

**ON SHARK TEETH AND SCALES FROM THE NETHERLANDS AND THE
BIOSTRATIGRAPHY OF THE TERTIARY OF THE EASTERN PART
OF THE COUNTRY**

by

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A summary is given of the stratigraphical distribution of Elasmobranch remains from the Tertiary and Early Pleistocene of the Netherlands. The faunas from Oligocene, Miocene and Early Pliocene deposits, from the eastern Netherlands have been tabulated, showing the stratigraphical characteristics.

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SAMENVATTING

Het onderzoek van overblijfselen van tertiaire Elasmobranchii richt zich in Nederland in hoofdzaak naar de stratigrafische karakteristieken. Omdat het mariene Tertiair economisch oninteressant is, worden deze lagen zelden ontgonnen, zodat men veelal op boringen voor drinkwatervoorziening of van de Nederlandse Aardolie Maatschappij is aangewezen. Deze boringen moeten dan continu bemonsterd worden en de monsters moeten tenminste enkele kilogrammen groot zijn. In boringen waar aan deze voorwaarden is voldaan, zijn reeds goede resultaten bereikt. De oudere boringen zijn door een gebrekkige bemonstering en documentatie voor stratigrafisch onderzoek aan Elasmobranchii meestal ongeschikt, evenals vroeger verzameld materiaal uit daglichtontsluitingen.

In Oost-Nederland is nu een gedetailleerde lithostratigrafie beschikbaar (Van den Bosch et al., 1975). Ook zijn in dit gebied grote collecties Elasmobranchii bijeengebracht, welke in de tabel ten opzichte van de lithostratigrafie zijn uitgezet. De stratigrafische karakteristieken komen hierin goed naar voren. Behalve uit het Tertiair in Oost-Nederland, zijn fauna's verzameld in een boring te Haamstede van de Rijkswaterstaat-Deltdienst, waarin het gaat om vroeg-miocene afzettingen; en in de Formatie van Maassluis (Oud Pleistoceen) van de boring te Ouwerkerk, eveneens op Schouwen-Duiveland, geboord door Rijkswaterstaat. Betrouwbaar materiaal uit de laat-oligocene afzettingen is in Nederland nog niet aanwezig; monsters van deze afzettingen, afkomstig uit een door het Rijksmuseum van Geologie en Mineralogie uitgevoerde boring te Lievelede, gem. Lichtenvoorde (Oost-Nederland), moeten op dit moment nog worden onderzocht. Eocene Elasmobranchii in situ zijn in Nederland nog nauwelijks bekend; onderzoek van boringmonsters is in dit opzicht noodzakelijk. Enkele Elasmobranchii werden verzameld in het Paleoceen van de Staatsmijn Maurits te Geleen-Lutterade in Zuid-Limburg.

INTRODUCTION

The research of elasmobranch remains in the Netherlands is mainly directed to the stratigraphical characteristics and to a lesser degree to the biological systematics and nomenclature.

It has always been a large problem that only little detailed research in the Netherlands has been done on the Tertiary deposits which occur so frequently in the subsoil. The marine Tertiary deposits are unimportant for the exploitation of minerals and for water supply. Only in the eastern part of the country marine Tertiary clays were locally exploited for brickworks, but the economical situation of that industrial branch has deteriorated so much that only one interesting clay-pit is still being worked, viz. near Winterswijk, where Middle Oligocene clay is exploited.

For the study of Tertiary deposits in the Netherlands we are dependent almost entirely on borings. Of course these borings have to conform to certain standards; for example there must be a continuous sampling and the samples must be at least some kilograms in size. The deep-borings made with bailer sampling by 'Rijkswaterstaat' in the southwestern part of the country in the sixties, answer to these demands. From these borings often 50 kg of sediment from each penetrated meter was collected for research purposes. Important faunas were collected from very fossiliferous glauconitic sands which very probably belong to the Early Miocene, also from marine Early Pleistocene deposits.

