like root. The teeth have a relatively slender crown, which widens and thickens at the base. The labial face is extended basally to form an apron. The lateral cutting edges are mesio-distally extended on the root.

Remarks — *Squatina prima* co-occurs in the Belgian Eocene with *S. crassa* Daimeries, 1889. Teeth of the latter species are rather massive, their crown widens strongly at the base, and presents a very convex labial face. It is possible that in fact these teeth are senile morphotypes of *S. prima*.

Stratigraphic range — In Great Britain, *Squatina prima* ranges from the Thanet Formation up to the Barton Formation (Palaeocene to Late Eocene) (Ward, 1980). In Belgium, it is known from the Orp-le-Grand Sands up to the Lede Sands (Palaeocene-Middle Eocene) (Herman, 1980). It is nowhere very common.

Order Heterodontiformes
Family Heterodontidae Gray, 1851
Genus *Heterodontus* Blainville, 1816

Heterodontus vincenti (Leriche, 1905)
Pl. 1, figs 14-15

1905 *Cestracion Vincenti* Leriche, p. 112, pl. 5, figs 3-4.
1966 *Heterodontus vincenti* (Leriche) - Casier, p. 53, pl. 3, figs 4-5, 7-9.
1981 *Heterodontus* cf. *vincenti* (Leriche, 1905) - Cappetta & Nolf, p. 88, pl. 1, figs 1-2.

Material — De Wijk-19, 350-355 m: 1 tooth (RGM 176 916); 438-443 m: 1 tooth (RGM 176 917). Opende-1, 617-627 m: 1 tooth (RGM 176 915); 627-637 m: 1 tooth (RGM 176 918).

Description — Our material consists of one symphyseal tooth (RGM 176 915) and three anterior teeth (RGM 176 916-176 918). The symphyseal tooth is symmetrical, both crown and root are slightly asymmetrical in the anterior teeth. The principal cusp is rather wide and flanked by one pair of short, blunt lateral cusplets, which are situated rather far from the edge of the crown. The labial face of the crown shows a wide apron overhanging the root. The enamel of the lower part of the labial surface is irregular, but the remainder of the crown is smooth. The medio-lingual protuberance of the crown is well developed. The root is hemiaulacorhizoid. It is rather high and well developed in the lingual region, causing a V-shape of the root in basilar view. The basilar surface of the root shows one large central foramen, also up to four labial foramina are present. The lingual protuberance of the root presents a medio-lingual foramen. One or two pairs of latero-lingual foramina are situated next to this lingual protuberance.

Remarks — Two further *Heterodontus* species were described from the Eocene of Belgium and Great Britain: *H. woodwardi* Casier, 1946 and *H. wardenensis* Casier, 1966. Anterior teeth of *H. woodwardi* differ from those of *H. vincenti* by their more massive crown and root. The principal cusp is much wider and thicker and the lateral cusplets are strongly reduced. *H. wardenensis* can be distinguished from *H. vincenti* by the presence of two pairs of very well developed lateral cusplets next to the principal cusp.

Stratigraphic range — In England, *Heterodontus vincenti* ranges from the London Clay up to the Huntingbridge Member (Early to Middle Eocene) (Ward, 1980). In Belgium, it is known from the Brussels and Lede Sands (Middle Eocene) (Herman, 1980).

Order Orectolobiformes
Family Stegostomatidae Gill, 1862
Genus *Eostegostoma* Herman, 1977

Eostegostoma angustum Nolf & Taverne in Herman, 1977
Pl. 2, fig. 1

1977 *Eostegostoma angustum* (Nolf & Taverne) in Herman, p. 133, textfig. 4, pl. 1, fig. 3.
1979 *Eostegostoma angusta* Nolf & Taverne in Herman, 1977 - Taverne & Nolf, p. 127, fig. 2.

Material — Opende-1, 599-604 m: 1 tooth (RGM 176 919).

Description — Only one incomplete antero-lateral tooth is present. The root and both lateral cusplets are broken off. The junctions of these two lateral denticles with the principal cusp are still recognizable. The crown is very slender, both the labial and lingual face are strongly convex. The apron is very extended. The crown is asymmetrical, pointing both in a lingual and distal direction. The lateral cutting edges are sharp, but not very pronounced. The enamel lacks ornamentation.

Stratigraphic range — In Belgium, *Eostegostoma angustum* has been recorded from the Lede Sands and Wemmel Sands (Middle to Late Eocene) (Herman, 1977). Ward (1980) mentioned the species from the British Selsey Formation and Barton Clays (Middle to Late Eocene).

PLATE 2

Fig. 1. *Eostegostoma angustum* Nolf & Taverne in Herman, 1977
Antero-lateral tooth; 1a labial, 1b lateral view; × 6.
Opende-1, 599-604 m-RT, RGM 176 919.

Figs 2-3. *Palaeorhincodon wardi* Herman, 1975
2a and 3 labial views, 2b lateral view; × 11.
2. Opende-1, 580-585 m-RT, RGM 176 920; 3. Opende-1, 590-595 m-RT, RGM 176 921.

Figs 4-5. *Anomotodon novus* (Winkler, 1874)
4a and 5 labial views, 4b lingual view; 4 × 11, 5 × 6.
4. Opende-1, 590-595 m-RT, RGM 176 924; 5. Opende-1, 614-617 m-RT, RGM 176 926.

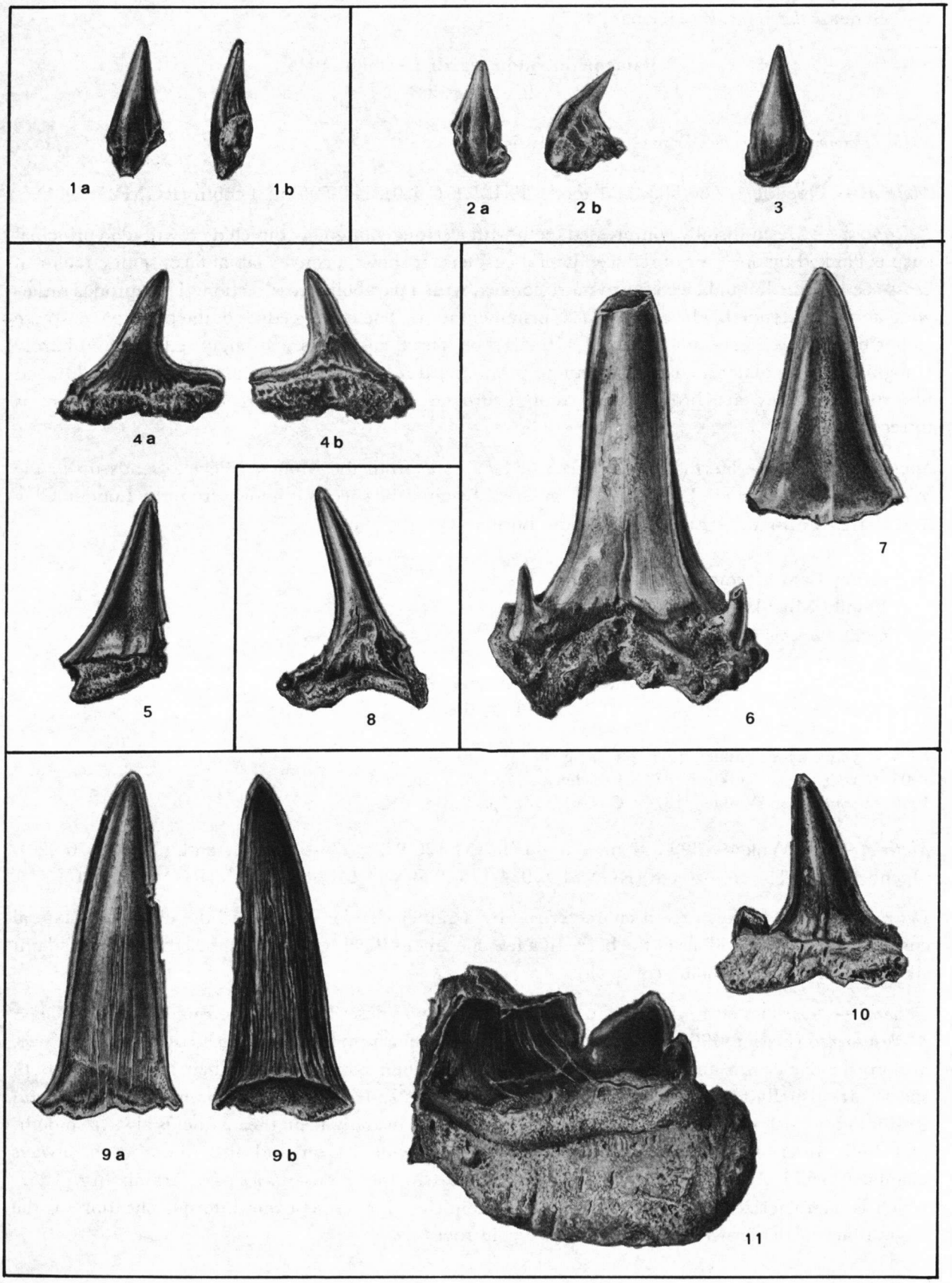
Figs 6-7. *Odontaspis hopei* (Agassiz, 1843)
Labial views; × 6.
6. Opende-1, 599-604 m-RT, RGM 176 928; 7. Opende-1, 595-599 m-RT, RGM 176 927.

Fig. 8. *Odontaspis winkleri* Leriche, 1905
Reworked tooth; labial view; × 6.
De Wijk-19, 327-332 m-RT, RGM 176 929.

Figs 9-11. *Striatolamia macrota* (Agassiz, 1843)
9 anterior tooth, 10-11 lateral teeth; 9a, 10 and 11 labial views, 9b lingual view; 9 × 2.5, 10 and 11 × 6.
9. De Wijk-19, 350-355 m-RT, RGM 176 934; 10. De Wijk-19, 346-350 m-RT, RGM 176 932; 11. De Wijk-19, 350-355 m-RT, RGM 176 935.

All specimens from the Eocene Dongen Formation in the northeastern part of The Netherlands.

Plate 2



Family Rhiniodontidae Müller & Henle, 1839
Genus *Palaeorhincodon* Herman, 1975

Palaeorhincodon wardi Herman, 1975
Pl. 1, figs 2-3

1975 *Palaeorhincodon wardi* Herman, p. 8, pl. 1, fig. 1.

Material — Opende-1, 580-585 m: 1 tooth (RGM 176 920); 590-595 m: 1 tooth (RGM 176 921).

Description — Mesio-distally compressed teeth with a strongly lingually directed crown. The principal cusp is flanked by one pair of reduced lateral cusplets. It shows a convex labial face, semi-circular in cross-section; the lingual face is even more convex, with a parabolic cross-section. The apron is rather wide and not extended. The enamel lacks ornamentation. The cutting edges of the principal cusp are rather blunt. In one specimen (RGM 176 921) the lateral cusplets are strongly reduced and hardly recognizable. The lateral cusplets are more pronounced in the other specimen (RGM 176 920), but unfortunately they are broken. The root is broken off in both specimens, so its structure is unrecognizable.

Stratigraphic range — Herman (1977) recorded *P. wardi* from the Mons-en-Pévèle Sands up to the Wemmel Sands (Early to Late Eocene). In Great Britain, the species is known from the London Clay and Earnly Formation (Early and Middle Eocene) (Ward, 1980).

Order Lamniformes
Family Mitsukurinidae Jordan, 1898
Genus *Anomotodon* Arambourg, 1952

Anomotodon novus (Winkler, 1874)
Pl. 2, figs 4-5

1874 *Oxyrhina nova* Winkler, p. 7, pl. 2, fig. 8.
1905 *Oxyrhina nova* Winkler, 1874 - Leriche, p. 127, pl. 7, figs 1-11.
1946 *Oxyrhina nova* Winkler, 1874 - Casier, p. 82, pl. 2, fig. 10.

Material — De Wijk-19, 392-397 m: 1 tooth (RGM 176 922); 438-443 m: 1 tooth (RGM 176 923). Opende-1, 590-595 m: 2 teeth (RGM 176 924-176 925); 614-617 m: 1 tooth (RGM 176 926).

Description — Lamniform teeth characterized by a rather slender crown and the absence of lateral cusplets. The crown widens at the base. In a few specimens the lingual face of the crown shows a faint striation. The root is holaulacorhizoid.

Remarks — A species closely related to *Anomotodon novus* was described from the English London Clay: *A. sheppeyensis* (Casier, 1966). The teeth of this species differ from those of *A. novus* by their larger size, a more slender crown and the presence of a quite pronounced striation on their lingual face. Both species are usually assigned to the genus *Oxyrhina* Agassiz, 1843, which is synonymous with *Isurus* Rafinesque, 1810. Cappetta (1976, p. 556) indicated that in *Isurus* teeth the enamel is always smooth, that both anterior and lateral teeth have a rather wide crown and that the root is always anaulacorhizoid. He therefore assigned both species to the genus *Anomotodon* Arambourg, 1952, which is characterized by teeth lacking lateral denticles, having a strong internal plication on the lingual face of the crown and a holaulacorhizoid root.

Stratigraphical range — In Great Britain, *Anomotodon novus* ranges from the Wittering Formation up to the Marsh Farm Formation (Early to Middle Eocene) (Ward, 1980). In Belgium, the species is known from the Erquelinnes Sands up to the Lede Sands (Palaeocene to Middle Eocene) (Herman, 1980).

Family Odontaspididae Müller & Henle, 1839
Genus *Odontaspis* Agassiz, 1836

Odontaspis hopei (Agassiz, 1843)
Pl. 1, figs 6-7

1843 *Lamna* (*Odontaspis*) *Hopei* Agassiz, p. 293, pl. 37a, figs 27-28, 30.
1946 *Odontaspis* (*Synodontaspis*) *hopei* (Agassiz, 1844) - Casier, p. 64, pl. 2, fig. 11.
1966 *Odontaspis* (*Synodontaspis*) *hopei* (Agassiz) - Casier, p. 68, pl. 4, figs 1-3.

Material — Opende-1, 595-599 m: 1 tooth (RGM 176 927); 599-604 m: 1 tooth (RGM 176 928).

Description — One incomplete anterior tooth (RGM 176 928) and the crown of a lower lateral tooth (RGM 176 927) are present. The first mentioned tooth shows a damaged apex and root. Next to the crown, a pair of rather slender, but not very extended lateral denticules are present. The crown widens at its base, but the lateral cutting edges remain subparallel at the labial face of the crown. The lingual face of the crown therefore is very convex. The lateral tooth presents a rather massive and low crown. Both specimens lack striation on the lingual face of the crown.

Stratigraphic range — *O. hopei* is known in Belgium from the Erquelinnes Sands up to the Wemmel Sands (Palaeocene to Late Eocene) (Herman, 1980). In Great Britain, it ranges from the Woolwich Bottom Bed up to the Barton Clay (Palaeocene to Late Eocene) (Ward, 1980).

