Meded. Werkgr. Tert. Kwart. Geol. | 25(1) | 73-86 | 1 tab., 5 figs. | Leiden, maart 1988

THE PLEISTOCENE MAMMALIAN FAUNAS FROM THE ZUURLAND BOREHOLES AT BRIELLE, THE NETHERLANDS

by

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Kolfschoten, T. van. The Pleistocene mammalian faunas from the Zuurland boreholes at Brielle, The Netherlands.—Meded. Werkgr. Tert. Kwart. Geol., 25(1): 73-86, 1 tab., 5 figs. Leiden, March 1988.

The boreholes Zuurland-1 and -2 are characterized by a large amount of mammalian fossils. The sections Zuurland-1 (-63 to -96 metres) and Zuurland-2 (0 to -64 metres) yielded hundreds of fossils representing 11 different faunas. The Faunas 1-4 are poor; Faunas 1 and 2 are of Holocene age, Fauna 3 is Weichselian, and Fauna 4 probably Eemian. Fauna 5 is rich in species; it is characterized by the co-occurrence of a small *Mimomys* (indicated as *Mimomys* sp.) and the larger *Mimomys savini* Hinton, 1910. The fauna is dated as Bavelian-Interglacial II of the "Cromerian Complex".

The stratigraphical position of Fauna 6 is not clear. The Faunas 7, 8 and 9 are characterized by the occurrence of *Microtus* (*Allophaiomys*) *deucalion* (Kretzoi, 1969)/*pliocaenicus* (Kormos, 1933). The evolutionary stage of the molars of this species indicates that these faunas do not differ very much in age. The faunas are dated as Late Tiglian/Eburonian (possible Early Waalian).

Mimomys pitymyoides Jarossy & van der Meulen, 1975 occurs in the Late Tiglien/Early Eburonian Fauna 10. Fauna 11 is correlated with a phase of the Tiglian pre-dating the Tiglian C5 (with the fauna from Tegelen) on the basis of the evolutionary stage of the molars of *Mimomys pliocaenicus* Major, 1902.

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CONTENTS

SAMENVATTING

Pleistocene zoogdierfauna's uit de Zuurland boringen te Brielle, Nederland.

Boring Zuurland wordt gekenmerkt door een enorme rijkdom aan fossiele zoogdierresten. Uit de trajecten Zuurland-1 (-63 tot -96 m) en Zuurland-2 (0 tot -64 m) zijn honderden fossielen verzameld afkomstig uit 11 verschillende fauna's.

De Fauna's 1-4 zijn arm; de jongste fauna's (1 en 2) stammen uit het Holoceen, Fauna 3 uit het Weichselien en Fauna 4 waarschijnlijk uit het Eemien. Fauna 5 is rijk en wordt gekenmerkt door het voorkomen van een kleine *Mimomys* (aangeduid als *Mimomys* sp.) en een grotere (*Mimomys savini*). De fauna wordt gecorreleerd met het Bavelien-Interglaciaal II van het "Cromer Complex".

De stratigrafische positie van Fauna 6 is niet duidelijk. In de Fauna's 7, 8 en 9 komt *Microtus* (*Allophaiomys*) *deucalion/pliocaenicus* voor. De kiezen van deze soort, afkomstig uit de verschillende fauna's, vertonen een vergelijkbaar evolutionair stadium hetgeen aangeeft dat de fauna's onderling niet veel in ouderdom verschillen. De fauna's worden gecorreleerd met het Laat Tiglien/Eburonien (eventueel Vroeg Waalien).

In de Laat Tiglien/Vroeg Eburonien Fauna 10 komt o.a. *Mimomys pitymyoides* voor. Op grond van het evolutionaire stadium van de kiezen van *Mimomys pliocaenicus* uit Fauna 11 wordt deze fauna gecorreleerd met een periode van het Tiglien die ouder is dan Tiglien C5 waaruit de fauna van Tegelen afkomstig is.

INTRODUCTION

The Zuurland-2 borehole is located near to borehole Brielle, which is well-known in the literature on Pleistocene mammal-biostratigraphy. This borehole, and others located in the same area, already revealed the presence of mammalian fossils in Pleistocene deposits, but some layers are surprisingly rich.

The first borehole, Zuurland-1 yielded 121 identifiable fossils from the part of the section between -63 and -96 metres. The upper part of that section was not investigated for the presence of mammalian fossils. The second borehole, Zuurland-2 has yielded, up to now, more than seven hundred mammalian remains from nine different parts of the section, representing nine different faunas. Most of the faunas are small (a small number of species represented by a few fossils) but certain parts yielded much material. The layer between -60 and -64 m is especially rich. More than five hundred molars from this horizon represent one of the richest Pleistocene faunas in The Netherlands.

This paper presents a review of the faunas from borehole Zuurland-1 and from the uppermost 64 metres of borehole Zuurland- 2. Each fauna is represented by the mammalian fossils from a particular layer which is separated from other fossiliferous layers by parts of the section which are poor in mammalian fossils or in which mammalian fossils are lacking. The faunas are numbered from top to base. They are also described in this order.

Elements from the upper jaw are indicated with a capital character (*e.g.* M3), lower jaw elements with a lower case character (*e.g.* m3).

THE FAUNAS

Fauna 1

Material—Borehole Zuurland-2 (-14 to -15 m):

RODENTIA

Microtus oeconomus Keijserling & Blasius, 1841	(1)*
Microtus sp.	(1)

* = number of elements

Remarks—The presence of the root vole, *Microtus oeconomus*, is not very significant for the age of Fauna 1. It is present in NW European faunas since the "Cromerian Complex", for instance from the fauna from West Runton (Stuart, 1982).