In 1975 a paper by van den Bosch, Cadée & Janssen (*Scripta Geologica* 29) was published in which a clear litho- and biostratigraphic survey of the Tertiary deposits in the Eastern part of the

Netherlands was given for the first time. In this publication clearcut short preliminary lists of elasmobranchs were given for each lithological unit. These lists have been elaborated here in detail for comparison purposes (Table 1).

At Lievelede, near Lichtenvoorde in the province of Guelders, a deep-boring with a large diameter was made by the National Museum of Geology and Mineralogy in the winter of 1977-78. In this boring Early Pliocene, Late and Middle Miocene, and Late and Middle Oligocene deposits were found, and 50 to 100 kg of sediment were collected per meter. Some of these samples contain shark teeth, but the preliminary results are not yet available.

Furthermore it is endeavoured to sample the complete trajects of some deep-borings for water supply, or some deep-borings of the 'Nederlandse Aardolie Maatschappij', as far as the Tertiary interval is concerned. The results of this are encouraging and the quality of the samples is often exceptional, but this way of sampling is always a particularly strenuous and time-consuming job. Therefore not all borings which are made can be sampled. A selection is made out of the many possibilities.

Concerning the older Dutch collections of Tertiary elasmobranchs it has to be noted that a valid documentation is usually lacking. Except for the old collections from exposures in the Eastern part of the Netherlands, almost the entire available material is of no stratigraphical value (except that from Southern Limburg, which is not treated here further). The large collections for instance from the Peel area, collected from the old deep-borings of the 'Rijksopsporing van Delfstoffen', are almost entirely unreliable, partly because it is not known from which boring or depth the material originates, partly also because the stratigraphical position is in doubt owing to contamination or other slipshod methods.

COLLECTING TECHNIQUES

With respect to collecting methods the following should be said. Up to several years ago fossils were collected practically only visually in exposures. Boring samples were sieved (often with 2 mm mesh) and superficially picked out. We have found, however, that systematical washing of large sediment samples with a 0.125 mm mesh may yield much material of elasmobranchs. Groups like *Raja*, *Scyliorhinus*, small Carcharhinidae and *Squalus* have proven to be considerably more common than was thought before. Also we find that the small scales of sharks in some sediments are tens of times more numerous than the teeth of the same species. Already a considerable percentage of the scales will be lost, if for instance a 0.250 mm mesh is used instead of a 0.125 mm mesh. Using a sieve with a mesh of 0.420 mm means that all shark scales and already a part of the smaller shark and ray teeth will be lost.

The collected sediment is washed in two fractions, one smaller than 1 mm, the other larger than 1 mm. The courser fraction is picked out without further treatment, but glauconite grains and fine clay-flakes often have to be removed from the finer fraction with the help of a magnetic separating device, before it can be picked out at a magnification of 50 x.

STRATIGRAPHICAL DIVISIONS

For further interpretations of the collected faunas it is necessary to divide the Dutch Tertiary deposits lithostratigraphically. The earlier stratigraphical divisions are generally insufficient for this

purpose, also there is no room for any extensions. The recent divisions as introduced by the Dutch Geological Survey in 1975 are no answer to our purpose either. These divisions have been chosen too roughly or illogically with respect to unconformities or hiatuses occurring in the deposits of the North Sea Basin. Moreover the definitions and type sections are sometimes open to further discussion.

A local lithostratigraphy has therefore been developed for the Eastern part of the Netherlands by van den Bosch, Cadée & Janssen (1975). This detailed division proved to be particularly satisfactory, although it would be better to raise the 'members' in rank to 'formations', in order to make further refinement possible, as is done for example on a large scale for the Quaternary deposits of the Netherlands. Also for other regions in the Netherlands, from which important collections are present from the Tertiary, it will undoubtedly be an improvement to fit the sampled sections in a well-founded lithostratigraphy in order to make an accurate bio- or chronostratigraphy possible in the future. The standard now available for the Eastern part of the Netherlands may partly be used for this purpose elsewhere.

STRATIGRAPHICAL SURVEY OF THE ELASMOBRANCH FAUNAS

In outline the following is known about elasmobranch stratigraphy in the Netherlands at the moment.