Odontaspis winkleri Leriche, 1905
Pl. 2, fig. 8

1905 *Odontaspis Winkleri* Leriche, p. 117, pl. 6, figs 1-12.
1946 *Odontaspis* (*Synodontaspis*) *winkleri* Leriche, 1905 - Casier, p. 72, pl. 2, fig. 6.
1966 *Odontaspis* (*Synodontaspis*) *winkleri* Leriche - Casier, p. 72, pl. 5, figs 1-4.

Material — De Wijk-19, 327-332 m: 1 reworked tooth (RGM 176 929).

Description — The only available tooth has a black colour and it shows distinct traces of extensive post-mortem transport. The crown is very slender and elongated. The lingual face is strongly convex and smooth. The labial face of the crown shows short plications at its base. The lateral denticles are broken off. The root is holaulacorhizoid.

Stratigraphic range — In England, *Odontaspis winkleri* has been recorded from the London Clay up to the Barton Clay (Early to Late Eocene) (Ward, 1980). It ranges in Belgium from the Forest Sands up to the Wemmel Sands (Early to Late Eocene) (Herman, 1980).

Genus *Striatolamia* Glyckman, 1964

Striatolamia macrota (Agassiz, 1843)
Pl. 2, figs 9-11

1843 *Otodus macrotus* Agassiz, p. 273, pl. 32, figs 29-31.
1946 *Odontaspis* (*Synodontaspis*) *macrota* (Agassiz, 1843) - Casier, p. 66, pl. 2, fig. 2.
1981 *Striatolamia macrota* (Agassiz, 1843) - Cappetta & Nolf, p. 90, pl. 1, figs 4-7.

Material — De Wijk-19, 327-332 m: 1 reworked tooth (RGM 176 930); 341-346 m: 1 tooth (RGM 176 931); 346-350 m: 2 teeth (RGM 176 932-176 933); 350-355 m: 2 teeth (RGM 176 934-176 935); 360-364 m: 1 tooth (RGM 176 936). Opende-1, 558-562 m: 1 tooth (RGM 176 937); 571-576 m: 1 tooth (RGM 176 938); 576-580 m: 1 tooth (RGM 176 939); 580-585 m: 1 tooth (RGM 176 940); 585-590 m: 1 tooth (RGM 176 941); 590-595 m: 4 teeth (RGM 176 942); 595-599 m: 1 tooth (RGM 176 943); 599-604 m: 1 tooth (RGM 176 944); 637-645 m: 1 tooth (RGM 176 945).

Description — The present material is rather fragmentary. In all specimens, the crown shows the very characteristic strong lingual striation. The lateral cusplets are blunt and rounded in lateral teeth.

Stratigraphic range — *Striatolamia macrota* is a common species in all Eocene deposits in NW Europe.

Lamniformes indet.

Material — De Wijk-19, 290-295 m: 1 tooth (RGM 176 946); 305-309 m: 1 tooth (RGM 176 947); 318-323 m: 7 teeth (RGM 176 948); 332-337 m: 1 reworked tooth (RGM 176 949)* and 4 teeth (RGM 176 950); 337-341 m: 2 teeth (RGM 176 951); 346-350 m: 5 teeth (RGM 176 952); 350-355 m: 2 teeth (RGM 176 953); 360-364 m: 4 teeth (RGM 176 954); 364-369 m: 1 tooth (RGM 176 955); 392-397 m: 3 teeth (RGM 176 956); 397-401 m: 1 tooth (RGM 176 957); 401-405 m: 1 tooth (RGM 176 958); 415-417 m: 1 tooth (RGM 176 959); 438-443 m: 2 teeth (RGM 176 960); 443-448 m: 2 teeth (RGM 176 961); 560-563 m: 1 tooth (RGM 176 962); 570-573 m: 2 reworked teeth (RGM 176 963). Opende-1, 562-567 m: 2 teeth (RGM 176 964); 567-571 m: 2 teeth (RGM 176 965);

PLATE 3

Fig. 1. *Abdounia beaugei* (Arambourg, 1935)
1a labial, 1b lingual view; × 6.
Opende-1, 692-702 m-RT, RGM 176 988.

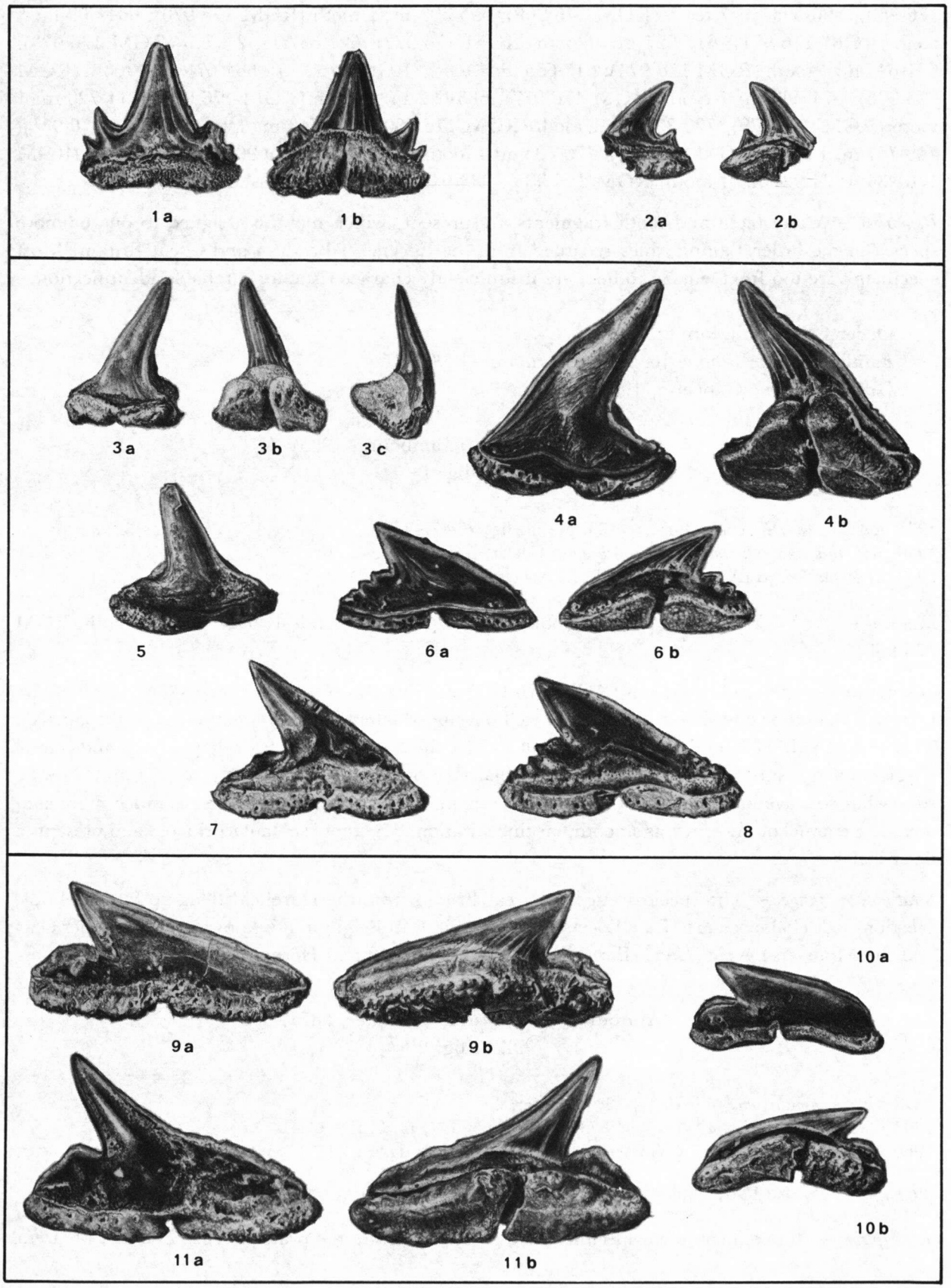
Fig. 2. *Abdounia minutissima* (Winkler, 1873)
2a labial, 2b lingual view; × 6.
De Wijk-19, 360-364 m-RT, RGM 176 989.

Figs. 3-8. *Physogaleus secundus* (Winkler, 1874)
3-5 anterior teeth, 6-8 lateral teeth; 3a, 4a, 5, 6a, 7 and 8 labial, 3c lateral, 3b and 4b lingual views; × 6.
3. De Wijk-19, 360-364 m-RT, RGM 176 999; 4. De Wijk-19, 314-318 m-RT, RGM 176 991; 5. De Wijk-19, 360-364 m-RT, RGM 176 000; 6. De Wijk-19, 323-327 m-RT, RGM 176 992; 7. De Wijk-19, 346-350 m-RT, RGM 176 996; 8. De Wijk-19, 346-350 m-RT, RGM 176 997.

Figs 9-11. *Scoliodon* sp.
Lateral teeth; 9a, 10a and 11a labial, 9b, 10b, 11b lingual views; × 11.
9. De Wijk-19, 346-350 m-RT, RGM 177 005; 10. De Wijk-19, 346-350 m-RT, RGM 177 008; 11. De Wijk-19, 346-350 m-RT, RGM 177 006.

All specimens from the Eocene Dongen Formation in the northeastern part of The Netherlands.

Plate 3



571-576 m: 2 teeth (RGM 176 966); 580-585 m: 5 teeth (RGM 176 967); 585-590 m: 1 tooth (RGM 176 968); 590-595 m: 7 teeth (RGM 176 969); 595-599 m: 1 tooth (RGM 176 970); 604-609 m: 3 teeth (RGM 176 971); 617-627 m: 1 tooth (RGM 176 972); 627-637 m: 2 teeth (RGM 176 973); 637-645 m: 1 tooth (RGM 176 974); 645-655 m: 1 tooth (RGM 176 975); 664-674 m: 1 tooth (RGM 176 976); 674-683 m: 1 tooth (RGM 176 977); 683-692 m: 2 teeth (RGM 176 978); 711-720 m: 1 tooth (RGM 176 979); 729-739 m: 1 tooth (RGM 176 980); 739-748 m: 1 tooth (RGM 176 981); 748-757 m: 1 tooth (RGM 176 892); 776-785 m: 1 tooth (RGM 176 983); 906-915 m: 1 tooth (RGM 176 984); 924-927 m: 1 tooth (RGM 176 985); 933-942 m: 1 tooth (RGM 176 986).

Remarks — Many teeth and tooth fragments are present, which may be assigned to one or more species in the order Lamniformes recorded from the Eocene of Belgium and Great Britain. Most specimens are too fragmentary, others are insufficiently characteristic for a reliable identification.

Order Carcharhiniformes
Family Carcharhinidae Jordan & Evermann, 1896
Genus *Abdounia* Cappetta, 1980

Abdounia beaugei (Arambourg, 1935)
Pl. 3, fig. 1

1935 *Eugaleus beaugei* Arambourg, p. 123, pl. 23, figs 20-47.
1946 *Scyliorhinus minutissimus* var. *biauriculatus* Casier, p. 57, pl. 1, fig. 6.
1980 *Abdounia beaugei* (Arambourg, 1935) - Cappetta, p. 36, fig. 4.

Material — De Wijk-19, 438-443 m: 1 tooth (RGM 176 987). Opende-1, 692-702 m: 1 tooth (RGM 176 988).

Description — One tooth fragment (RGM 176 987) and one complete specimen (RGM 176 988) are present. The latter one shows two pairs of well developed lateral cusplets next to the principal cusp. The second pair of lateral denticles is smaller than the first pair. Both principal cusp and lateral cusplets have a subtriangular outline. The labial face of the crown is slightly convex and shows a somewhat concave basal outline. It does not overhang the root. The lingual face is much more convex. The enamel of the crown is smooth, lacking striation. The root is holaulacorhizoid and presents a flat basal surface.

Stratigraphic range — The species ranges in great Britain from the Harefield Beds up to the Middle Headon Beds (Palaeocene to Late Eocene) (Ward, 1980). In Belgium, it is known from the Ieper Clay and the Mons-en-Pévèle Sands (Early Eocene) (Casier, 1946 and Herman, 1980).

Abdounia minutissima (Winkler, 1873)
Pl. 3, fig. 2

1873 *Otodus minutissimus* Winkler, p. 3, pl. 1, fig. 2.
1905 *Scyllium minutissimum* Winkler, 1873 - Leriche, p. 113, pl. 5, figs 14-41.
1966 *Scyliorhinus minutissimus* (Winkler) - Casier, p. 66, pl 3, figs 21-22.

Material — De Wijk-19, 360-364 m: 3 teeth (RGM 176 989-176 990).

Description — Three incomplete specimens are present. Next to the principal cusp one pair of lateral

cusplets is present. The principal cusp and the lateral cusplets have a subtriangular outline. The labial face of the crown is slightly convex and does not overhang the root, the lingual face is convex. Short, faint striations are present on the lingual face of the lateral denticles and the latero-basal region of the labial face of the crown. The root is holaulacorhizoid and has a flat basal surface.

Remarks — Teeth of *Abdounia minutissima* may be separated from those of *A. beaugei* (Arambourg, 1935) by the following characteristics: the principal cusp of *A. minutissima* is slightly wider, only one pair of lateral denticles is present, and short striae are present on the lingual face of these lateral denticles and the latero-basal region of the labial face of the crown. This striation is usually much more pronounced than in the present material, but this may be due to intraspecific variation.

Stratigraphic range — *A. minutissima* ranges in Belgium from the Forest Sands up to the Lede Sands (Early to Middle Eocene) (Herman, 1980), in which it is a rather common species. Ward (1980) recorded the species in England from the Marsh Farm and Selsey Formations (Middle Eocene).

Genus *Physogaleus* Cappetta, 1980

Physogaleus secundus (Winkler, 1874)
Pl. 3, figs 3-8

1874 *Trigonodus secundus* Winkler, p. 5, pl. 1, figs 4-5.
1905 *Carcharias (Physodon) secundus* Winkler, 1874 - Leriche, p. 132, pl. 8, figs 1-8.
1980 *Physogaleus secundus* (Winkler, 1874) - Cappetta, p. 38, fig. 5.

Material — De Wijk-19, 314-318 m: 1 tooth (RGM 176 991); 323-327 m: 1 tooth (RGM 176 992); 327-332 m: 3 reworked teeth (RGM 176 993); 337-341 m: 1 tooth (RGM 176 994); 341-346 m: 1 tooth (RGM 176 995); 346-350 m: 4 teeth (RGM 176 996-176 998); 360-364 m: 2 teeth (RGM 176 999-177 000); 383-388 m: 1 tooth (RGM 177 001); 392-397 m: 2 teeth (RGM 177 002). Opende-1, 580-585 m: 1 tooth (RGM 177 003); 590-595 m: 2 teeth (RGM 177 004).

