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# Muridae (Mammalia, Rodentia) from the Zuurland boreholes near Rotterdam (the Netherlands)

# *Muridae (Mammalia, Rodentia) de los sondeos de Zuurland cerca de Rotterdam (Holanda)*

**Jelle W.F. Reumer [1]**

**Abstract:** The true mice (Muridae) from the Zuurland boreholes are described. Four species have been identified. The most common taxon is *Apodemus sylvaticus*, present in the 42-93 m levels, while one specimen of *A. flavicollis* was found in the Holocene 20-21 m levels. Representatives of the genus *Micromys* are found in the 91-92 m levels (*M.* cf. *M. praeminutus*) and the 14-66 m levels (*Micromys minutus*). The biostratigraphical and paleoecological implications of the finds are discussed. An ecological and thus stratigraphical differentiation is suggested within the interval of 42 to 66 m depth, with Eburonian or Early Waalian age in the upper part, and Late Tiglian age in the lower part of this interval.
**Key words**: Pleistocene, Holocene, Rodentia, Muridae, *Apodemus*, *Micromys*, taxonomy.

**Resumen :** En este trabajo se describen los Muridae de los sondeos de Zuurland. Se han identificado cuatro especies. El taxon más frecuente es *Apodemus sylvaticus*, presente en los niveles entre 42 y 93 m, se ha encontrado un espécimen de *A. flavicollis* en los niveles del Holoceno, 20-21 m. Aparecen representantes del género *Micromys* en los niveles 91-92 m (*M.* cf. *M. praeminutus*) y en los niveles 14-66 m (*Micromys minutus)*. Se discuten las implicaciones bioestratigráficas y paleoecológicas. Se sugiere una diferenciación ecológica, y por tanto estratigráfica, en el intervalo entre los 42 y 66 m de profundidad, con Eburoniense o Waaliense temprano en la parte superior y Tiglianense tardío en la parte inferior del intérvalo.
**Palabras clave**: Pleistoceno, Holoceno, Rodentia, Muridae, *Apodemus, Micromys*, taxonomía.

## INTRODUCTION

For about twenty years, Mr LEEN W. HORDIJK has performed borings in the Zuurland polder (close to the ancient city of Brielle, province of South Holland, some 30 km W of Rotterdam, The Netherlands) as a private project out of scientific curiosity. The technique employed is that of manual bailer sampling, by which means relatively large amounts of sediment can be raised to the surface (HORDIJK, 1988 a, b). All borings have been executed in the same area, the greatest distance between two borings is about 200 m. Preliminary results of part of the second boring (Zuurland-2) were published in a volume edited by VAN KOLFSCHOTEN & DE BOER (1988). Since that date much new material has been retrieved, both from the deeper levels of Zuurland-2 and from borings Zuurland-3, -4, -5, -6, and the highest levels of Zuurland-7. The stratigraphy of the locality is not unambiguously clear, but can generally be summarized as follows: up till 21 m below surface Holocene; 29-36 m Cromerian; 38-45 m Eburonian or Early Waalian; 51-55 m Eburonian; 61-67 m Late Tiglian (TC5); and below 76 m Middle or Early Tiglian (see also Figure 1). Since the late 1990's, several publications have appeared describing various groups of small mammals from the boreholes: some *Allophaiomys* material (VAN KOLFSCHOTEN, 1998); seven arvicolid molars belonging to the (new) species *Mimomys hordijki* (VAN KOLFSCHOTEN & TESAKOV, 1998); the Insectivora (REUMER & HORDIJK, 1999); and lately the Gliridae with another new species *Eliomys briellensis*

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(REUMER, 2001). A publication about the Sciuridae is forthcoming (REUMER & VAN DEN HOEK OSTENDE, in press).

## MATERIAL AND METHODS

For descriptions of the boring techniques employed, we refer the reader to HORDIJK (1988 a, b). The bailer sampling method employed enabled us to retrieve large amounts of sediment from certain levels that proved rich in fossils. This implies that not all levels have been equally sampled, so that there is no quantitative relationship between the number of fossils from the various levels. For example, in borings Zuurland-3, -4, -5, and -6, effort was concentrated on sampling material from depths between 14-15 m, 21-22 m, 42-44 m, 50-56 m, and between 62-65 m. The sediment recovered was sieved (the finest sieve having an 0.4 mm mesh) and picked for the fossil content by Mr Hordijk, who also selected the Muridae from the total stock of small mammal fossils. The teeth were subsequently mounted on putty. Measurements were taken with a Leitz Ortholux microscope fitted with a movable stage and measuring clocks, at the Institute for Earth Sciences at Utrecht University. In the tables and the text, all measurements are given in millimeters. Drawings were made with a Wild M5 binocular fitted with a drawing equipment. The material is stored in the private collection of Mr Hordijk and is available for study upon request through the Natuurmuseum Rotterdam. The nomenclature of parts of the dental morphology is after VAN DE WEERD (1976).

The provenance of the material is indicated by the letter Z for Zuurland, the number of the borehole, followed by the depth in metres. E.g., Z4/62.85-64 means that the material originates from borehole Zuurland-4, at a depth of 62.85 to 64 m.