Paleocene

In the southern part of the province of Limburg very fossiliferous Paleocene deposits were sampled in 1956 by the Dutch Geological Survey from shaft III of State Mine 'Maurits' at Geleen-Lutterade. The material was collected from a depth between 167.20 and 169.20 m. Stratigraphical details are still lacking. The following shark teeth have been recognized in the samples picked out up to now:

<i>Rhinoptera</i> sp.	1 x
<i>Odontaspis rutoti</i> (Winkler, 1878)	1 x
<i>Odontaspis hopei</i> Agassiz 1843	1 x
<i>Striatolamia striata</i> (Winkler, 1874) ?	5 x (juv. specimens)

Eocene

From the Dutch Eocene deposits no elasmobranch remains are available that have been collected in situ and labelled with stratigraphical documentation. The few known finds are unreliable at present. Especially in the Eastern part of the country Eocene deposits must be present with an abundance of shark teeth, but these deposits never have been exposed. The rich fauna of reworked Eocene shark teeth at the base of the Rupelian deposits in Twente certainly reflects this fauna, of which the precise stratigraphical position in the Eocene is of course impossible to determine. This fauna was already published by Leriche (1936) and van den Bosch (1964).

It should be attempted to track down these Eocene deposits by detailed investigations in the field and to exploit them for the collections. Also it will be necessary to investigate the content of Eocene shark teeth in situ from boring samples.

Oligocene

Important collections from the Eastern part of the Netherlands are present from the Middle

Oligocene deposits. This was already communicated by van den Bosch et al. (1975). We have found new evidence that a number of changes in the fauna occurred during the Rupelian, more or less parallel with the lithological developments. In the accompanying table an important difference between the lower and the higher parts of the Brinkheurne Member is very striking because of the sudden common occurrence of *Squalus* in the higher parts.

The top of the Brinkheurne Member and the base of the Winterswijk Member were sampled in quantity in the clay-pit 'De Vlijt' at Winterwijk. This clay was washed on a 0.125 mm mesh and picked out subsequently. In some cases more than 2,000 small teeth and scales of sharks and rays could be collected per 50 kg of sediment. It has been attempted to identify the scales, but research on this subject is still in an initial stage. Nine types of scales were found, including those of *Squalus*. Five types of *Raja*, two types of *Dasyatis*, a very small *Galeus* (= *Pristiurus*), *Odontaspis acutissima* Agassiz, 1844, *Hexanchus primigenius* (Agassiz, 1843) and rather much fine material of *Pristiophorus* was collected. In total thousands of teeth and scales are available of which only some tens are larger than 3 mm (compare Steurbaut & Herman, 1978).

With respect to the younger Rupelian, the Winterwijk Member, little can be said. The fauna occurring at the boundary with the Brinkheurne Member was already mentioned above. Nothing is known up to now about shark and ray teeth from the higher part of these very thick deposits (± 130 m!).

The Late Oligocene in the Netherlands is especially well-developed in the Peel region. Well-documented collections of shark teeth from the well-known borings of the 'Rijksopsporing van Delfstoffen' are, however, lacking. Recently very fossiliferous Late Oligocene deposits could be sampled by the National Museum of Geology and Mineralogy at considerable depth from a boring at Lielvelde near Lichtenvoorde in the eastern part of the Netherlands. According to information of Mr. A. W. Janssen the molluscs might indicate the so-called Chattian A. The samples have not yet been picked out, but it is already certain that some elasmobranchs occur, especially *Odontaspis* and *Rhinoptera*.

The larger part of the Late Oligocene deposits, as well as the Early Miocene sediments, have disappeared by erosion. In some parts of the Netherlands a basal gravel with many shark teeth occurs at the base of the Middle Miocene deposits. These teeth are derived from the eroded deposits. This gravel is found at Elsloo, and in the Guelders Achterhoek at various places. A fauna list is given by van den Bosch et al. (1975: 74 - 75).