Description — Anterior and lateral teeth are present. The former are strongly compressed mesio-distally, having a slender and sigmoidal principal cusp, which is slightly inclined towards the commissure. The lingual face of the crown is strongly convex. The base of the mesial cutting edge may bear some fine serrations and a rounded distal cusplet may be present. The root is massive and shows a very well developed lingual protuberance. The basal face of the root is flat and has a median groove. In more laterally situated teeth, the principal cusp flattens and inclines increasingly towards the commissure. Up to four distal cusplets are present in lateral teeth and the lower part of the mesial cutting edge is serrated. The lingual protuberance of the root flattens towards the commissure.

Stratigraphic range — Ward (1980 and pers. comm.) recorded *Physogaleus secundus* in England from the London Clay up to the Middle Headon Beds (Early to Late Eocene). In Belgium, the species ranges from the Ieper Clay up to the Lede Sands (Early to Middle Eocene) (Herman, 1980). It is possible, that in literature this species has been confused with *Scoliodon* sp.

Genus *Scoliodon* Müller & Henle, 1837

Scoliodon sp.
Pl. 3, figs 9-11

1981 *Scoliodon* aff. *ganntourensis* Arambourg, 1952 - Cappetta & Nolf, p. 91, pl. 1, figs 8-18.

Material — De Wijk-19, 346-350 m: 7 teeth (RGM 177 005-177 009); 350-355 m: 1 tooth (RGM 177 010); 364-369 m: 1 tooth (RGM 177 011); 392-397 m: 2 teeth (RGM 177 012); 457-466 m: 1 tooth (RGM 177 013).

Description — The present material comprises only lateral teeth. The crown is directed strongly towards the commissure. Upper lateral teeth have a slightly broader principal cusp than those from the lower rows and a convex instead of a concave mesial cutting edge. The mesial cutting edge does not show any serration. One rather large distal cusplet is present, showing a convex and sometimes slightly irregular outline. Both labial and lingual faces are convex. The lingual face is smooth, the labial face may have a faint basal striation. The basal surface of the root is flat and shows an oblique and wide median groove, bearing a rather large central foramen.

Remarks — Only one *Scoliodon* species was described from the Eocene, namely *Scoliodon ganntourensis* Arambourg, 1952 from the Lutetian of the Ganntour Basin in Morocco. Teeth of this species differ from the present specimens by having a broader principal cusp, a generally concave mesial cutting edge, whereas the angle between the two lobes of the root usually is more acute.

The present teeth are identical with those described by Cappetta & Nolf (1981) as *Scoliodon* aff. *ganntourensis* from the Late Eocene of the Paris Basin.

Stratigraphic range — Up to now *Scoliodon* sp. has not been described from the British and Belgian Palaeogene, because it has been confused with *Physogaleus secundus* (Winkler, 1874). In England, *Scoliodon* sp. ranges from the Wittering Formation up to the Hamstead Beds (Early Eocene to Oligocene) (Ward, pers. comm.).

Family Scyliorhinidae Gill, 1862
Genus *Scyliorhinus* Blainville, 1816

Scyliorhinus casieri Cappetta, 1976
Pl. 4, fig. 1

1966 *Scyliorhinus* sp. - Casier, p. 67, pl. 3, figs 29-30.
1976 *Scyliorhinus casieri* Cappetta, p. 558, pl. 3, figs 3-6.

Material — Opende-1, 595-599 m: 1 tooth (RGM 177 014); 683-692 m: 1 tooth (RGM 177 015); 803-813 m: 1 tooth (RGM 177 016); 831-841 m: 1 tooth (RGM 177 017).

Description — Small teeth with a slender and elongated principal cusp. The labial and lingual faces of the crown have some pronounced plications which may reach the apex. The labial face is slightly convex, the lingual face is strongly convex. One pair of lateral cusplets is present next to the principal cusp, but unfortunately these cusplets are broken in most specimens. One specimen (RGM 177 015) still shows one very pronounced and elongated lateral cusplet, having more than half the length of the principal cusp. This lateral cusplet also shows a few pronounced striations. The lateral denticles are situated more labially with respect to the principal cusp, causing a depressed medio-basal region of the crown. The root is holaulacorhizoid. Its basal surface is rather large and flat, and shows a pronounced median groove.

Stratigraphic range — Up to now *Scyliorhinus casieri* was only known from the London Clay (Early Eocene) in England (Cappetta, 1976 and Ward, 1980).

Scyliorhinus gilberti Casier, 1946
Pl. 4, figs 2-4

1946 *Scyliorhinus gilberti* Casier, p. 58, pl. 1, fig. 14.
1976 *Scyliorhinus gilberti* Casier, 1946 - Cappetta, p. 559.
1981 *Scyliorhinus gilberti* Casier, 1976 - Cappetta & Nolf, p. 93, pl. 2, fig. 13.

Material — De Wijk-19, 327-332 m: 2 reworked teeth (RGM 177 018); 397-401 m: 1 tooth (RGM 177 019). Opende-1, 571-576 m: 1 tooth (RGM 177 020); 576-580 m: 2 teeth (RGM 177 021-177 022); 580-585 m: 1 tooth (RGM 177 023); 585-590 m: 1 tooth (RGM 177 024); 590-595 m: 1 tooth (RGM 177 025); 609-614 m: 1 tooth (RGM 177 026).

Descriptions — One or two pairs of lateral cusplets are present next to the principal cusp. These lateral cusplets are rather wide and not very extended. The second pair of lateral cusplets is always strongly reduced in size. The labial face of the crown slightly overhangs the root, and the basal part shows a striation. The degree of striation is highly variable. The lingual face of the crown shows some faint striations. The labial face of the crown has a straight or convex basal outline. The root is holaulacorhizoid.

Stratigraphic range — In Belgium, the species was recorded from the Ieper Clay up to the Lede Sands (Early to Middle Eocene) (Taverne & Nolf, 1979 and Herman, 1980). In England, it ranges from the Woolwich Bottom Bed to the Huntingbridge Member (Palaeocene to Middle Eocene) (Ward, 1980).

Scyliorhinus pattersoni Cappetta, 1976
Pl. 4, fig. 5

1966 *Scyliorhinus* aff. *gilberti* Casier - Casier, p. 67, pl. 3, figs 26-28.
1976 *Scyliorhinus pattersoni* Cappetta, p. 559, pl. 4, fig. 1-5.

Material — De Wijk-19, 503-512 m: 1 tooth (RGM 177 027); 522-531 m: 1 tooth (RGM 177 028). Opende-1, 655-664 m: 1 tooth (RGM 177 029).

Description — Two fragmentary teeth and one complete specimen (RGM 177 028) are present. The latter tooth shows two pairs of reduced lateral cusplets next to the principal cusp. The labial face of the crown is rather flat and presents a concave basal outline and a very pronounced basal plication. The lingual face of the crown is striated. The lingual face of the principal cusp is strongly convex. The cutting edges of the principal cusp are sharp and concave in labio-lingual view. The base of the root is wide and flat, and bears a not completely developed median groove.

Remarks — Teeth of *Scyliorhinus pattersoni* resemble those of *S. gilberti* Casier, 1946 in general morphology, but the species can be separated on the following characteristics: the crown of the former is generally smaller, the lingual face of the principal cusp is more convex, the lateral denticles are less well developed and more slender, and the labial face of the crown presents a concave basal outline.

Stratigraphic range — *Scyliorhinus pattersoni* has been recorded from the English Eocene only, where it ranges from the London Clay up to the Barton Clay (Ward, 1980).

Scyliorhinus sp.
Pl. 4, fig. 6

Material — Haaksbergen 34G.2-8, 38.21-39.25 m: 1 tooth (RGM 177 030).

Sescription — Next to the principal cusp of the crown, one pair of well developed and one pair of very reduced lateral cusplets is present. The labial face of the crown is convex and shows a bilobate basal outline. A labial basal striation is present, a few striae extend to the lateral denticles. The lingual face is very convex and shows a striation, which is very pronounced at the crown/root junction. The principal cusp shows concave cutting edges in labio-lingual view. The root is damaged, so its structure is unknown, unfortunately.

Remarks — The present tooth cannot be assigned to one of the several *Scyliorhinus* species described from the Eocene of NW Europe. It shows some affinities with the above described *Scyliorhinus pattersoni*, from which it differs by its larger size, the more developed lateral denticles and its more massive appearance.

Family Triakidae Gray, 1851
Genus *Galeorhinus* Blainville, 1816

Galeorhinus ypresiensis (Casier, 1946)
Pl. 4, figs 7-8

1946 *Eugaleus ypresiensis* Casier, p. 86, pl. 1, fig. 11.
1979 *Galeorhinus* sp. (? aff. *ypresiensis* Casier, 1946) - Taverne & Nolf, p. 130, fig. 5.

PLATE 4

Fig. 1. *Scyliorhinus casieri* Cappetta, 1976
1a labial, 1b lateral, 1c lingual view; × 23.
Opende-1, 595-599 m-RT, RGM 177 014.

Figs 2-4. *Scyliorhinus gilberti* Casier, 1946
2a, 3a and 4 labial, 3b lateral, 2b and 3c lingual views; × 11.
2. Opende-1, 590-595 m-RT, RGM 177 025; 3. Opende-1, 571-576 m-RT, RGM 177 020; 4. Opende-1, 576-580 m-RT, RGM 177 021.

Fig. 5. *Scyliorhinus pattersoni* Cappetta, 1976
5a labial, 5b lateral, 5c lingual view; × 23.
De Wijk-19, 522-531 m-RT, RGM 177 028.

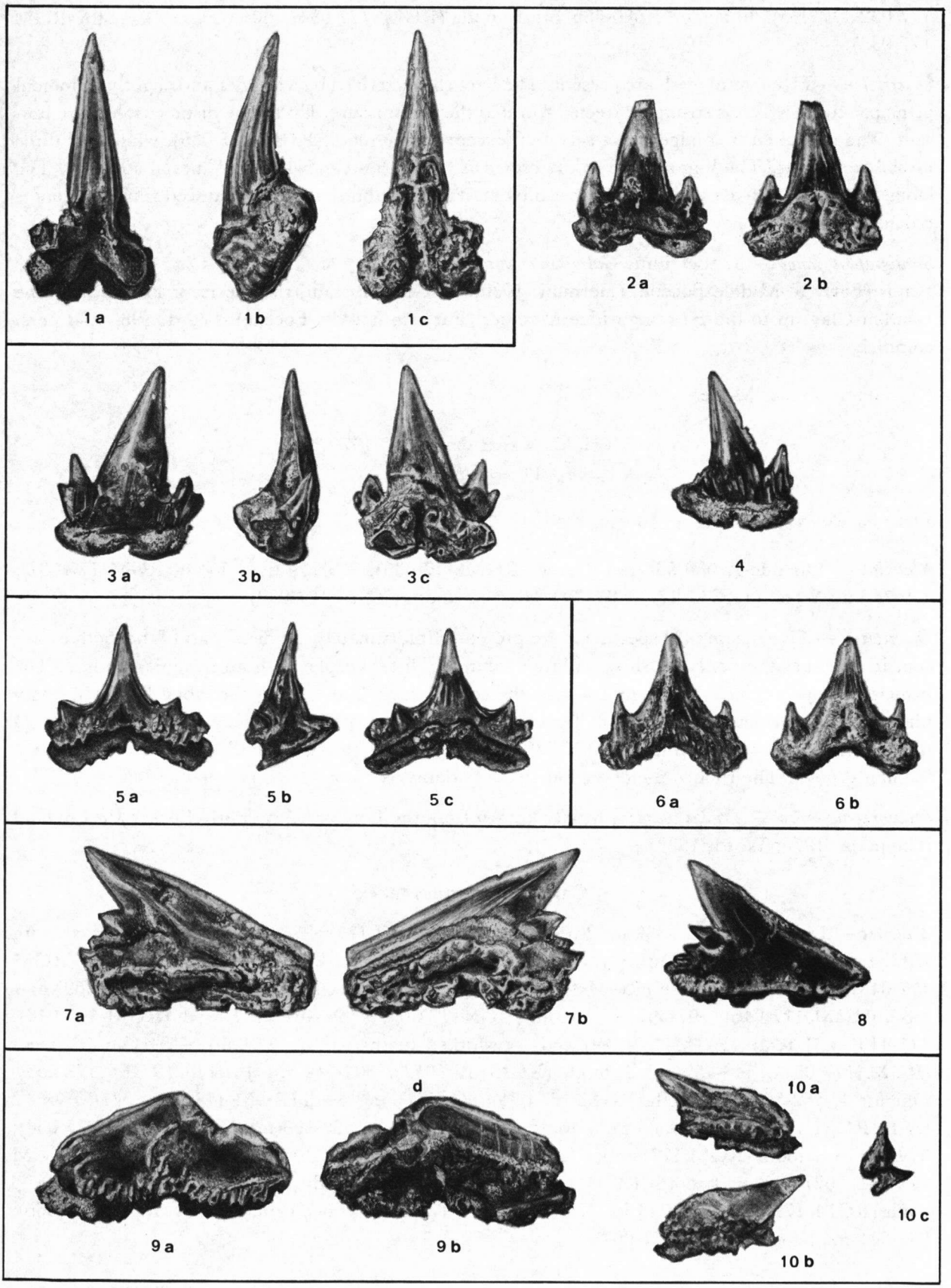
Fig. 6. *Scyliorhinus* sp.
6a labial, 6b lingual view; × 23.
Haaksbergen 34G.2-8, 38.21-39.25 m, RGM 177 030.

Figs 7-8. *Galeorhinus ypresiensis* (Casier, 1946)
Lateral teeth; 7a and 8 labial views, 7b lingual view; × 11.
7. De Wijk-19, 383-388 m-RT, RGM 177 033; 8. De Wijk-19, 383-388 m-RT, RGM 177 032.

Figs 9-10. *Triakis wardi* Cappetta, 1976
9a and 10a labial, 10c lateral, 9b and 10b lingual views; × 23.
9. Opende-1, 580-585 m-RT, RGM 177 036; 10. Opende-1, 803-813 m-RT, RGM 177 039.

All specimens from the Eocene Dongen Formation in the northeastern part of The Netherlands.

Plate 4



Material — De Wijk-19, 327-332 m: 1 reworked tooth (RGM 177 031); 383-388 m: 2 teeth (RGM 177 032-177 033). Opende-1, 580-585 m: 1 tooth (RGM 177 034); 604-609 m: 1 tooth (RGM 177 035).

Description — Five lateral teeth are present. They are characterized by a slender and slightly sigmoidal principal cusp, which is strongly directed towards the commissure. Up to five distal cusplets are present. The mesial cutting edge is not serrated, except in one tooth (RGM 177 035), which has three mesial serrations. The lingual face of the crown is convex and shows a faint mesial striation. The labial face is less convex and basally limited by an irregular and slightly pronounced rim. The root is holaulacorhizoid.