## TAXONOMY

Genus *Micromys* DEHNE, 1841

*Micromys minutus* (PALLAS, 1778)

(Plate 1a,b,c)

### MATERIAL AND MEASUREMENTS

1 M1 sin. from Z7/42.75-43.10; L = 1.34; W = 0.83

1 m1 dex. from Z6/14.75-17.75; L = 1.36; W = 0.79

1 m1 dex. from Z6/64.25-65; L = 1.37; W = 0.82

1 m1 sin. from Z2/65-66; L = 1.35; W = 0.75

### DESCRIPTION

The lower molar (Plate 1b) from Z6/14.75-17.75 (Holocene level) has a small and cone-shaped anterocentral cusp, which is well separated from the anteroconid complex. A short and narrow labial cingulum is present next to the protoconid, it is not connected to the anterolabial cusp and bears no cuspules. The posterior accessory cusp is low and cingulum-like. The terminal heel is elongate and connected to the hypoconid, but clearly separated from the entoconid. There are two major roots and a small extra root underneath the protoconid (which is typical for *Micromys*, see BÖHME, 1978: 290).

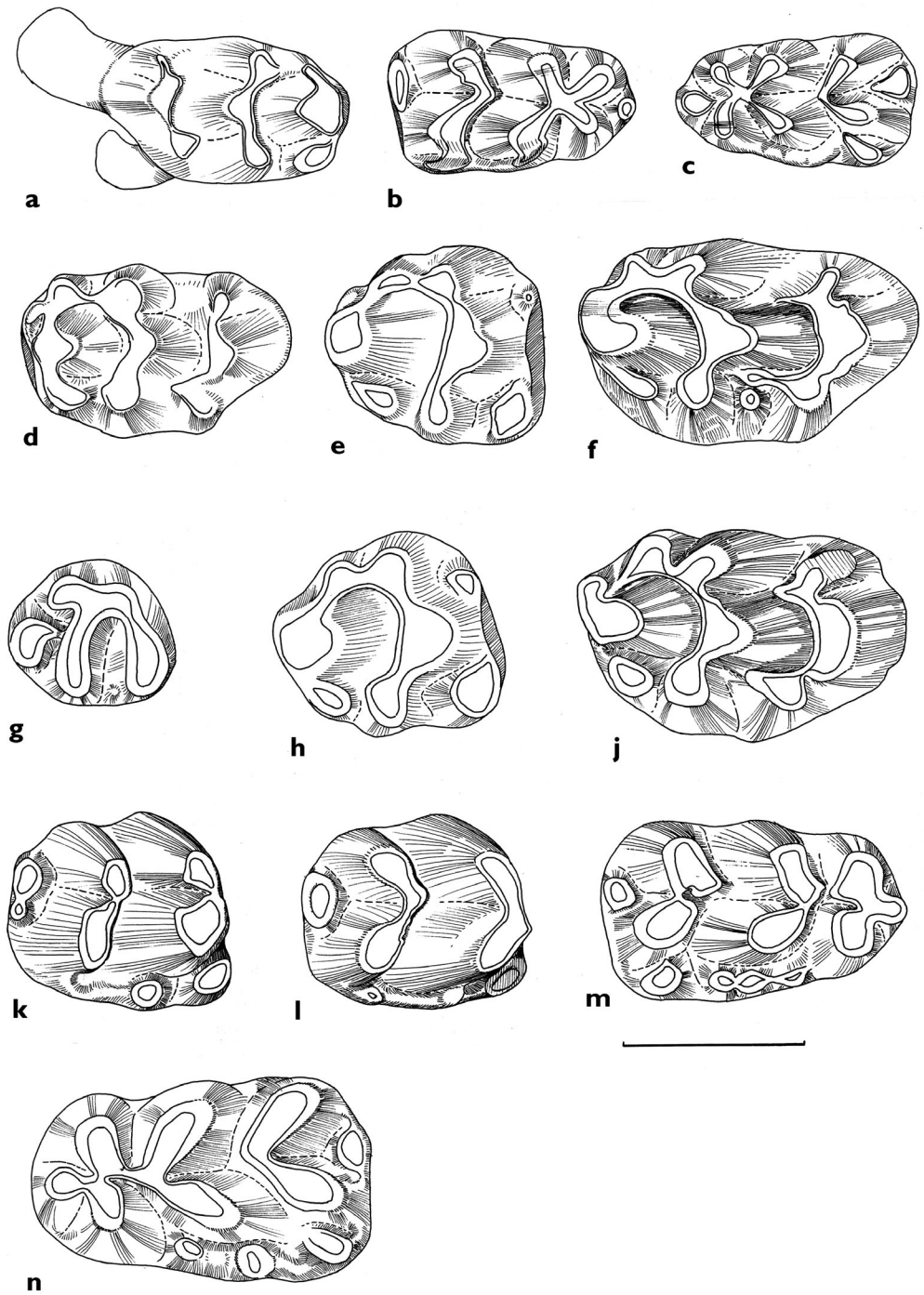
In the two m1's from deeper (Tiglian) levels (one of them depicted in Plate 1c) the anterocentral cusp is