The species occurs in a wide range of habitats; so it also doesnot give detailed information about the palaeoecological conditions.

Fauna 2

Material—Borehole Zuurland-2 (-20 to -22 m):

RODENTIA

Microtus sp.	(4)
Apodemus sylvaticus (Linnaeus, 1758)	(1)

Remarks—The presence of *Apodemus sylvaticus* indicates temperate to warm climatic conditions. None of the two species from Fauna 2 give detailed information about the age of the fauna.

Fauna 3

Material—Borehole Zuurland-2 (-22.70 m):

RODENTIA

Microtus oeconomus (Keijserling & Blasius, 1841)	(1)

Remarks—The lower molar of the root vole, *Microtus oeconomus*, from this fauna is remarkably larger than the same element in Fauna 1. This might indicate glacial conditions; the English fossil record shows that the remains of the populations which lived under glacial conditions are larger than those from interglacial and/or interstadial periods. However the late Eemian *Microtus oeconomus* from England is also rather large. Therefore, it can be concluded that we are dealing with a Late Eemian or a Weichselian fossil.

Fauna 4

Material—Borehole Zuurland-2 (-25.70 m):

RODENTIA

Arvicola terrestris (Linnaeus, 1758)	(1)

Remarks—The molar of the water vole, *Arvicola terrestris*, shows a so-called Microtus-enamel-differentiation. This type of differentiation is typical for the living water voles from NW Europe. Water voles with this type of enamel differentiation occur in The Netherlands since the Saalian.

Fossils of these water voles were collected from ice-pushed sediments deposited during the Bantega-Interstadial, the second and last warm phase of the Saalian glacial period. More primitive water voles with molars characterized by the absence of a clear enamel differentiation are known from faunas such as Maastricht- Belvédère and Wageningen-Fransche Kamp (van Kolfschoten, in press). These faunas are correlated with the Hoogeveen interstadial, the first and earliest temperate warm phase of the Saalian glacial period (van Kolfschoten, 1985).

The water vole has a wide range of habitats; mainly along small streams, brooks and stagnant water, but also far away from water. The fossil record shows that *Arvicola terrestris* occurred in NW Europe during glacials and interglacials.

Fauna 5
Material—Borehole Zuurland-2 (-27 to -37 m):

INSECTIVORA	
Desmana sp.	(1)
Sorex (*Drepanosorex*) sp.	(1)
Sorex araneus Linnaeus, 1758	(1)
RODENTIA	
Clethrionomys glareolus (Schreber, 1780)	(3)
Mimomys savini Hinton, 1910	(3)
Mimomys sp. (large species)	(31)
Mimomys sp. (small species)	(1)
Microtus cf *arvalis* (Pallas, 1779)	(3)
Pitymys gregaloides Hinton, 1923	(1)
Microtus sp.	(14)

Remarks—More than half of the mammalian fossils of this fauna originates from the part of the section between -31 and -33 m. Most of the material belongs to a large type of *Mimomys* (Fig. 1.1). The size and the hypsodonty of the molars, the high enamel- free areas and the absence of a Mimomys-island (Figs 4 and 5) indicate that we are dealing with *Mimomys savini*, the ancestor of *Arvicola terrestris*.

The large *Mimomys savini* co-occurs with a smaller type of the genus *Mimomys*; the exact species cannot be identified on the basis of the single molar found.

The presence of *Clethrionomys glareolus*, which nowadays inhabits a wooded environment, indicates interglacial or interstadial climatic conditions during deposition of this part of the section.

Age of the fauna—The presence of *Mimomys savini*, a small *Mimomys* species and *Pitymys gregaloides*, and the absence of *Microtus* (*Allophaiomys*) indicate that the fauna should be correlated with the Templomhegy-Phase (Pitymys arvalidens Partial Range Zone) of the Lower Biharian (van der Meulen, 1973).

Mimomys savini was replaced by *Arvicola terrestris* during the "Cromerian Complex" (van Kolfschoten, in press). Boreholes Noordbergum 13 and 14 yielded *Arvicola* molars from deposits which are palynologically dated as Interglacial IV of the "Cromerian Complex". The fauna of West Runton (Eastern England) with *Mimomys savini* (see Stuart, 1982) is correlated with the same interglacial, but in my opinion the fauna from West Runton might be somewhat older (van Kolfschoten, in press).