Stratigraphic range — In Belgium, *Galeorhinus ypresiensis* ranges from the Ieper Clay up to the Lede Sands (Early to Middle Eocene) (Herman, 1980). In Great Britain, the species is known from the London Clay up to the Huntingbridge Member (Early to Middle Eocene) (Ward, 1980 and pers. comm.).

Genus *Triakis* Müller & Henle, 1838

Triakis wardi Cappetta, 1976
Pl. 4, figs 9-10

1976 *Triakis wardi* Cappetta, p. 561, pl. 2, figs 9-15.

Material — Opende-1, 580-585 m: 1 tooth (RGM 177 036); 729-739 m: 1 tooth (RGM 177 037); 739-748 m: 2 teeth (RGM 177 038); 803-813 m: 1 tooth (RGM 177 039).

Description — Five incomplete specimens are present. Unfortunately the distal part of the tooth is present in one specimen only. It shows a large, rounded distal cusplet with an irregular outline. The principal cusp is directed strongly towards the commissure. The base of the labial face is strongly plicated and overhangs the root. The lingual face shows a striation, especially on the mesial part of the crown. In one specimen (RGM 177 039) the root has an enlarged, flat basal surface, bearing a median groove. The root of the other four teeth is damaged.

Stratigraphic range — *Triakis wardi* was only known from the London Clay (Early Eocene) in England (Cappetta, 1976; Ward, 1980).

Carcharhiniformes indet.

Material — De Wijk-19, 327-332 m: 2 reworked teeth (RGM 177 040); 332-337 m: 1 reworked tooth (RGM 177 041)*; 337-341 m: 1 reworked tooth (RGM 177 042)*; 346-350 m: 1 tooth (RGM 177 043); 355-360 m: 2 teeth (RGM 177 044); 360-364 m: 2 teeth (RGM 177 045); 364-369 m: 1 tooth (RGM 177 046); 392-397 m: 1 tooth (RGM 177 047); 397-401 m: 1 tooth (RGM 177 048); 411-415 m: 1 tooth (RGM 177 049) and 1 reworked tooth (RGM 177 050); 415-417 m: 3 teeth (RGM 177 051); 448-452 m: 1 tooth (RGM 177 052); 503-512 m: 1 tooth (RGM 177 053). Opende-1, 562-567 m: 2 teeth (RGM 177 054); 567-571 m: 3 teeth (RGM 177 055); 571-576 m: 2 teeth (RGM 177 056); 576-580 m: 1 tooth (RGM 177 057); 590-595 m: 2 teeth (RGM 177 058); 599-604 m: 1 tooth (RGM 177 059); 614-617 m: 1 tooth (RGM 177 060); 617-627 m: 1 tooth (RGM 177 061); 627-637 m: 1 tooth (RGM 177 062); 655-664 m: 2 teeth (RGM 177 063); 683-692 m: 3 teeth (RGM 177 064); 739-748 m: 1 tooth (RGM 177 065); 766-776 m: 1 tooth (RGM 177 066); 831-841 m: 1 tooth (RGM 177 067).

Remarks — The present teeth are too incomplete for a definite assignment. Most specimens probably belong to the genera *Physogaleus* Cappetta, 1980, *Scoliodon* Müller & Henle, 1837 or *Galeorhinus* Blainville, 1816.

Order Rajiformes
Family Rajidae Bonaparte, 1831
Genus *Raja* Linnaeus, 1758

Raja cecilae Steurbaut & Herman, 1978
Pl. 5, figs 1-2

1978 *Raja cecilae* Steurbaut & Herman, p. 306, pl 2, fig. 4.

Material — De Wijk-19, 300-305 m: 1 tooth (RGM 177 068); 318-323 m: 1 tooth (RGM 177 069).

Description — Two teeth are present, less than one millimetre in size. The crown is extended lingually and directed upwards. The labial face has an hemispherical external outline and it is limited laterally by a sharp, slightly convex mesial crest and a somewhat concave distal crest converging at the posterior point. The enamel lacks ornamentation. The teeth are asymmetrical, as the crown is distally twisted with respect to the root. The root/crown junction lies in a shallow depression in the basal surface of the crown. The basal surface of the root is very enlarged and flat. A pronounced median groove is present between the two lobes of the bifid root.

Stratigraphic range — *Raja cecilae* has only been recorded from Middle Oligocene deposits in Belgium (Steurbaut & Herman, 1978) and The Netherlands (van den Bosch, 1980).

Raja heinzelini Steurbaut & Herman, 1978
Pl. 5, fig. 3

1978 *Raja heinzelini* Steurbaut & Herman, p. 306, pl. 2, fig. 2.

Material — De Wijk-19, 290-295 m: 1 tooth (RGM 177 070).

Description — One incomplete specimen is present. The root is broken off. The crown is low and the labial face has a subrhomboidal outline. The latero-external edges of the crown are blunt and form a rounded external angle. The latero-internal edges of the labial face are rather sharp and form a blunt cusp at conjunction. The latero-internal faces are slightly concave and form a nearly straight internal crest. The root/crown junction lies in a shallow depression in the basal surface of the crown.

Stratigraphic range — The species has been reported only from the Middle Oligocene of Belgium (Steurbaut & Herman, 1978) and The Netherlands (van den Bosch, 1980).

Raja sp. 1
Pl. 5, fig. 5

Material — Opende-1, 729-739 m: 1 tooth (RGM 177 071).

Description — The labial face of the crown has a subrhomboidal outline and it bears a central depression. The latero-external edges of the crown are convex in outline and bear an irregular, unpronoun-

ced ridge. The sharp latero-internal edges of the labial face have a concave outline and they form a blunt cusp at conjunction. The latero-internal faces are concave and form a concave internal crest. The latero-internal rims of the crown are lingually extended to form a downturned lip. The root/crown junction is situated in a depression of the crown. The bifid root is massive, but rather low, presenting an enlarged and slightly concave basal surface. A pronounced median groove is present between the two lobes, bearing two large foramina.

Remarks — The present tooth resembles the teeth of *Raja casieri* Steurbaut & Herman, 1978, a species known from the Rupelian of Belgium and The Netherlands, but it differs in the following aspects: the root is lower and less massive, having a much narrower and shallower median groove, and the latero-internal edges of the crown bear an irregular, unpronounced ridge.

Raja sp. 2
Pl. 5, fig. 4

Material — Opende, 849-859 m: 1 tooth (RGM 177 072).

Description — The crown is rather low. The labial face is slightly convex and limited laterally by a rather sharp crest with a pronounced median cusp. Externally, the labial face extends to form a rather large apron, which overhangs the root. The latero-lingual faces of the crown are concave. The enamel is smooth. The root/crown junction is situated in a depression of the crown. The root is relatively massive and shows an enlarged and flat basal surface. The median groove is only partly developed (hemiaulacorhizoid) and bears a large central foramen.

PLATE 5

Figs 1-2. *Raja cecilae* Steurbaut & Herman, 1978
1a and 2a labial views, 1b basal, 2b oblique basal, 1c oblique lateral, 2c lateral view; × 23.
1. De Wijk-19, 318-323 m-RT, RGM 177 069; 2. De Wijk-19, 300-305 m-RT, RGM 177 068.

Fig. 3. *Raja heinzelini* Steurbaut & Herman, 1978
3a oblique labial, 3b lateral view; × 50.
De Wijk-19, 290-295 m-RT, RGM 177 070.

Fig. 4. *Raja* sp. 2
4a oblique labial, 4b basal, 4c lateral view; × 46.
Opende-1, 849-859 m-RT, RGM 177 072.

Fig. 5. *Raja* sp. 1
5a oblique apical, 5b basal, 5c oblique lateral view; × 23.
Opende-1, 729-739 m-RT, RGM 177 071.

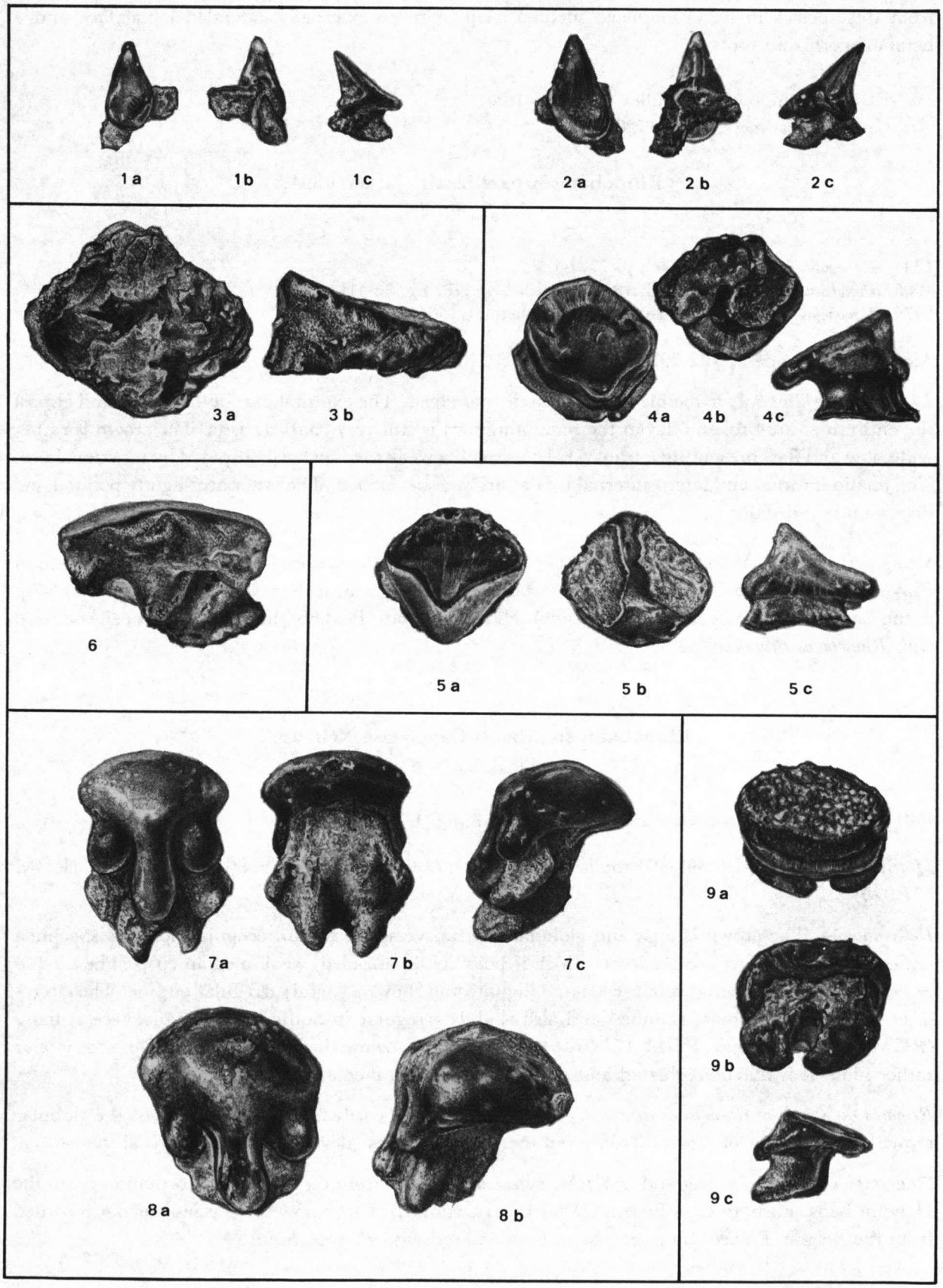
Fig. 6. *Rhinobatos bruxelliensis* (Jaekel, 1894)
Lingual view; × 47.
Opende-1, 702-711 m-RT, RGM 177 073.

Figs 7-8. *Rhinobatos steurbauti* Cappetta & Nolf, 1981
7a and 8a lingual views, 7b labial, 7c and 8b lateral view; × 23.
7. Opende-1, 580-585 m-RT, RGM 177 075; 8. De Wijk-19, 397-401 m-RT, RGM 177 074.

Fig. 9. *Coupatezia* sp.
9a oblique labial, 9b oblique basal, 9c lateral view; × 23.
De Wijk-19, 318-323 m-RT, RGM 177 087.

All specimens from the Eocene Dongen Formation in the northeastern part of The Netherlands.

Plate 5



Remarks — The present tooth shows some affinities with *Raja heinzelini*, described above. It differs from this species in its pronounced median cusp, a more externally extended labial face and a hemiaulacorhizoid root.

Family Rhinobatidae Müller & Henle, 1838
Genus *Rhinobatos* Linck, 1790

Rhinobatos bruxelliensis (Jaekel, 1894)
Pl. 5, fig. 6

1894 *Rhinobatus bruxelliensis* Jaekel, p. 77, fig. 8.
1905 *Rhinobatus bruxelliensis* Jaekel, 1894 - Leriche, p. 178, fig. 36-41.
1976 *Rhinobatos bruxelliensis* (Jaekel, 1894) - Cappetta, p. 564, pl. 4, fig. 7.

Material — Opende-1, 702-722 mm: 1 tooth (RGM 177 073).

Description — The only available tooth is heavily damaged. The external part of the crown and almost the entire root are broken off, but the remaining part is still very characteristic. The crown is rather wide, low and flat, presenting a transverse crest with a weak median cusp, abraded by functional use. The medio-internal and latero-internal uvulas are well developed. The latter are slightly pointed and diverge mesio-distally.

Stratigraphic range — Ward (1980 and pers. comm.) recorded the species in England from the London Clay up to the Barton Clays (Early to Late Eocene). In Belgium, it ranges from the Forest Sands up to the Lede Sands (Early to Middle Eocene) (Herman, 1980). Possibly this species has been confused with *Rhinobatos steurbauti*.

Rhinobatos steurbauti Cappetta & Nolf, 1982
Pl. 5, figs 7-8

1981 *Rhinobatos steurbauti* Cappetta & Nolf, p. 95, pl. 3, fig. 1-5.

Material — De Wijk-19, 397-401 m: 1 tooth (RGM 177 074). Opende-1, 580-585 m: 1 tooth (RGM 177 075).

Description — The crown is high and globular. A transverse crest is unrecognizable. One specimen (RGM 177 074) shows a wear facet, which is possibly an abraded, weak median cusp. The medio-internal uvula is very long, rather wide and digitate and shows a slightly irregular outline. The latero-internal uvulas are short, rounded and also slightly irregular in outline. The lingual face is more (RGM 177 075) or less (RGM 177 074) constricted just below the lateral angles. The root is also rather high. It is holaulacorhizoid and shows a wide, deep median groove.

Remarks — Teeth of *Rhinobatos steurbauti* can be distinguished easily from *R. bruxelliensis* by the globular crown, the irregular outline of its internal uvulas and the less developed latero-internal uvulas.