Miocene

A borehole with a diameter of 45 cm was drilled by 'Rijkswaterstaat' at Haamstede, on the isle of Schouwen-Duiveland (province of Zeeland) in the winter of 1968-69. This boring reached a glauconitic sand at a depth of 132 m below surface, which continued to a depth of 155 m. The higher part of this sand was rather coarse, gradually changing into very fine sand downwards. This glauconitic sand contains a number of shell beds and, especially in the lower part, rather large amounts of elasmobranch teeth. It is almost certain that these are Early Miocene deposits. By special techniques much material could be collected from this boring, resulting in a collection of hundreds of teeth. A paper on this fauna is in preparation. Strikingly common groups in this fauna are *Dasyatis* and *Squalus*, moreover species like *Sphyrna arambourgi* Cappetta, 1970, *Carcharhinus priscus* (Ag.), *Lamna cattica* (Philippi, 1846), *Odontaspis acutissima* Agassiz, 1844, *O. molassica* Joleaud, 1912, *Hexanchus primigenius* (Agassiz, 1843), *Squatina*, *Scyliorhinus*, *Isurus desori* (Ag.), etc.

The Middle Miocene deposits are commonly represented in the subsoil. The hundreds of shark teeth collected by the 'Rijksopsporing van Delfstoffen' in the Peel region seem to originate especially from these deposits. Reliable documentation of these samples is lacking, excluding these samples from this stratigraphical investigation. Rather recently comparable deposits of Middle Miocene age have been found in the Guelders Achterhoek. The sampling of these strata up to now furnished already large collections of teeth, obviously belonging to a younger fauna than the fauna just mentioned from the Haamstede boring. This rich elasmobranch fauna from the Aalten Member, already mentioned by van den Bosch et al. (1975), has now been included in the table. The small and narrow form of *Isurus hastalis* (Ag.) is characteristic for these deposits.

In the Eibergen Member, following the Aalten Member, this species becomes already considerably larger and wider. (See also: de Ceuster, 1976). These latter deposits, which are reckoned to the Late Miocene, are characterized by the strong dominance of *Isurus hastalis*. The other species mentioned in 1975 form only a small part of the total number of teeth.

On top of the Eibergen Member the Zenderen Member occurs, which is also considered to belong to the Late Miocene. These deposits contain a richer fauna and there is a typical ratio between *Isurus hastalis* and *I. escheri*, viz. 3 : 1. The groups of *Raja* and *Squalus* appear together again, with a still undescribed *Lamna* (= *Lamna* sp. van den Bosch, 1969). This assemblage is typical for the deposits. This *Lamna* species is closely allied to the recent *Lamna nasus* (Bonnaterre, 1788).

Pliocene

A rich fauna is known only from the Delden Member, restricted to the eastern part of the Netherlands. It can be placed in the neighbourhood of the boundary between Pliocene and Miocene. This fauna was already mentioned in 1975. The dominance of some *Raja* species is characteristic for these deposits. *Isurus hastalis* has become considerably less frequent. It is here that we find the very large and wide teeth of this species. Moreover teeth of *Squalus* and a *Cetorhinus* species, differing from *C. maximus* (Gunnerus), attract attention. The other species are mentioned in the table.