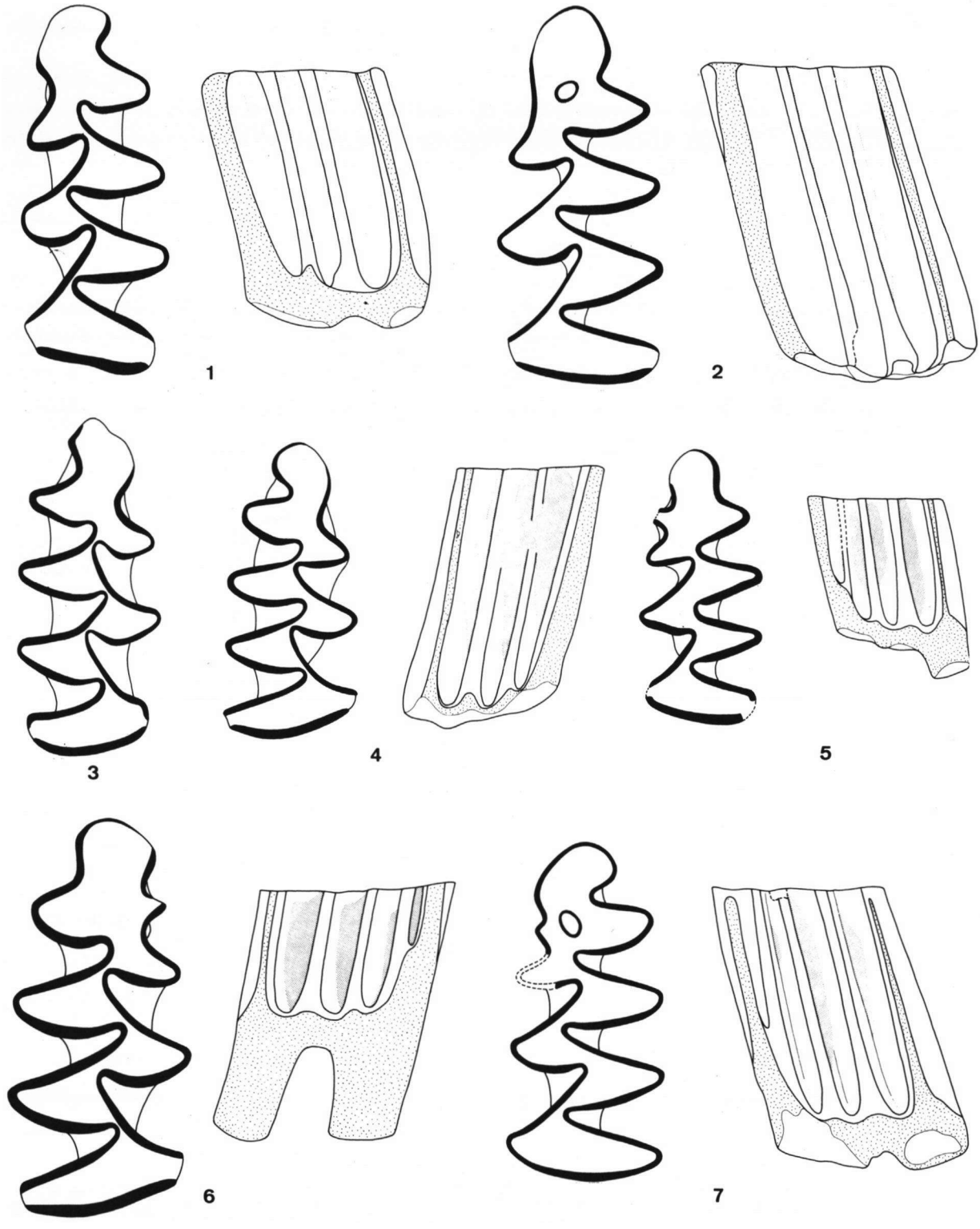

Fig. 1. Rodent molars from boreholes Zuurland-1 and -2.

1. Fauna 5: *Mimomys savini*, m1 sin.
2 and 3. Fauna 7: 2. *Mimomys* sp. (large species), m1 sin.; 3. *Microtus* (*Allophaiomys*) *deucalion*/*pliocaenicus*, m1 dext.
4-6. Fauna 10: 4. *Mimomys blanci*, m1 dext.; 5. *Mimomys pitymyoides*, m1 sin.; 6. *Mimomys pliocaenicus*, m1 dext.
7. Fauna 11: *Mimomys reidi*, m1 sin.

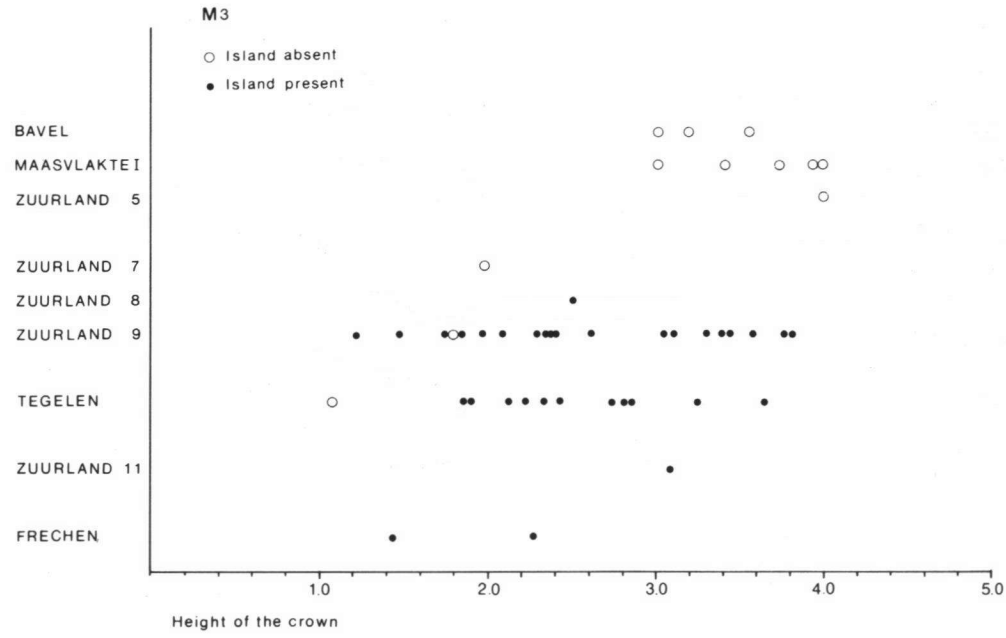

Fig. 2. Mean height of the anterior enamel free areas of the M3 of the large *Mimomys* species from different localities (Frechen: *M. polonicus* Kowalski, 1960; Zuurland 11 and Tegelen: *M. pliocaenicus*; Zuurland 9, 8 and 7: *Mimomys* sp.; Zuurland 5, Maasvlakte 1 and Bavel: *M. savini*).
(arrow means that the mean height of the areas is higher than the indicated value)