Stratigraphic range — In England, *Rhinobatos steurbauti* ranges from the Wittering Formation up to the Headon Beds (Early to Late Eocene) (Ward, pers. comm.). Up to now the species was not recorded from the Belgian Palaeogene, because it was confused with *R. bruxelliensis*.

Family Rhynchobatidae Garman, 1913
Genus *Rhynchobatus* Müller & Henle, 1837

Rhynchobatus vincenti Jaekel, 1894
Pl. 6, figs 1-3

1894 *Rhynchobatus Vincenti* Jaekel, p. 76, fig. 7.
1905 *Rhinchobatus Vincenti* Jaekel, 1894 - Leriche, p. 97, pl. 4, fig. 16-25.
1946 *Rhynchobatus vincenti* Jaekel - Casier, pl. 5, fig. 1.

Material — De Wijk-19, 318-323 m: 1 tooth (RGM 177 076); 346-350 m: 2 teeth (RGM 177 077); 350-355 m: 1 tooth (RGM 177 078); 360-364 m: 3 teeth (RGM 177 079-177 081); 383-388 m: 1 tooth (RGM 177 082); 397-401 m: 1 tooth (RGM 177 083). Opende-1, 590-595 m: 1 tooth (RGM 177 084); 664-674 m: 1 tooth (RGM 177 085); 849-859 m: 1 tooth (RGM 177 086).

Description — The crown is rather globular and shows a subrhomboidal oral surface. The medio-internal uvula is well developed, but relatively short. Latero-internal uvulas are absent. The oral face has a sharp transverse crest and a brain-like ornamentation; they are easily abraded by functional use. The root is holaulacorhizoid, having a wide and deep median groove. In this groove one or more foramina are present. Next to the medio-internal uvula of the crown, one pair of latero-internal foramina are present.

Stratigraphic range — *Rhynchobatus vincenti* is a common species in the Early and Middle Eocene of Belgium, where it ranges from the Mons-en-Pévèle Sands up to the Lede Sands (Herman, 1980). In England, the species is recorded by Ward (1980) from the Wittering Formation up to the Barton Clay (Early to Late Eocene).

Order Myliobatiformes
Family Dasyatidae Jordan, 1888
Genus *Coupatezia* Cappetta, 1982

Coupatezia sp.
Pl. 5, fig. 9

Material — De Wijk-19, 318-323 m: 1 tooth (RGM 177 087).

Description — The crown is wider than long, having a labial face with an elliptical outline. The lateral angles are hardly developed. The labial surface shows a central depression and a scalloped ornamentation. The lingual face has an irregular surface and a constriction just above the rim of the crown, forming a slight lip overhanging the root and causing a concave outline in lateral view. The root/crown junction lies in a shallow depression in the basal surface of the crown. The labio-basilar surface of the crown is rather large and slightly convex. The bifid root is rather massive and shows slightly diverging, internally extended lobes. The root has a rather large and flat basal surface. Between the lobes of the root a wide and deep median groove is present.

Remarks — The present tooth differs from teeth of *Coupatezia woutersi* Cappetta, 1982 (p. 118, pls 2-3), described from the Brussels Sands (Middle Eocene) in Belgium, by a much coarser ornamentation of the oral surface and the absence of a transverse anterior crest.

Genus *Dasyatis* Rafinesque, 1810

Dasyatis sp. div.
Pl. 7, figs 1-6

Material — De Wijk-19, 318-323 m: 1 tooth (RGM 177 088); 327-332 m: 2 reworked teeth (RGM 177 089); 346-350 m: 3 teeth (RGM 177 090); 360-364 m: 3 teeth (RGM 177 091-177 093); 392-397 m: 2 teeth (RGM 177 094); 397-401 m: 2 teeth (RGM 177 095); 415-417 m: 1 tooth (RGM 177 096); Opende-1, 655-664 m: 1 tooth (RGM 177 097); 692-702 m: 1 tooth (RGM 177 098); 803-813 m: 1 tooth (RGM 177 099); 924-927 m: 1 tooth (RGM 177 100).

Description — The morphology of the present teeth is highly variable. All specimens are typically dasyatiform. Rather low crowned teeth with a subrhomboidal oral face may be attributed to females or immature males, while higher crowned tetrahedral teeth are supposed to belong to mature males. In some specimens, the oral face of the crown bears a central depression, others have a convex oral surface. The enamel of the crown may be rather smooth or show a scalloped ornamentation. Some teeth have a mesio-distally rather compressed crown, while others are rather extended mesio-distally. The root is holaulacorhizoid and relatively small in most specimens.

Remarks — The present material is heterogeneous, but the available number of teeth is insufficient for a sound separation of the species, as intraspecific morphological variation may be considerable in *Dasyatis* species. Hitherto four nominal *Dasyatis* species were described from the Eocene of Belgium and England: *D. jaekeli* (Leriche, 1905), *D. tricuspidatus* Casier, 1946, *D. davisi* Casier, 1966 and *D. wochadunensis* Ward, 1978. The former three species need to be revised, as the original descriptions and illustrations are not satisfactory. Our material may be assigned largely to these three species.

Family Gymnuridae Fowler, 1934
Genus *Gymnura* van Hasselt, 1823

Gymnura grootaerti Herman, 1984
Pl. 6, figs 4-5

1984 *Gymnura grootaerti* Herman, p. 50, pl. 1, figs 1-3.

Material — Opende-1, 604-609 m: 1 tooth (RGM 177 101); 627-637 m: 1 tooth (RGM 177 102).

PLATE 6

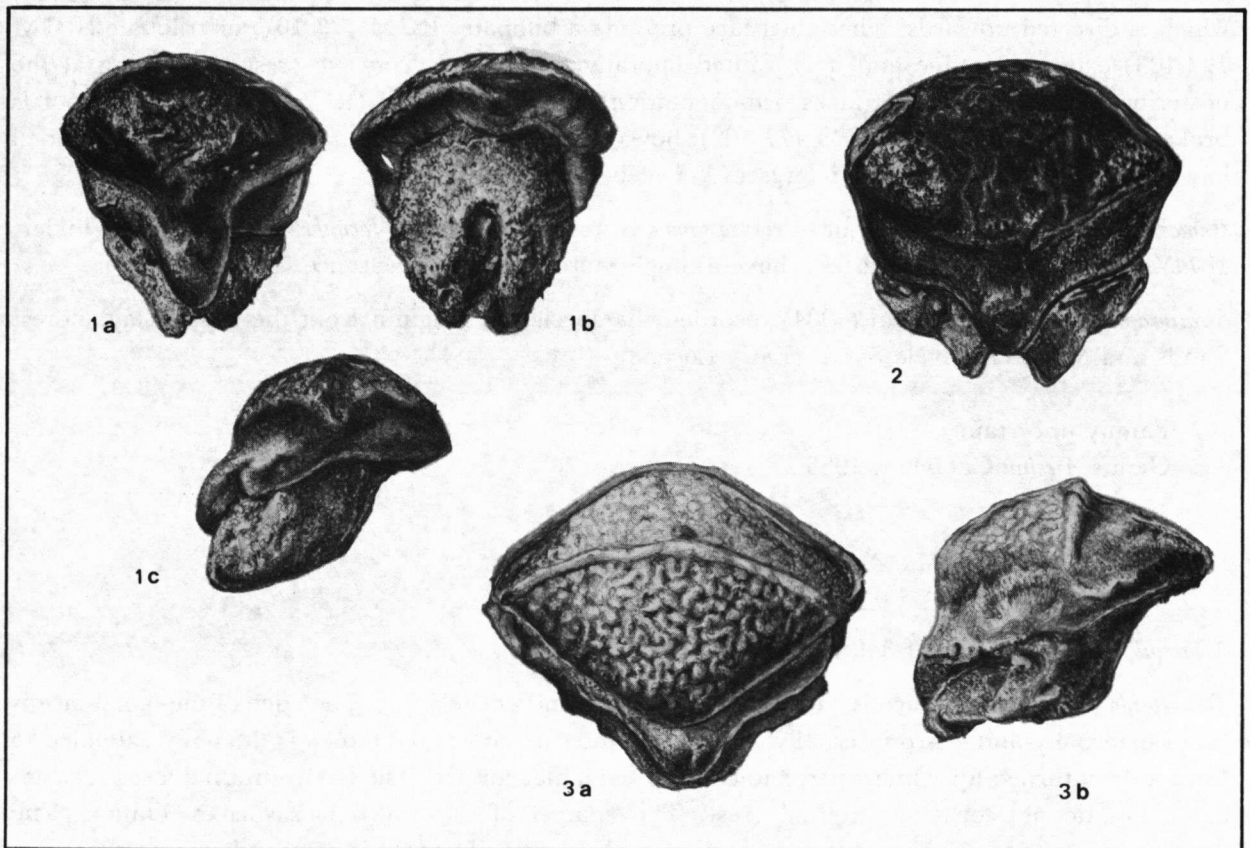
Figs 1-3. *Rhynchobatus vincenti* Jaekel, 1894
1a, 2 and 3a oblique lingual, 1b oblique labial, 1c and 3b lateral views; × 23.
1. De Wijk-19, 350-355 m-RT, RGM 177 078; 2. De Wijk-19, 360-364 m-RT, RGM 177 080; 3. De Wijk-19, 360-364 m-RT, RGM 177 079.
Note the sharp transverse crest and brain-like ornamentation on the oral face of the not full-grown tooth in fig. 3.

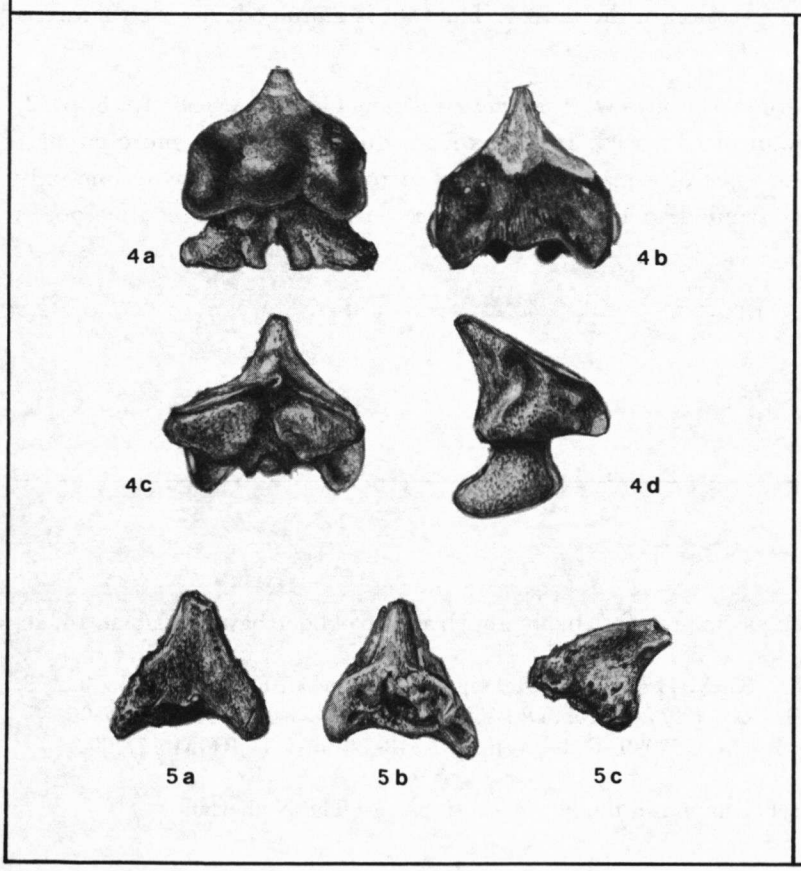
Figs 4-5. *Gymnura grootaerti* Herman, 1984
4a labial, 4b and 5a oblique labial, 4c and 5b oblique basal, 4d and 5c lateral views; × 23.
4. Opende-1, 627-637 m-RT, RGM 177 102; 5. Opende-1, 604-609 m-RT, RGM 177 101.

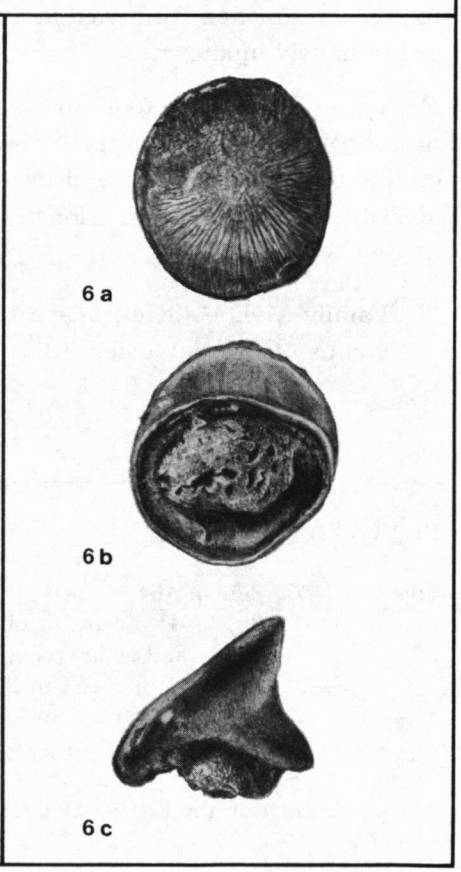
Fig. 6. ? *Arechia* sp.
6a labial, 6b oblique basal, 6c lateral view; × 23.
Opende-1, 841-849 m-RT, RGM 177 126.

All specimens from the Eocene Dongen Formation in the northeastern part of The Netherlands.

Plate 6







Description — The crown is rather high and massive, showing a lingually extended and pointed cusp, which is directed upwards. The labial face presents a bilobate (RGM 177 101) or trilobate (RGM 177 103) external outline and it is limited laterally by a sharp, concave crest converging at the posterior point. The enamel lacks ornamentation. In one specimen (RGM 177 101), the root is broken off, the other tooth (RGM 177 102) shows a bifid root with internally and laterally extended lobes. A wide and deep groove is present between the lobes.

Remarks — At first sight, teeth of *Gymnura grootaerti* resemble those of *Jacquhermania duponti* (Winkler, 1874), but the latter are larger and have a much more massive appearance.

Stratigraphic range — Herman (1984) recorded the species in Belgium from the Ieper Clay, Forest Sands and Mons-en-Pévèle Sands (Early Eocene).

Family uncertain
Genus *Arechia* Cappetta, 1983

? Arechia sp.
Pl 5, fig. 6

Material — Opende-1, 841-849 m: 1 tooth (RGM 177 126).

Description — The labial face is subcircular in outline and entirely flat. The edge of the labial face is blunt externally and sharp internally. The latero-internal rim of the crown is lingually extended to form a downturned lip, almost perpendicular to the labial surface. The latero-internal faces are concave, but do not form an internal crest. The enamel of the crown lacks ornamentation. The root/crown junction is situated in a depression of the crown. The root is damaged, so its structure is unfortunately unknown.