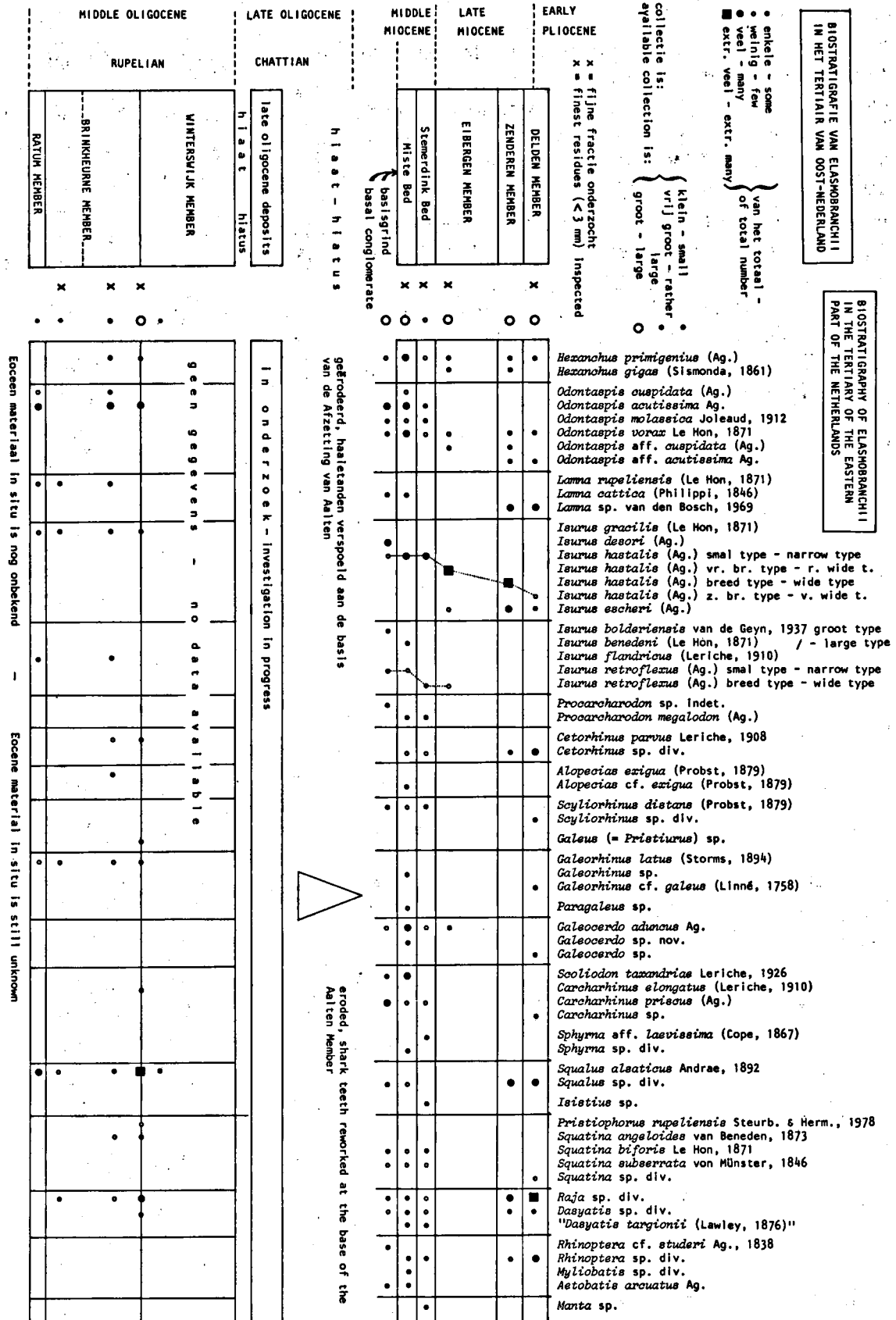
Elasmobranchs from younger Pliocene deposits are hardly known from the Netherlands.

Pleistocene

Only the marine Early Pleistocene deposits, the deposits of the Maassluis Formation (= marine 'Icenian') have furnished a fauna. In borings for water supply in the south-western part of the country sometimes the small teeth and dermal spines of *Raja clavata* Linné, 1758 are found. In the boring Ouwkerk of 'Rijkswaterstaat' on the isle of Schouwen-Duiveland (province of Zeeland) a representative fauna was collected, consisting of some hundreds of teeth of *Raja clavata* Linné, male and female; also several dermal spines were found. Furthermore *Raja montagui* Fowler and two other *Raja* types, *Squalus acanthias* Linné, 1758, *Squatina squatina* (Linné, 1758), *Lamna nasus* (Bonnaterre, 1788) and *Galeorhinus galeus* (Linné, 1758) occur in this fauna. In the higher parts of the Maassluis Formation also *Raja batis* Linné, 1758 was found, but the fauna is much poorer in species. These faunas will be published in future.

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