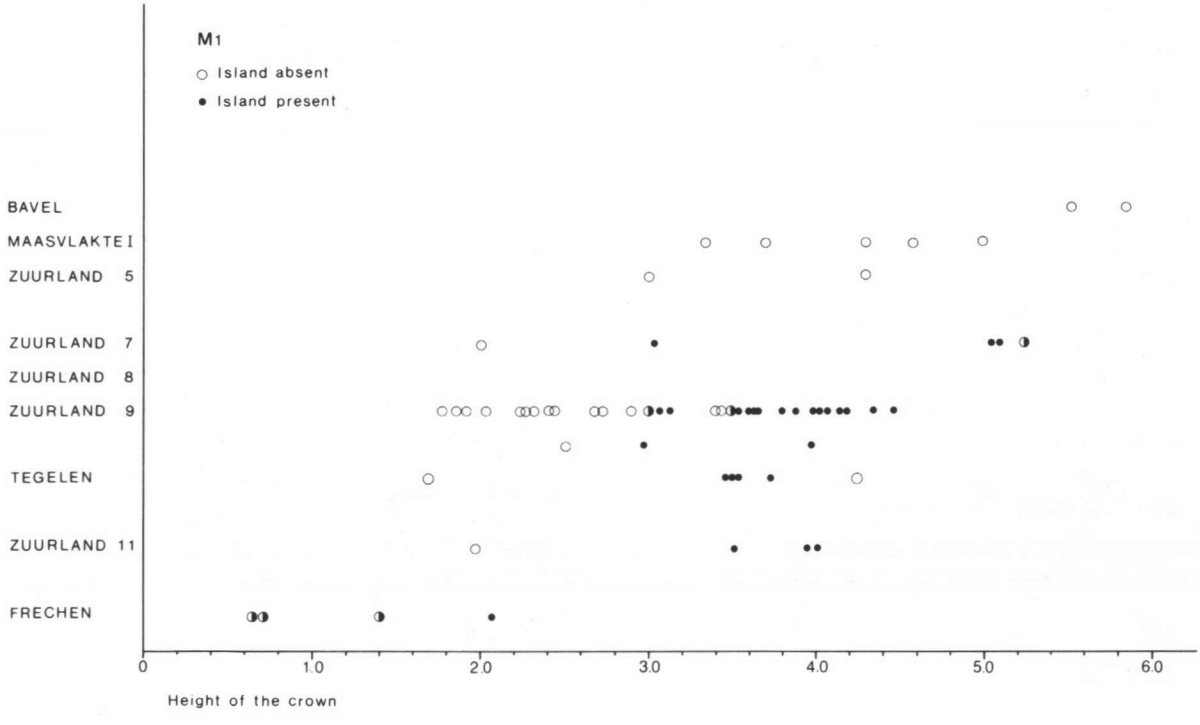

Fig. 3. Height of the lingual enamel free area of the m1 of the large *Mimomys* species from different localities (Frechen: *M. polonicus*; Zuurland 11 and Tegelen: *M. pliocaenicus*; Zuurland 9, 8 and 7: *Mimomys* sp.; Zuurland 5, Maasvlakte 1 and Bavel: *M. savini*).
(arrow means that the mean height of the areas is higher than the indicated value)

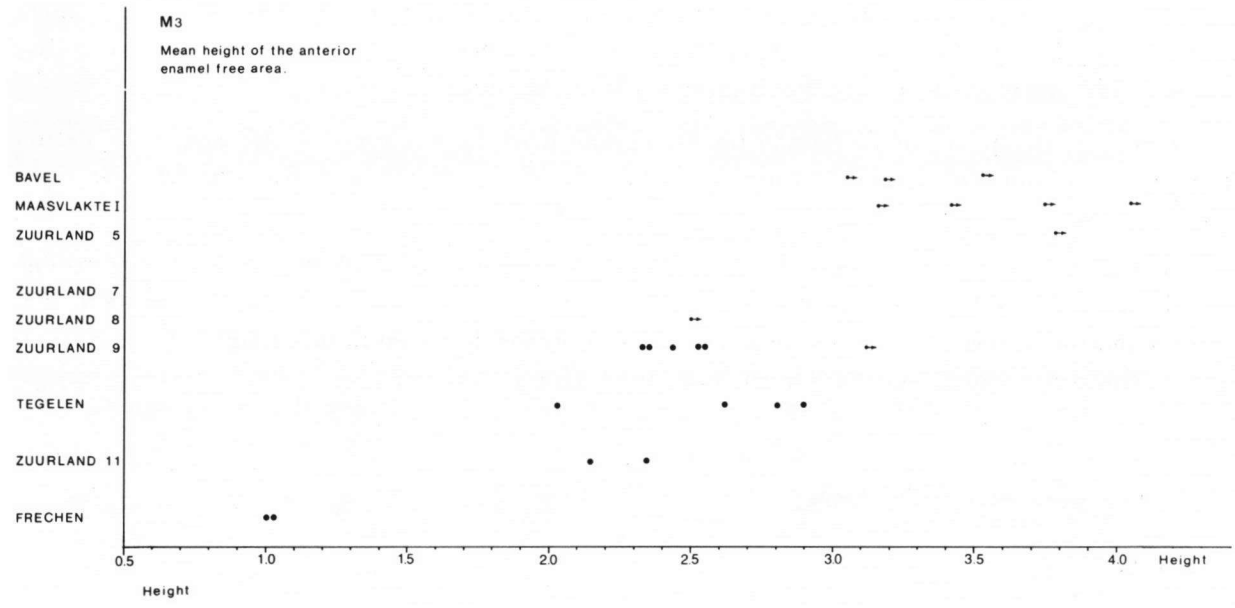

Fig. 4. Diagram showing the relation between the height of the crown and the absence or presence of a Mimomys-island of the M3 of the large *Mimomys* species from different localities (Frechen: *M. polonicus*; Zuurland 11 and Tegelen: *M. pliocaenicus*; Zuurland 9, 8 and 7: *Mimomys* sp.; Zuurland 5, Maasvlakte 1 and Bavel: *M. savini*).