Remarks — The present tooth shows some affinities with *Arechia arambourgi* Cappetta, 1983 (p. 3, pl. 2, figs. 1-5), described from the Ypresian of Morocco. It differs from this species by a more circular outline of the oral surface and the absence of a pronounced rim surrounding the crown. The only available specimen is provisionally assigned to the genus *Arechia*, as the structure of the root is unknown.

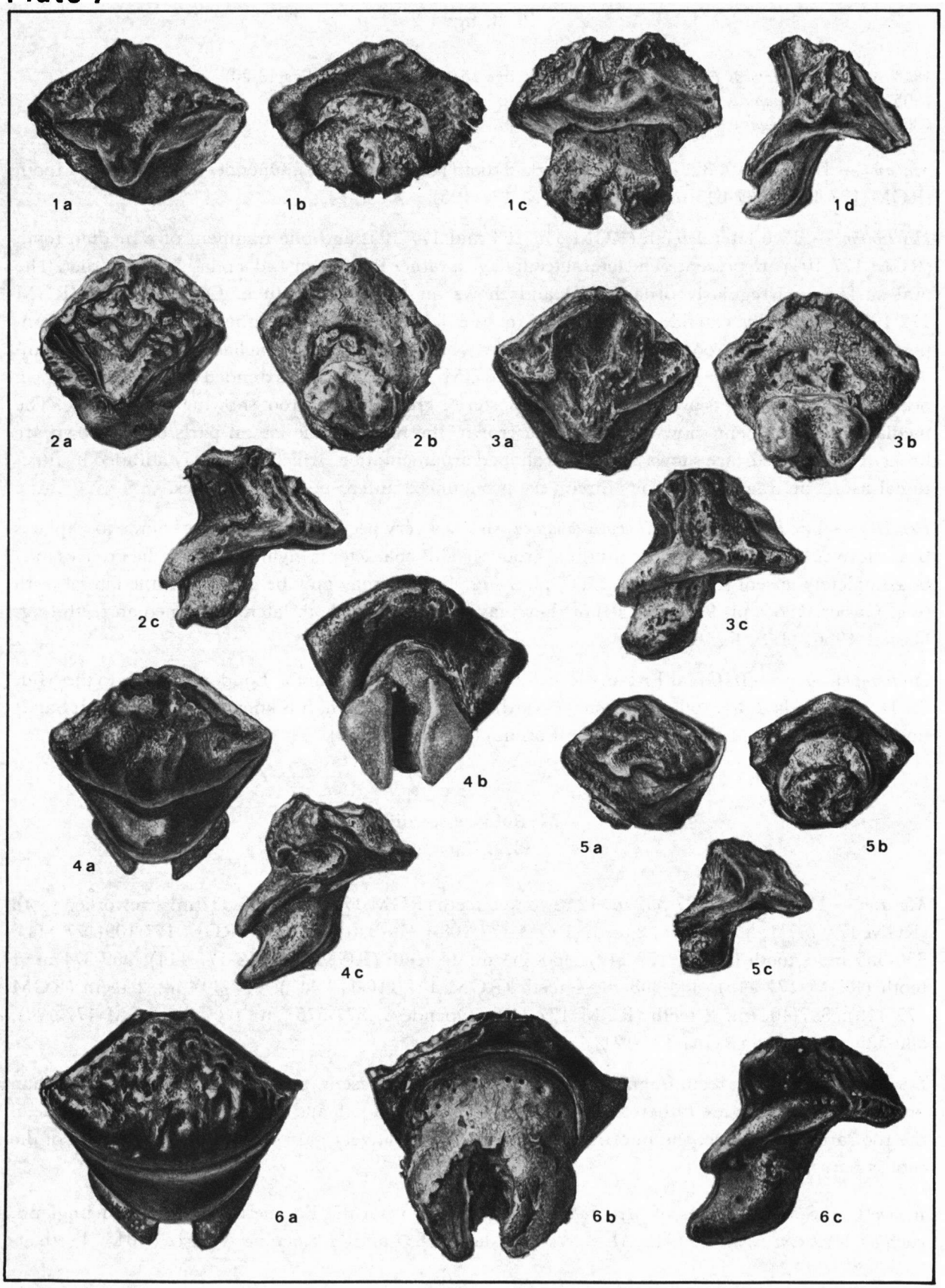
Family Myliobatidae Bonaparte, 1838
Genus *Myliobatis* Cuvier, 1817

PLATE 7

Figs 1-6. *Dasyatis* sp. div
1a, 2a, 3a, 4a, 5a and 6a oblique lingual, 1b, 2b, 3b, 4b, 5b and 6b oblique basal, 1c labial, 1d, 2c, 3c, 4c, 5c and 6c lateral views; × 23.
1. Opende-1, 655-664 m-RT, RGM 177 097; 2. De Wijk-19, 360-364 m-RT, RGM 177 092; 3. De Wijk-19, 360-364 m-RT, RGM 177 093; 4. De Wijk-19, 360-364 m-RT, RGM 177 091; 5. Opende-1, 803-813 m-RT, RGM 177 099; 6. De Wijk-19, 318-328 m-RT, RGM 177 088.

All specimens from the Eocene Dongen Formation in the northeastern part of The Netherlands.

Plate 7



Myliobatis toliapicus Agassiz, 1843
Pl. 8, figs 1-2

1843 *Myliobatis toliapicus* Agassiz, p. 321, pl. 47, figs 15-17 (partim, non figs 18-20).
1905 *Myliobatis toliapicus* Agassiz, 1843 - Leriche, p. 104, pl. 4, figs 33-34.
1966 *Myliobatis toliapicus* Agassiz - Casier, p. 95, pl. 9, figs 2-6, 10.

Material — De Wijk-19, 327-332 m: 1 reworked tooth (RGM 177 103). Opende-1, 576-580 m: 1 tooth (RGM 177 104); 637-645 m: 1 tooth (RGM 177 105).

Description — Two lateral teeth (RGM 177 103 and 177 105) and one fragment of a median tooth (RGM 177 104) are present. The lateral teeth have a rather low crown and a relatively high root. The oral surface is irregularly ornamented and shows an hexagonal outline. One specimen (RGM 177 105) is laterally extended and shows an oral face bearing four rather pronounced, antero-posterior grooves. Its root is extended posteriorly and possesses six lamellae with rather wide intermediate grooves. The second lateral tooth (RGM 177 103) is less extended laterally, having an oral surface with two less pronounced antero-posterior grooves, and a root showing five lamellae. The median tooth fragment shows a rather high crown, the root and the lateral parts of the crown are broken. The oral surface shows a rough, scalloped ornamentation, which is strongly abraded by functional use. The fragment exhibits three very pronounced antero-posterior grooves.

Remarks — The dentition of *Myliobatis toliapicus* shows a very peculiar phenomenon. Some toothplates bear more or less pronounced longitudinal grooves. This character is highly variable: the grooves may be completely absent (e.g. Casier, 1966, pl. 9, fig. 1), they may only be present on the lateral teeth (e.g. Casier, 1966, pl. 9, figs 3, 10) or they may be present on both lateral and median teeth (e.g. Casier, 1966, pl. 9, fig. 6).

Stratigraphic range — In Great Britain, *Myliobatis toliapicus* ranges from the London Clay up to the Middle Headon Beds (Early to Late Eocene) (Ward, 1980). In Belgium, it is known from the Forest Sands up to the Lede Sands (Early to Middle Eocene) (Herman, 1980).

Myliobatis sp. div.
Pl. 8, figs 3-6

Material — De Wijk-19, 327-332 m: 12 reworked teeth (RGM 177 106); 332-337 m: 1 reworked tooth (RGM 177 107)*; 337-341 m: 2 teeth (RGM 177 108); 346-350 m: 4 teeth (RGM 177 109-177 111); 350-355 m: 1 tooth (RGM 177 112); 360-364 m: 14 teeth (RGM 177 113-177 114); 369-374 m: 1 tooth (RGM 177 115); 383-388 m: 4 teeth (RGM 177 116-177 117); 392-397 m: 2 teeth (RGM 177 118); 397-401 m: 2 teeth (RGM 177 119). Opende-1, 571-576 m: 1 tooth (RGM 177 120); 580-585 m: 2 teeth (RGM 177 121).

Description — Median teeth fragments and lateral teeth are present, probably belonging to more than one species. All teeth are rather small. The oral surface is smooth and not depressed. The lamellae of the root are rather wide, the intermediate grooves are relatively narrow. The basilar surface of the root is flat.

Remarks — Several species of *Myliobatis* were described from the Eocene of Belgium and England, such as *M. dixoni* Agassiz, 1845, *M. striatus* Buckland, 1837 and *M. toliapicus* Agassiz,. 1843. Teeth at-

tributed to these species are generally larger. Usually only more or less complete toothplates can be identified. Nomenclature of Eocene Myliobatidae is very confused and needs revision.

Family Mobulidae Gill, 1893
Genus *Burnhamia* Cappetta, 1976

Burnhamia daviesi (Woodward, 1889)
Pl. 8, figs 7-8

1889 *Rhinoptera Daviesii* Woodward, p. 126, pl. 3, fig. 6.
1905 *Rhinoptera Daviesi* Woodward, 1889 - Leriche, p. 101, fig. 10-12.
1952 *Rhinoptera Daviesi* Woodward 1889 - Arambourg, p. 216, pl. 32, fig. 1-14.

Material — Opende 1, 590-595 m: 1 tooth (RGM 177 122); 595-599 m: 1 tooth (RGM 177 123); 711-720 m: 1 tooth (RGM 177 124); 720-729 m: 1 tooth (RGM 177 125).

Description — The present four teeth all originate from the lateral rows of the jaw. The oral surface of the crown shows a subhexagonal outline, with extended anterior and posterior sides. The oral surface is depressed and shows a scalloped ornamentation. One specimen (RGM 177 124) has a less scalloped oral surface, probably as a result of functional abrasion. The root is rather massive and polyaulacorhizoid. The root possesses three or four rather narrow and widely spaced lamellae, between which wide, U-shaped grooves are present. Several large interlamellar foramina are present in each groove.

Remarks — In the older literature, this species is usually assigned to the genus *Rhinoptera* Cuvier, 1829. Cappetta (1976) explained that there are important morphological differences in dentition between the genera *Burnhamia* and *Rhinoptera*. Teeth of the latter genus have a higher crown, with nearly vertical anterior and posterior faces. The oral surface lacks a central depression and ornamentation. The root has a much larger number of lamellae, between which the grooves are much less wide and less deep than in *Burnhamia*. These morphological differences are consequences of these animals' diet. *Rhinoptera*, belonging to the Myliobatidae, feeds on molluscs and crustaceans, which it crushes with its pavement-like teeth. The dentition of *Burnhamia*, however, is more suitable for feeding on fishes, a behaviour known from the Mobulidae.

Stratigraphic range — Ward (1980) recorded *Burnhamia daviesi* in Great Britain from the London Clay (Early Eocene) and *Burnhamia* sp. from the Wittering Formation up to the Barton beds (Early to Late Eocene). Herman (1980) mentioned *B. daviesi* in Belgium from the Ieper Clay up to the Wemmel Sands (Early to Late Eocene).

Unidentifiable tooth fragments

Material — De Wijk-19, 323-327 m: 2 fragments (RGM 177 127); 327-332 m: 1 reworked fragment (RGM 177 128); 332-337 m: 1 fragment (RGM 177 129); 337-341 m: 1 fragment (RGM 177 130); 341-346 m: 1 fragment (RGM 177 131); 346-350 m: 6 fragments (RGM 177 132); 350-355 m: 4 fragments (RGM 177 133); 355-360 m: 1 fragment (RGM 177 134); 360-364 m: 4 fragments (RGM 177 135); 379-383 m: 1 fragment (RGM 177 136); 383-388 m: 4 fragments (RGM 177 137); 392-397 m: 3 fragments (RGM 177 138); 401-405 m: 1 fragment (RGM 177 139); 411-415 m: 2 fragments (RGM 177 140); 415-417 m: 2 reworked fragments (RGM 177 141); 429-434 m: 1 fragment (RGM

177 142); 448-452 m: 2 fragments (RGM 177 143); 452-457 m: 3 fragments (RGM 177 144); 457-466 m: 1 fragment (RGM 177 145); 466-476 m: 1 fragment (RGM 177 146); 503-512 m: 1 fragment (RGM 177 147); 522-531 m: 1 fragment (RGM 177 148). Opende-1, 558-562 m: 7 fragments (RGM 177 149); 567-571 m: 2 fragments (RGM 177 150); 571-576 m: 4 fragments (RGM 177 151); 576-580 m: 2 fragments (RGM 177 152); 580-585 m: 4 fragments (RGM 177 153); 585-590 m: 4 fragments (RGM 177 154); 590-595 m: 7 fragments (RGM 177 155); 595-599 m: 5 fragments (RGM 177 156); 599-604 m: 2 fragments (RGM 177 157); 604-609 m: 3 fragments (RGM 177 158); 609-614 m: 4 fragments (RGM 177 159); 614-617 m: 5 fragments (RGM 177 160); 617-627 m: 3 fragments (RGM 177 161); 627-637 m: 3 fragments (RGM 177 162); 637-645 m: 1 fragment (RGM 177 163); 655-664 m: 1 fragment (RGM 177 164); 674-683 m: 2 fragments (RGM 177 165); 692-702 m: 4 fragments (RGM 177 166); 702-711 m: 1 fragment (RGM 177 167); 711-720 m: 1 fragment (RGM 177 168); 720-729 m: 3 fragments (RGM 177 169; 739-748 m: 2 fragments (RGM 177 170); 748-757 m: 1 fragment (RGM 177 171); 766-776 m: 2 fragments (RGM 177 172); 776-785 m: 3 fragments (RGM 177 173); 785-794 m: 1 fragment (RGM 177 174); 803-813 m: 2 fragments (RGM 177 175); 813-823 m: 2 fragments (RGM 177 176); 841-849 m: 1 fragment (RGM 177 177); 859-868 m: 1 fragment (RGM 177 178); 878-887 m: 4 fragments (RGM 177 179); 887-896 m: 1 fragment (RGM 177 180); 896-906 m: 2 fragments (RGM 177 181); 906-915 m: 1 fragment (RGM 177 182); 924-927 m: 1 fragment (RGM 177 183); 942-952 m: 1 fragment (RGM 177 184).

Remarks — Many unidentifiable tooth fragments are present. Most specimens can probably be assigned to the orders Carcharhiniformes or Lamniformes.