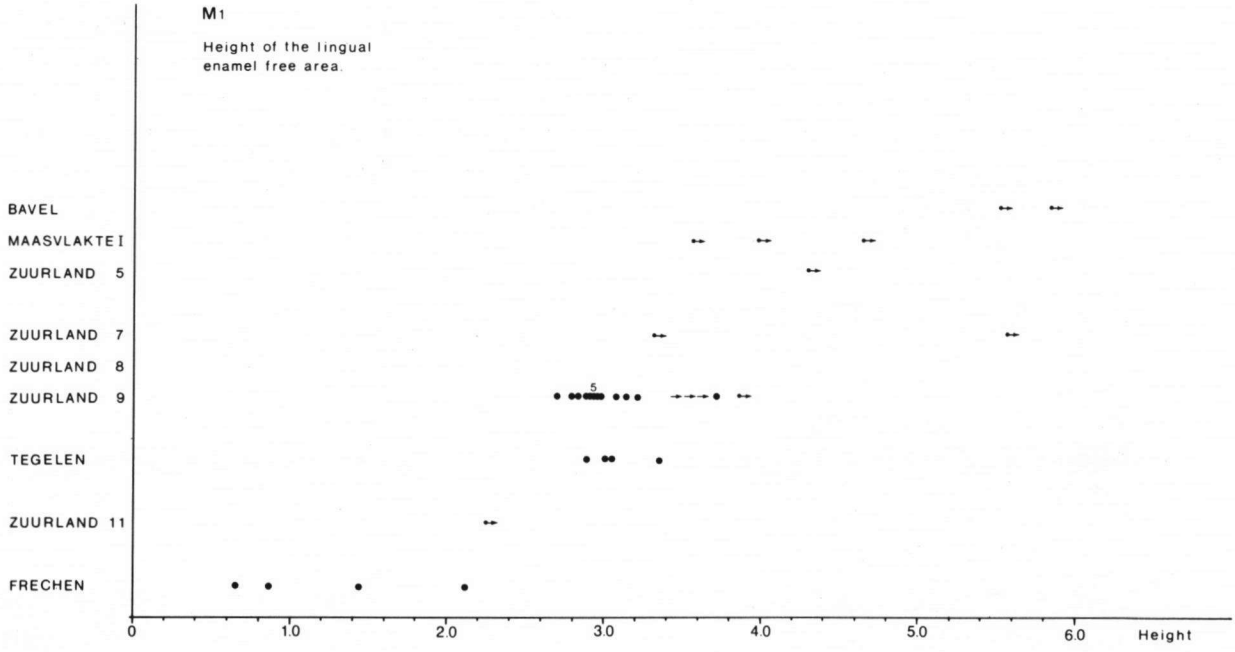

Fig. 5. Diagram showing the relation between the height of the crown and the absence or presence of a Mimomys-island of the m1 of the large *Mimomys* species from different localities (Frechen: *M. polonicus*; Zuurland 11 and Tegelen: *M. pliocaenicus*; Zuurland 9, 8 and 7: *Mimomys* sp.; Zuurland 5, Maasvlakte 1 and Bavel: *M. savini*).

Fauna 5 of borehole Zuurland differs from the West Runton fauna by the presence of a small *Mimomys* species which doesnot occur in the fauna of West Runton. It is therefore concluded that Fauna 5 is somewhat older than the fauna from West Runton.

Fauna 5 corresponds to the fauna from Bavel (van Kolfschoten, in press). *Mimomys savini* occurs in both faunas and *Microtus arvalis* occurs in the fauna from Bavel, as known from the Bavelian type-locality.

Summarizing it may be stated that Fauna 5 should be correlated with the late Early Pleistocene or the early Middle Pleistocene. The contradiction between the age on the basis of the mammalian faunas and that on basis of the sediment-petrological data is discussed in the chapter on the correlation between the faunas and the Dutch Standard division.

Fauna 6
Material—Borehole Zuurland-2 (-42.20 to -42.60 m):

INSECTIVORA
- *Desmana* sp. (1)
- *Talpa europaea* Linnaeus, 1758 (1)

RODENTIA
- *Lemmus lemmus* (Linnaeus, 1758) (3)
- *Mimomys* sp. (large species) (3)
- *Mimomys* sp. (small species) (4)
- *Microtus* sp. (5)

Remarks—The small *Mimomys*-species is better represented in this fauna than in the previous one. Fauna 6 is characterized by the presence of the norway lemming, *Lemmus lemmus*. Its present distribution is restricted to the arctic areas. However, in Poland *Lemmus lemmus* was found in Early and Middle Pleistocene faunas, indicating a temperate climate and the presence of forest and steppe (Kowalski, 1977). The species also occurs, although rarely, in the Middle Pleistocene faunas from Petersbuch (von Koenigswald, 1970) and Miesenheim (van Kolfschoten, in press), together with species indicating warm-temperate climatic conditions. According to Kowalski (1977) *Lemmus lemmus* is restricted to the arctic zone since the Late Pleistocene.

Fauna 7
Material—Borehole Zuurland-2 (-43.75 to -46.00 m):

INSECTIVORA
- *Galemys kormosi* (Schreuder, 1940) (2)
- *Desmana thermalis* Kormos, 1930 (4)
- *Desmana* sp. (3)
- *Talpa europaea* Linnaeus, 1758 (1)
- *Sorex* (*Drepanosorex*) cf *praearaneus* Kormos, 1934 (4)

RODENTIA
- *Eliomys quercinus* Linnaeus, 1766 (1)
- *Apodemus sylvaticus* (Linnaeus, 1758) (1)
- *Lemmus lemmus* (Linnaeus, 18758) (3)
- *Mimomys* sp. (large species) (12)
- *Mimomys* sp. (small species) (44)
- *Microtus* (*Allophaiomys*) *deucalion* (Kretzoi, 1969)/*pliocaenicus* (Kormos, 1933) (33)

Remarks—*Lemmus lemmus* and *Apodemus sylvaticus* occur only in the upper 0.25 m of this part of the section. The single molar of *Eliomys quercinus*, a species which indicates interglacial climatic conditions, originates from a depth between -44 and -45 m.

The large amount of variation within the fossil desmans of Fauna 7 is remarkable. The elements of *Galemys kormosi* and *Desmana thermalis* are morphologically similar to those of the corresponding species from the fauna from Tegelen, but the desman fossils of this fauna are larger. The material referred to *Desmana* sp. is either too small or too large to be assigned to *Desmana thermalis* (pers. comm. Rümke, 1987).

The molars of the large *Mimomys* species are high-crowned and have rather high enamel-free areas (Fig. 1.2). Some m1 show the presence of a Mimomys-island (Fig. 5); in the single M3 the island is absent. The elements assigned to the large type of *Mimomys* differ from those of *Mimomys savini* from the upper part of the section between -27 and -37 m and from those of *Mimomys pliocaenicus* from the lower part of the section between-65.25 and -66.55 m by the presence of a Mimomys-island and the height of the enamel-free areas (Fig. 3). Therefore the material is referred to *Mimomys* sp. (large type).

The smaller *Mimomys* molars are not very high-crowned; the enamel-free areas of the M3 are rather low. The little worn M3 shows the presence of a Mymomys-island; in the other M3 it is absent. No m1 of the smaller *Mimomys* species from this part of the section is available. Therefore the material could not be identified to specific level.

The molars assigned to *Microtus* (*Allophaiomys*) *deucalion/pliocaenicus* (Fig. 1.3) show hardly any differentiation in the enamel. Also the A/L ratio, a value for the relative length of the anterior part of the m1, indicates that we are dealing with *Microtus* molars with an evolutionary stage in between that of *M.* (*A.*) *deucalion* and that of *M.* (*A.*) *pliocaenicus*.

Age of the fauna—The stratigraphical range of *Microtus* (*Allophaiomys*) is restricted to the Late Villanyian and the Early Biharian. The genus doesnot occur in the late Villanyian fauna from Tegelen. Therefore this fauna must be younger than the fauna from Tegelen.

Borehole Brielle also yielded, from a part of the section between -57 and -58 m, an element of *Microtus* (*Allophaiomys*) (van der Meulen & Zagwijn, 1974). The characteristics of this element fit within the variability of the elements of Fauna 7. Therefore I prefer to assign this element from borehole Brielle also to *Microtus* (*Allophaiomys*) *deucalion/pliocaenicus*, the type transitional between *M.* (*A.*) *deucalion* and *M.* (*A.*) *pliocaenicus*.

The element from borehole Brielle was dated as Eburonian (van der Meulen & Zagwijn, 1974). This might also be the case for Fauna 7 of borehole Zuurland.

Fauna 8
Material—Borehole Zuurland-2 (-50 to -56 m):

INSECTIVORA
Sorex (*Drepanosorex*) *praearaneus* Kormos, 1934 (1)
RODENTIA
Mimomys sp. (large species) (3)
Mimomys sp. (small species) (9)
Microtus (*Allophayomys*) *deucalion* (Kretzoi, 1969)/*pliocaenicus* (Kormos, 1933) (19)

Remarks—The faunal list is based on a small number of partly incomplete fossils. The fauna resembles Fauna 7 very much; the composition of the fauna and the morphology of the different elements correspond well. This indicates that we are dealing with faunas from about the same biotope which do not differ very much in age.

Fauna 9
Material—Borehole Zuurland-1 (-63.10 to -64.00 m):

RODENTIA	
Lemmus lemmus (Linnaeus, 1758)	(1)
Mimomys sp. (large species)	(5)
Mimomys reidi Hinton, 1910	(2)
Mimomys blanci van der Meulen, 1973	(4)
? *Mimomys pitymyoides* Janossy & van der Meulen, 1975	(2)

Borehole Zuurland-2 (-62.00 to -64.00 m) (-64 m is the depth of borehole Zuurland-2 to date):

INSECTIVORA	
Soricidae sp. (small species)	(3)
Soricidae sp. (large species)	(9)
Desmana thermalis Kormos, 1930	(4)
Galemys kormosi (Schreuder, 1940)	(9)
Talpa sp.	(1)
LAGOMORPHA	
Hypolagus ? sp.	(3)
RODENTIA	
Spermophilus sp.	(1)
Ungaromys sp.	(3)
Clethrionomys sp.	(4)
Lemmus lemmus (Linnaeus, 1758)	(10)
Mimomys sp. (large species)	(183)
Mimomys reidi Hinton, 1910 and *Mimomys blanci* van der Meulen, 1973	(283)
Mimomys sp. nov.	(1)
Microtus (*Allophaiomys*) *deucalion* (Kretzoi, 1969)/*pliocaenicus* (Kormos, 1933)	(26)
CARNIVORA	
Mustelidae sp.	(1)

Remarks—The Fauna 9 list of species was compiled from the fossils from boreholes Zuurland-1 and -2, because the distance between these two boreholes is only a few metres. Therefore I suppose that the fossils from both boreholes originate from the same interval. The lithological data confirm this idea.