RESULTS

A total number of 516 teeth and tooth fragments, referable to 37 species, are recorded from the Dongen Formation in NAM-wells De Wijk-19 and Opende-1, and RGM-boring Haaksbergen 34G.2-8. All species, with the encountered number of teeth, are listed in text-fig. 7. It appeared that 50.8% of the total number of specimens could not be identified to generic or specific level, 26.6% of

PLATE 8

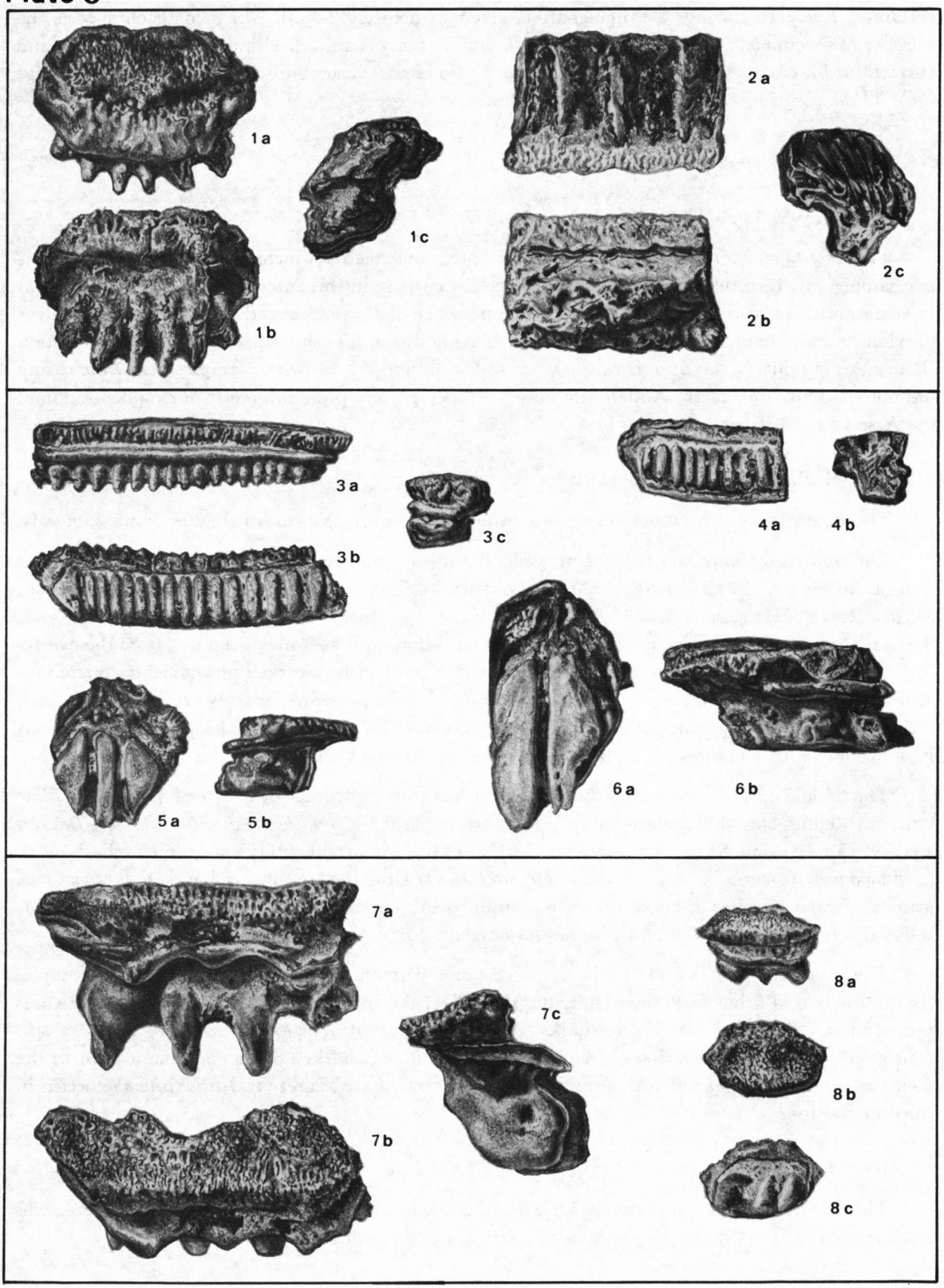
Figs 1-2. *Myliobatis toliapicus* Agassiz, 1843
1 lateral tooth, 2 median tooth fragment; 1a oblique lingual, 2a occlusal, 2b basal, 1b oblique basal view, 1c and 2c lateral views; × 6.
1. Opende-1, 637-645 m-RT, RGM 177 105; 2. Opende-1, 576-580 m-RT, RGM 177 104.

Figs 3-6. *Myliobatis* sp. div.
3-4 median tooth fragments, 5-6 lateral teeth; 3a lingual, 3b, 4a, 5a and 6a basal, 4b, 5b, and 6b lateral views; 3-4 × 6, 5-6 × 11.
3. De Wijk-19, 346-350 m-RT, RGM 177 110; 4. De Wijk-19, 346-350 m-RT, RGM 177 109; 5. De Wijk-19, 360-364 m-RT, RGM 177 113; 6. De Wijk-19, 383-388 m-RT, RGM 177 116.

Figs 7-8. *Burnhamia daviesi* (Woodward, 1889)
Lateral teeth. 7a lingual view, 7b and 8a oblique lingual views, 8b occlusal, 8c basal, 7c lateral view; × 11.
7. Opende-1, 595-599 m-RT, RGM 177 123; 8. Opende-1, 590-595 m-RT, RGM 177 122.

All specimens from the Eocene Dongen Formation in the northeastern part of The Netherlands.

Plate 8



all specimens, usually tooth fragments, even could not be attributed to an order with some degree of certainty. For each boring, a range-chart is given in text-figs 2-4, in which for each species the number of specimens per sample is indicated. Combination of samples within stratigraphic units and corrections for caving produced for each boring a number of elasmobranch associations (cf. text-figs 5-6). These associations will be elucidated below.

NAM-Well De Wijk-19

Asse Clay Member (290-318 m)

The Asse Clay Member is rather poor in elasmobranch teeth. A mean number of 1.3 specimens per sample was recorded. Typical Eocene species occurring in this interval are *Squalus* sp., *Isistius trituratus* and *Physogaleus secundus*. Striking is the presence of *Raja cecilae* and *R. heinzelini*, two species previously only known from the Rupelian. Caving from the superimposed Rupel Formation (Rupelian) is unlikely, because casing was set to 266 m and the Rupelian samples below the casing did not yield any *Raja* teeth. Apparently these two species were present already during deposition of the Asse Clay Member.

Brussels Sand Member (318-415 m)

The Brussels Sand Member is rich in elasmobranch teeth. We can distinguish three intervals:

The uppermost interval (318-332 m) yielded a mean number of 6.0 specimens per sample and quite a number of species: *Isistius trituratus* is rather common, furthermore the species *Squalus* sp. *Squatina prima, Physogaleus secundus, Rhynchobatus vincenti, Coupatezia* sp. and *Dasyatis* sp. are present. The presence of a tooth of *Raja cecilae* in this interval is doubtful, as it may originate from the overlying Asse Clay Member. At the base of this interval, a level with reworked phosphoritic concretions and quite a number of black, rolled elasmobranch teeth is present. This reworked elasmobranch fauna reflects the association from the underlying interval (332-364 m) with phosphoritic concretions in situ. Noteworthy is the very high percentage (42%) of *Myliobatis* teeth in this reworked fauna.

The middle part (332-364 m) is the richest interval with an average of 14.7 teeth per sample. The bottom-dwelling batoid fishes are the dominant group (32.0%): *Myliobatis* sp. div. (20.4%), *Dasyatis* sp. div. (5.8%), and *Rhynchobatus vincenti* (5.8%). Other important groups are the Carcharhinidae (*Abdounia minutissima, Physogaleus secundus* and *Scoliodon* sp.) and the lamniform sharks (e.g. *Striatolamia macrota*). *Isistius trituratus* is less common than in the overlying interval. Rare species occurring in this interval are *Hexanchus hookeri* and *Heterodontus vincenti*.

The lower interval (364-415 m) is the poorest one, with an average of 4.1 specimens per sample. Again, the batoid fishes form the dominant group (32.1%), in which here also *Rhinobatos steurbauti* is represented. The carcharhiniform sharks are also important: *Physogaleus secundus, Scoliodon* sp., *Scyliorhinus gilberti* and *Galeorhinus ypresiensis*. The lamniform sharks are less dominant than in the overlying interval. Instead of *Striatolamia macrota, Anomotodon novus* is present. *Isistius trituratus* occurs in this interval too.

Ieper Clay Member (415-548 m)

This member is poor in elasmobranch teeth. A mean number of 1.2 specimens per sample was observed. Within the member two intervals with elasmobranch teeth occur.

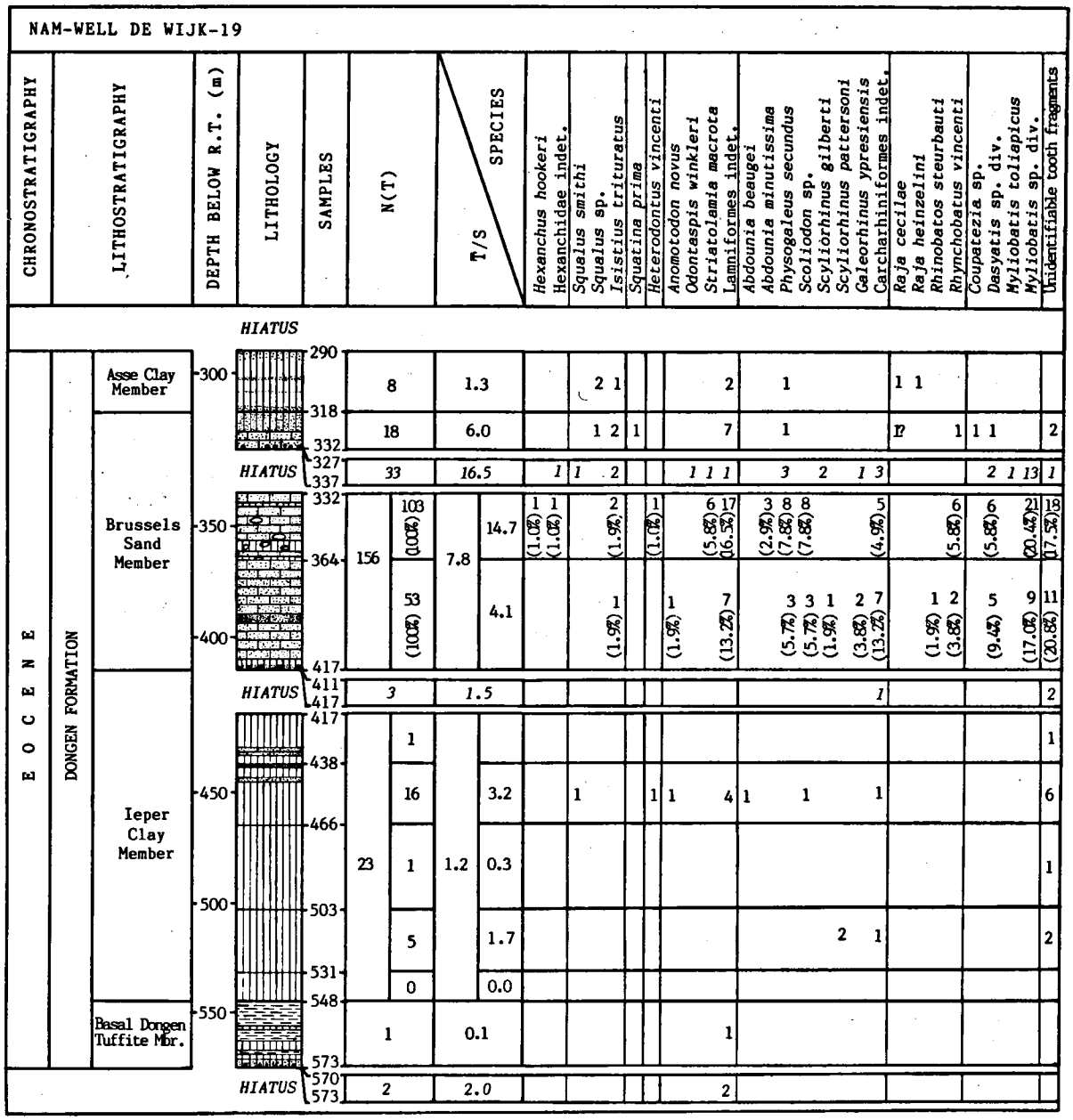


Fig. 5. Associations of elasmobranch teeth for the Dongen Formation (Eocene) in NAM-well De Wijk-19, The Netherlands. Samples within stratigraphic units were combined and corrections made for caving. N (T) is total number of teeth and tooth fragments; $\bar{T}$/S is mean number of teeth and tooth fragments per sample. Reworked specimens in italics, percentages are placed in brackets.

The upper interval (438-466 m) is the richest. The following species were recorded: *Squalus smithi, Heterodontus vincenti, Anomotodon novus, Abdounia beaugei* and *Scoliodon* sp.

The lower interval (503-531 m) yielded only a few small teeth of the dogfish, *Scyliorhinus pattersoni.*

Basal Dongen Tuffite Member (548-573 m)

This interval is very poor in elasmobranch teeth. Only one unidentifiable lamniform tooth was recorded. The base of this member yielded a few reworked, unidentifiable lamniform teeth.

NAM-Well Opende-1

Brussels Sand Member (558-700 m)

The Brussels Sand Member is very rich in elasmobranch teeth. An average of 9.5 teeth and tooth fragments per sample was encountered. We can divide the member into two parts.

The upper part (558-626 m) is the richest interval with a mean number of 11.8 specimens per sample. *Isistius trituratus* is the most abundant species (16.9%). The lamniform sharks are the most common group of sharks in this interval (23.7%), among which *Striatolamia macrota* is an important species. Other species of this group occurring in this interval are *Anomotodon novus* and *Odontaspis hopei*. Another important group are the carcharhiniform sharks (15.8%), of which *Scyliorhinus gilberti* is the most common species. Interesting species of this group occurring in this interval are *Scyliorhinus casieri, Galeorhinus ypresiensis* and *Triakis wardi*. Important is the presence of the orectolobiform sharks *Eostegostoma angustum* and *Palaeorhincodon wardi*. Other species noteworthy are hexanchoid sharks, *Squalus smithi, Squatina prima* and *Heterodontus vincenti*. Striking is the low percentage of *Myliobatis*, only 2.3%, and other bottom-dwelling batoid fishes like *Rhinobatos steurbauti* and *Rhynchobatus vincenti*. The stingray *Dasyatis* is even absent. Interesting is the presence of the butterfly ray *Gymnura grootaerti* and the devil ray *Burnhamia daviesi*.