The above list is preliminary, as the material from the Zuurland-2 Fauna 9 is not yet studied in detail.

The fauna is characterized by the occurrence of the norway lemming, *Lemmus lemmus*, and a groundsquirrel, *Spermophilus* sp., indicative of a rather open vegetation. Indeed, species such as *Apodemus sylvaticus* and the glirids, which indicate a wooded environment, are absent. This points to continental climatic conditions during deposition of this particular part of the section.

Age of the fauna—According to Kretzoi's original concept (Kretzoi, 1965) the European Villanyian faunas are characterized by a dominance of *Mimomys*, as in the Biharian faunas *Microtus* is dominant.

In Fauna 9 *Mimomys* is dominant and therefore I correlate this fauna with the Late Villanyian. The morphology and the differentiation in the enamel-thickness of the molars of *M.* (*A.*) *deucalion/pliocaenicus* is very similar to that of corresponding elements of the Faunas 7 and 8. This means that these faunas do not differ in age very much.

Fauna 10
Material—Borehole Zuurland-1 (-65.25 to -66.55 m):

RODENTIA

Mimomys pliocaenicus Major, 1902	(7)
Mimomys reidi Hinton, 1910	(4)
Mimomys blanci van der Meulen, 1973	(3)
Mimomys pitymyoides Janossy & van der Meulen, 1975	(1)

Remarks—The part of the section of borehole Zuurland-1 yielding the fossils of Fauna 10 is separated from the part in which Fauna 9 was found by a non-fossiliferous layer. Therefore, and because of the morphological differences between the molars of *Mimomys pliocaenicus* of Fauna 10 (Fig. 1.6) and *Mimomys* sp. (large species) of Fauna 9, both faunas are treated separately.

The occurrence of *Mimomys pitymyoides* (Fig. 1.5) is remarkable. The *Mimomys pitymyoides*-fauna, known from many localities in Central Europe and from East and West Runton (Crag) in Britain (Mayhew & Stuart, 1986), is encountered here for the first time in The Netherlands. The fauna of East Runton has been correlated with the Tegelen fauna because of the similarity of both faunas and because of the corresponding evolutionary stage of the *M. pliocaenicus* molars (Mayhew & Stuart, 1986). However *M. pitymyoides* does not occur in the rather rich fauna of Tegelen. Therefore I suppose that the *M. pitymyoides* faunas of Eastern England and Fauna 10 of borehole Zuurland are somewhat younger than the Tegelen fauna and should be correlated with the latest part of the Tiglian (TC6) or with the earliest part of the Eburonian.

The molluscan evidence from this part of the section indicates cool climatic conditions and is correlated with the level of borehole Brielle dated as TC6 in which *Dicrostonyx torquatus* (Pallas, 1779) occurs (Meijer, 1985, 1988).

Fauna 11
Material—Borehole Zuurland-1 (-91 to -96 m):

INSECTIVORA

Galemys cf *kormosi* (Schreuder, 1940)	(1)
Sorex (*Drepanosorex*) *praearaneus* Kormos, 1934	(1)
Mimomys pliocaenicus Major, 1902	(51)
Mimomys reidi Hinton, 1910	(15)
Mimomys blanci van der Meulen, 1973	(7)

Remarks—All species in this fauna occur also in the Tegelen fauna. The elements of *Galemys* cf *kormosi* correspond in size with those of the Tegelen fauna, in contradiction to the *Galemys* fossils of the other faunas from borehole Zuurland which are nearly all distinctly larger.

Mimomys pliocaenicus is dominant in this fauna, whereas *M. reidi* (Fig. 1.7) together with *M. blanci* are dominant in the fauna from Tegelen. Also the evolutionary stages of the *M. pliocaenicus* molars of the two faunas differ. The height of the enamel-free areas (Fig. 2 and 3) and the absence or occurrence of the Mimomys-island in the M3 and m1 (Fig. 4 and 5) indicate that the molars of Fauna 11 are the more primimtive ones. Therefore Fauna 11 is correlated with an earlier phase of the Tiglian (TC4 ?).

CORRELATION BETWEEN THE FAUNAS AND THE DUTCH STANDARD DIVISION OF THE PLEISTOCENE

The fossil remains of Fauna 1 and 2 originate from sediments assigned to the Westland Formation (Burger, 1988), deposited during the Holocene. Fauna 3 with *Microtus oeconomus* is correlated with the Weichselian on the basis of its occurrence in deposits assigned to the Twente Formation.

Sediments of the Kreftenheye/Eem Formation (-23.60 to -36.25 m) yielded faunal remains of the Faunas 4 and 5. The occurrence of *Arvicola terrestris* in Fauna 4 indicates a post Early Saalian Hoogeveen interstadial age for this fauna. This corresponds to the lithostratigraphical, palynological and malacological data for this part of the section. However, Fauna 5, from a depth of -27 to -37 m, indicates an Early to early Middle Pleistocene age. Most probably the fauna dates from a temperate phase of the Bavelian or the first part of the "Cromerian Complex". This conclusion is in disagreement with sediment-petrological data (Burger, 1988). The contradiction between the sediment-petrological and mammal paleontological data can be due to reworking of the mammalian fossils. However, the remains do not show any traces of reworking. Furthermore, although the highest concentration is found at the level around -32 m remains of Fauna 5 are found scattered over the entire interval of -27 to -37 m.

Fauna 5 corresponds in many aspects with the smaller mammals of the oldest fauna-association collected from the Maasvlakte (Vervoort-Kerkhoff & van Kolfschoten, 1988). Therefore I suppose that both faunas are derived from about the same stratigraphical level.

The Faunas 6, 7 and 8 were collected from sediments assigned to the Kedichem Formation, deposited during the Early Pleistocene. The stratigraphical position of Fauna 6 is not clear. The occurrence of *Lemmus lemmus* might point to deposition under rather continental climatic conditions. Furthermore the rather poor Fauna 6 differs from Faunas 5 and 7 in composition. Fauna 6 should be correlated with a phase with an age in between that of fauna 5 and Fauna 7. However, the occurrence of *Pitymys gregaloides* in Fauna 5 and the occurrence of *Microtus* (*Allophaiomys*) *deucalion*/*pliocaenicus* in Fauna 7 indicates that there is a large stratigraphical hiatus between both intervals.

Because of the similarities between the composition of the Faunas 7 and 8 and the evolutionary stage of the present *Microtus* molars it can be stated that the faunas do not differ very much in age. The evolutionary stage of the *Microtus* (*Allophaiomys*) molars indicates that we deal with rather primitive *Microtus* (*Allophaiomys*) faunas which are much older than the fauna from Bavel and postdate the Tegelen fauna.

In the opinion of Meijer (1988) Faunas 7 and 8 should date respectively from the Waalian and from an interglacial with a Waalian age or older. A Waalian age of the level with Fauna 7, as is suggested by Meijer (1988) and de Jong (1988) cannot be excluded on the basis of the smaller mammals.

FAUNA	DIEPTE m.o.m.	Sorex D. praearaneus	Sorex araneus	Soricidae (kleine vorm)	Soricidae (grote vorm)	Desmana thermalis	Desmana sp.	Galemys kormosi	Talpa europaea	Talpa sp.	Hypolagus?	Spermophilus sp.	Eliomys quercinus	Muscardinus sp.	Ungaromys sp.	Clethrionomys sp.	Clethrionomys glareolus	Lemmus lemmus	Mimomys pliocaenicus	Mimomys reidi	Mimomys blanci	Mimomys pitymyoides	Mimomys sp. (grote vorm)	Mimomys sp. (kleine vorm)	Mimomys sp. (new species)	Mimomys savini	Arvicola terrestris	Microtus (A.) deucalion /pliocaenicus	Microtus arvalis	Microtus oeconomus	Microtus sp.	Pitymys gregaloides	Apodemus sylvaticus	Mustelidae
1	14 - 15	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	+	+	•	•	•
2	20 - 22	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	+	•	+	•
3	22.70	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	+	•	•	•	•
4	25.70	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	+	•	•	•	•	•	•	•
5	27 - 37	●	+	•	•	•	+	•	•	•	•	•	•	•	•	•	•	+	•	•	•	•	+	+	•	+	•	•	●	•	+	+	•	•
6	42.20- 42.60	•	•	•	•	•	+	•	+	•	•	•	•	•	•	•	•	+	•	•	•	•	+	+	•	•	•	•	•	•	+	•	•	•
7	43.75- 46.00	●	•	•	+	+	+	+	•	•	•	•	+	•	•	•	•	+	•	•	•	•	+	+	•	•	+	•	•	•	•	•	+	•
8	50 -56	+	•	•	•	•	•	+	•	•	•	•	•	+	•	•	•	•	•	•	•	•	+	+	•	•	+	•	•	•	•	•	•	•
9	62 - 64	•	•	+	+	+	•	+	•	+	+	+	•	•	+	+	•	+	•	+	•	+	•	+	•	•	+	•	•	•	•	•	•	+
10	65.25- 66.55	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	+	+	+	+	•	•	•	•	•	•	•	•	•	•	•	•
11	91 - 96	+	•	•	•	•	•	●	•	•	•	•	•	•	•	•	•	•	+	+	+	•	•	•	•	•	•	•	•	•	•	•	•	•

Table 1. Range-chart showing the stratigraphical distribution of the mammalian fossils from borehole Zuurland.
(heavy dots mean 'cf' or 'aff.' identifications)

If we are dealing with a Waalian fauna I prefer, in view ot the difference between Fauna 7 and the fauna from Bavel, to correlate the fauna with the early Waalian.

Fauna 9 originates from the Kedichem/Tegelen Formation, from a level which is, on the basis of malacological data, Late Tiglian in age (Meijer, 1988). Such a correlation is, in view of the rather primitive evolutionary stage of the *Microtus* (*Allophaiomys*) molars, well possible, although a slightly younger age cannot be excluded.

Fauna 9 differs from the Faunas 7 and 8 mainly in the composition of the fauna. The evolutionary stage of the molars of *Microtus* (*Allophaiomys*) of Fauna 9 is very similar to that of the molars of Faunas 7 and 8 and to the molar from borehole Brielle, which was dated as Eburonian (van der Meulen & Zagwijn, 1974). This indicates that the Faunas 7, 8 and 9 do not differ very much in age and might date from the Eburonian. The first statement doesnot corresponds with Meijer's (1988) opinion. He correlates the level with Fauna 9 with the late Tiglian and the level with Fauna 7 with the Waalian.

Fauna 10 post-dates the Tegelen fauna and should also be correlated with the latest part of the Tiglian or the earliest part of the Eburonian (see remarks on the fauna).

Fauna 11 is correlated with an earlier phase of the Tiglian, pre-dating the Tiglian TC5 fauna from Tegelen and post-dating the Late Pliocene fauna from Frechen considering the evolutionary stage of the *Mimomys pliocaenicus* molars.

ACKNOWLEDGEMENTS

I am greatly indebted to Mr L.W. Hordijk for his work on the borehole and his permission to study his material. I should like to thank Mrs E. Turner for improving the English text and Dr P.L. de Boer for critical reading of the manuscript.

I am also grateful to Mr J. Luteijn for preparing the illustrations and to all fellow-researchers in this Zuurland- project for the constructive discussions.

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Manuscript received 9 February 1988