The lower interval (620-700 m) is less rich in elasmobranch teeth with an average of 4.4 specimens per sample. *Isistius trituratus* is again the dominant species, although with a much lower percentage (9.7%) than in the overlying interval. The lamniform and carcharhiniform sharks are again the most common groups in this interval, with respectively 22.6% and 25.8%. Noteworthy is the presence of the two small dogfishes *Scyliorhinus casieri* and *S. pattersoni*, and the carcharhinid shark *Abdouna beaugei*. The bottom-dwelling batoid fishes are more common in this interval (12.9%). Half the number of these specimens belong to the stingray *Dasyatis*, the other half to the eagle ray *Myliobatis toliapicus* and the wedgefish *Rhynchobatus vincenti*.

Ieper Clay Member (700-915 m)

The Ieper Clay Member is rather poor in elasmobranch teeth with an average of 2.5 specimens per sample. Within the member we can distinguish two intervals with elasmobranch teeth: 700-766 m and 803-859 m. The remaining intervals yielded only some unidentifiable teeth and tooth fragments.

Triakis wardi and *Burnhamia daviesi* are the most important species in the upper interval. Again *Isistius trituratus* is present. It is interesting to record the presence of *Xenodolamia eocaena, Rhinobatos bruxelliensis* and an undescribed skate, *Raja* sp. 1.

The lower interval is characterized by the presence of *Squalus* sp. and *Scyliorhinus casieri*, while *Isistius trituratus* and *Triakis wardi* are also present. Noteworthy is the occurrence of hexanchoid sharks, *Rhynchobatus vincenti, Dasyatis* sp. and two undescribed rays, *Raja* sp. 2 and ? *Arechia* sp.

Basal Dongen Tuffite Member (915-945 m)

This member is very poor in elasmobranch teeth. An average of 1.0 teeth and tooth fragments per sample was encountered. Only two species could be identified, *Isistius trituratus* and *Dasyatis* sp.

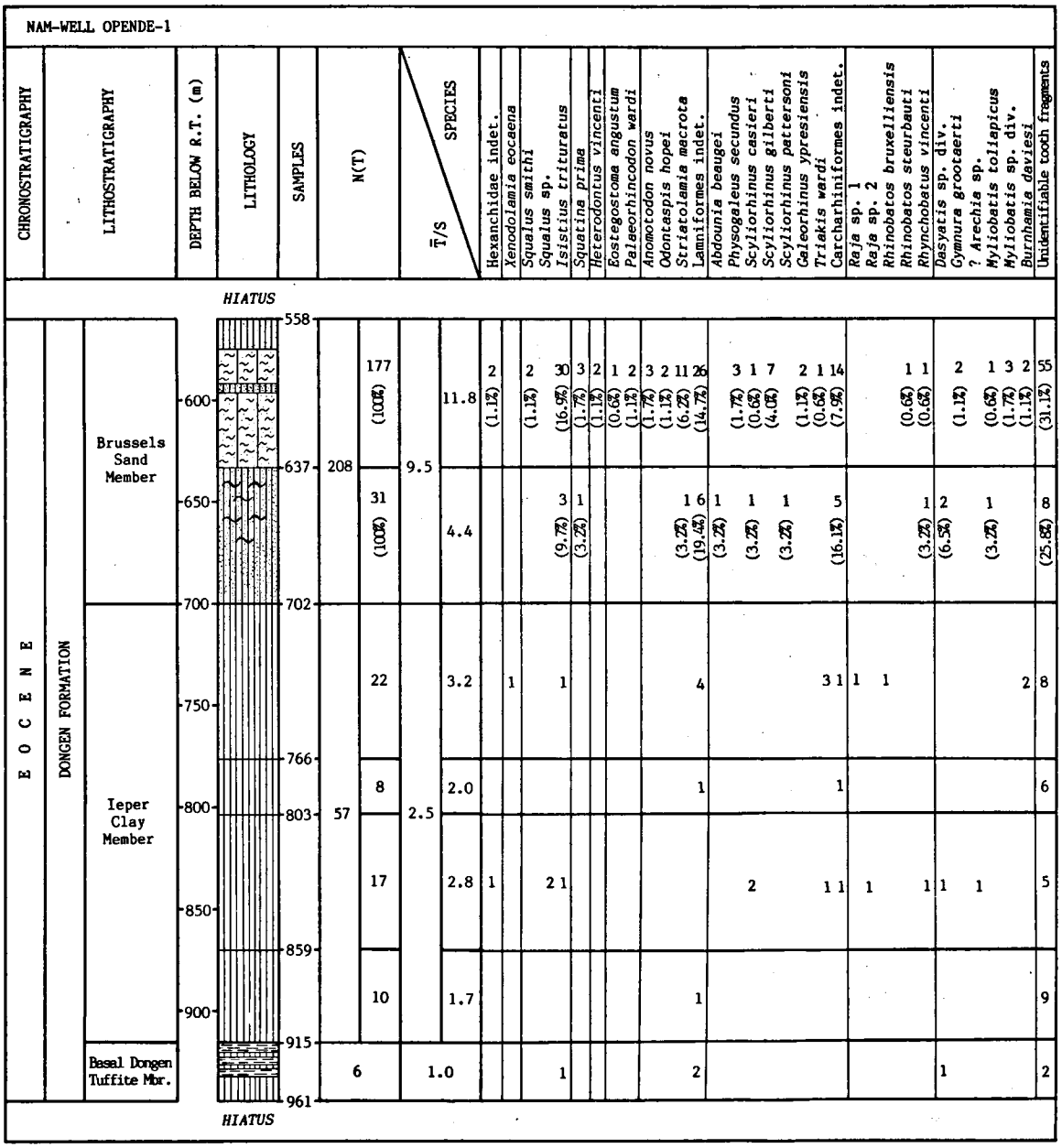


Fig. 6. Associations of elasmobranch teeth for the Dongen Formation (Eocene) in NAM-well Opende-1, The Netherlands. Samples within stratigraphic units were combined and corrections made for caving. N (T) is total number of teeth and tooth fragments; T̄/S is mean number of teeth and tooth fragments per sample. Percentages are placed in brackets.

RGM-boring Haaksbergen 34G.2-8

Brussels Sand Member (33.70-42.00 m)

Two teeth were recorded: *Isistius trituratus* and *Scyliorhinus* sp.

Hexanchidae	*Hexanchus hookeri*	1
	Hexanchidae indet.	5
Family uncertain	*Xenodolamia eocaena*	1
Squalidae	*Squalus smithi*	4
	Squalus sp.	5
	Isistius trituratus	46
Squatinidae	*Squatina prima*	4
Heterodontidae	*Heterodontus vincenti*	4
Stegostomatidae	*Eostegostoma angustum*	1
Rhiniodontidae	*Palaeorhincodon wardi*	2
Mitsukurinidae	*Anomotodon novus*	5
Odontaspididae	*Odontaspis hopei*	2
	Odontaspis winkleri	1
	Striatolamia macrota	19
Family uncertain	Lamniformes indet.	81
Carcharhinidae	*Abdounia beaugei*	2
	Abdounia minutissima	3
	Physogaleus secundus	19
	Scoliodon sp.	12
Scyliorhinidae	*Scyliorhinus casieri*	4
	Scyliorhinus gilberti	10
	Scyliorhinus pattersoni	3
	Scyliorhinus sp.	1
Triakidae	*Galeorhinus ypresiensis*	5
	Triakis wardi	5
Family uncertain	Carcharhiniformes indet.	39
Rajidae	*Raja cecilae*	2
	Raja heinzelini	1
	Raja sp. 1	1
	Raja sp. 2	1
Rhinobatidae	*Rhinobatos bruxelliensis*	1
	Rhinobatos steurbauti	2
Rhynchobatidae	*Rhynchobatus vincenti*	12
Dasyatidae	*Coupatezia* sp.	1
	Dasyatis sp. div.	18
Gymnuridae	*Gymnura grootaerti*	2
Family uncertain	? *Arechia* sp.	1
Myliobatidae	*Myliobatis toliapicus*	3
	Myliobatis sp. div.	46
Mobulidae	*Burnhamia daviesi*	4
Order uncertain	Unidentifiable tooth fragments	137
	Total number	516

Fig. 7. List of elasmobranch species with the number of teeth and tooth fragments collected from the Dongen Formation (Eocene) in NAM-wells De Wijk-19 and Opende-1 and RGM-boring Haaksbergen 34G.2-8, The Netherlands.

CONCLUSIONS

The elasmobranch associations collected from the Dongen Formation in NAM-well De Wijk-19, NAM-well Opende-1 and RGM-boring Haaksbergen 34G.2-8 indicate beyond any doubt an Eocene age for this formation.

The Asse Clay Member is only present in NAM-well De Wijk-19 and yields few elasmobranch teeth. The following species occur: *Squalus* sp., *Isistius trituratus, Physogaleus secundus, Raja cecilae* and *R. heinzelini*. This association might indicate a Late Eocene age for the Asse Clay Member.

The Brussels Sand Member, especially the upper part, is very rich in elasmobranch teeth. If we compare the elasmobranch associations from NAM-well De Wijk-19 and NAM-well Opende-1, we may notice some important differences. In De Wijk-19, there is a dominance of bottom-dwelling batoid fishes, particularly of the eagly ray *Myliobatis*, and the Carcharhinidae *Abdounia minutissima, Physogaleus secundus* and *Scoliodon* sp. are common. In Opende-1, these groups occur much less fre-

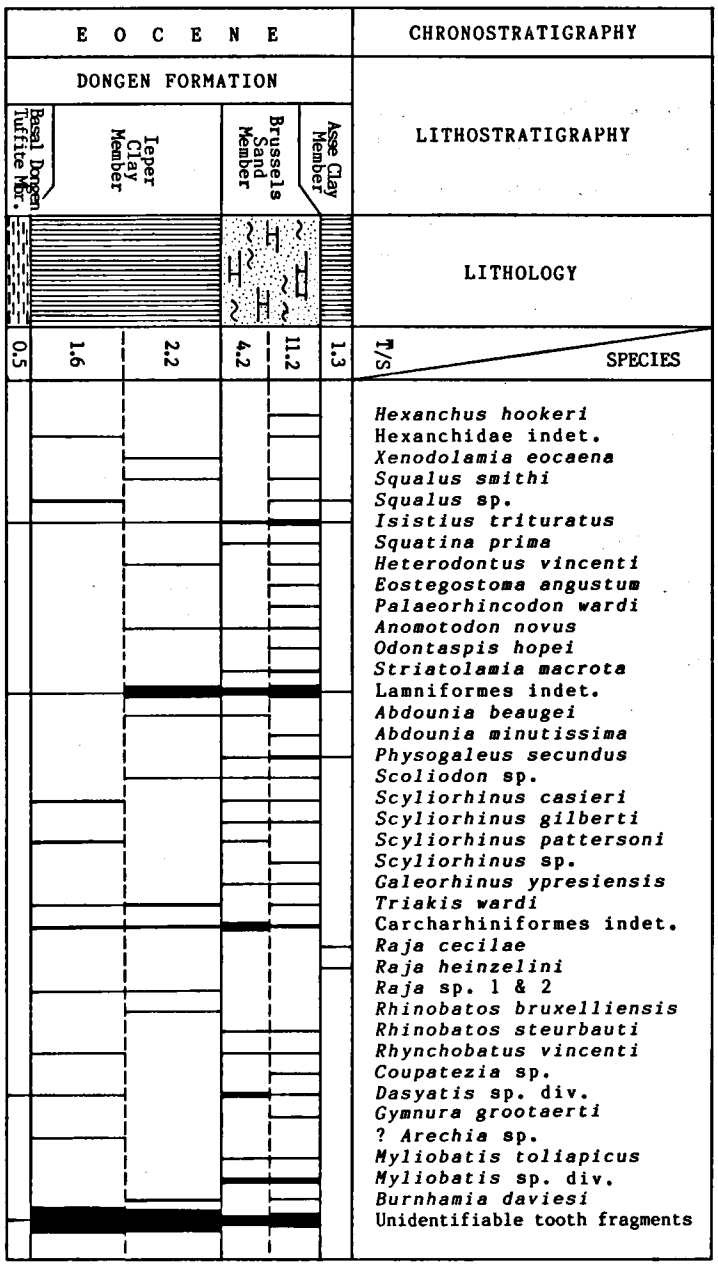


Fig. 8. Schematic compilation of the stratigraphic ranges of elasmobranch teeth in the Dongen Formation (Eocene) in the NE part of The Netherlands. The relative abundance of a species is given by different widths of the bars. $\bar{T}/S$ is mean number of teeth and tooth fragments per sample.

quent and we see a dominance of *Isistius trituratus* instead. In addition orectolobiform sharks, *Eostegostoma angustum* and *Palaeorhincodon wardi*, the pelagic devil ray *Burnhamia daviesi* and some small sharks previously only known from the English London Clay, *Scyliorhinus casieri, S. pattersoni* and *Triakis wardi*, are present. These differences indicate deposition in greater water depths and at a greater distance from the shore for the Brussels Sand Member in Opende-1. This is supported by the finer grain-size of the sediment and the more northern location of the well. The co-occurrence of

Heterodontus vincenti, Eostegostoma angustum and *Palaeorhincodon wardi*, and the presence of rather large specimens of *Striatolamia macrota* is indicative of a Middle Eocene age for the Brussels Sand Member.

The Ieper Clay Member yields relatively few elasmobranch teeth. The available number of teeth is too small to draw any sound conclusions on differences between the elasmobranch associations of De Wijk-19 and Opende-1. Regularly occurring species in this member are *Xenodolamia eocaena, Squalus* sp. div., *Isistius trituratus, Scyliorhinus casieri, S. pattersoni, Triakis wardi*, two undescribed *Raja* sp., ? *Arechia* sp. and *Burnhamia daviesi*. This association indicates an Early Eocene age for the Ieper Clay Member.

Elasmobranch teeth occur very rarely in the Basal Dongen Tuffite Member. Hitherto only two species are known: *Isistius trituratus* and *Dasyatis* sp. In Belgium and England, both species appear for the first time in the Early Eocene. So, an Early Eocene age is most likely for the Basal Dongen Tuffite Member.

A schematic representation of the stratigraphic distribution and relative abundances of elasmobranch teeth in the Dongen Formation in the NE part of The Netherlands is given in text-fig. 8. This scheme is a compilation of the data from text-figs 4-6. It is still premature, because it is mainly based on data from only two wells. The sampling and study of more well sections is necessary to complete and improve the present scheme.

It is not possible to compare the allochthonous Eocene elasmobranch faunas present at the base of the Oligocene in the eastern part of The Netherlands (van den Bosch, 1964 and 1980) and in the glacial boulder clay at Losser (Spaink, 1978) with the authochthonous Eocene elasmobranch associations from the Dongen Formation described in this paper, because the allochthonous Eocene elasmobranch material was obtained by collecting visually in exposures and specimens below 15 mm in size were hardly found (van den Bosch, 1980). So all small elasmobranch species which make up the greater part of the authochthonous elasmobranch material from the Dongen Formation are lacking in the collections of allochthonous Eocene elasmobranch teeth.

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