PLATE 1

*Micromys minutus*. (a): M1 sin. from Z7/42.75-43.10; (b): m1 dex. from Z6/14.75-17.75; (c): m1 sin. from Z2/65-66. *Micromys* sp. indet. cf. *M .praeminutus*. (d): M1 dex. from Z2/91-92. *Apodemus sylvaticus*. (e): M2 dex. from Z2/92-93; (f): M1 dex. from Z4/50.70-54.50; (g): M3 dex. from Z2/43-44; (h): M2 dex. from Z4/43-44; (j): M1 dex. from Z5/42-43; (k): m2 dex. from Z7/42.75-43.10; (l): m2 dex. from Z2/92-93; (m): m1 dex. from Z7/43.70-44.25. *Apodemus flavicollis*. (n): m1 sin. from Z2/20-21.

LÁMINA 1

Micromys minutus*. (a): M1 izq. de Z7/42.75-43.10; (b): m1 der. de Z6/14.75-17.75; (c): m1 izq. de Z2/65-66.* Micromys *sp.* indet. *cf.* M .praeminutus*. (d): M1 der. de Z2/91-92.* Apodemus sylvaticus*. (e): M2 der. de Z2/92-93; (f): M1 der. de Z4/50.70-54.50; (g): M3 der. de Z2/43-44; (h): M2 der. de Z4/43-44; (j): M1 der. de Z5/42-43; (k): m2 der. de Z7/42.75-43.10; (l): m2 der. de Z2/92-93; (m): m1 der. de Z7/43.70-44.25*. Apodemus flavicollis*. (n): m1 izq. de Z2/20-21*


a
b
c
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j
k
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m
n

larger than in the Holocene specimen. The posterior accessory cusp is also better individualised. The labial cingulum is without cuspules and continues to the anterolabial cusp. In one of the specimens (not depicted) there is a small accessory cuspule situated in the valley between metaconid and entoconid. The root configuration is the same as in the Holocene tooth.

The M1 from the 42.75-43.10 m level (Plate 1a) is an extremely worn specimen that appears to have been etched by gastric acids, parts of the enamel have gone. The t3 and the t9 are relatively small. There is no t12. The molar has 5 roots.

### *Micromys* cf. *M. praeminutus* KRETZOI, 1959 (Plate 1d)

MATERIAL AND MEASUREMENTS

1 M1 dex from Z2/91-92; L = 1.51; W = 0.95

DESCRIPTION

A molar from the deep 91-92 m levels (of pre-Late Tiglian age, see REUMER & HORDIJK, 1999) shows relatively pointed cusps. The t1 is placed at the level between the t2 and the t5, the t2 and the t3 are at the same level, while the t6 is more posteriorly placed than the t5. The t12 is well developed and separated from the t8. The t6 and t9 are connected, as are the t9 and the t12, but the t3 and t6 are separated by a wide and deep valley.

REMARKS

As the *Micromys* molar from 91-92 m is larger than the M1 from the 42-43 m levels, I consider it as probably belonging to another taxon. However, it cannot be ruled out that this molar should also be attributed to *M. minutus* that it strongly resembles (e.g., Recent *M. minutus* often possess a t12). When the sizes of this tooth are plotted in the scatter-diagram of length and width of *Micromys* M1, published by VAN DE WEERD (1979), it is closer to the *praeminutus* cluster than to the *minutus* cluster (Table 1).

*Micromys* species reported from the Late Pliocene and Pleistocene in Europe are *M. praeminutus* KRETZOI, 1959 and *M. minutus*. The former taxon was described from the Hungarian Late Pliocene (MN 15) locality of Csarnóta-2. The diagnosis, stating that the occlusal pattern resembles *Apodemus*, that there are no accessory cuspules but a weak cingulum (a statement presumably meant to apply to m1), and that the dimensions are very small (KRETZOI, 1959), is rather inadequate. Csarnóta-2 is considerably older than the 91-92 m levels of Zuurland, which are most probably Tiglian (MN 17) in age. STORCH *et al*. 1973 doubted the validity of the taxon *M. praeminutus*, and attrib-

| | Length | | | | Width | | | | Reference |
|---|---|---|---|---|---|---|---|---|---|
| | n | min | **mean** | max | n | min | **mean** | max | |
| **M1** | | | | | | | | | |
| Zuurland *minutus* | 1 | | **1.34** | | 1 | | **0.83** | | this study |
| Recent *minutus* | 12 | 1.24 | **1.31** | 1.44 | 12 | 0.80 | **0.87** | 0.98 | We |
| German Recent *minutus* | 205 | 1.3 | | 1.5 | 205 | 0.9 | | 1.0 | Sto |
| Hohensülzen *minutus* | 2 | 1.4 | **1.4** | 1.4 | 2 | 0.9 | **0.9** | 0.9 | Sto |
| Zuurland cf. *praeminutus* | 1 | | **1.51** | | 1 | | **0.95** | | this study |
| Sète *praeminutus* | 2 | 1.59 | **1.63** | 1.66 | 2 | 1.00 | **1.04** | 1.07 | Mi |
| **m1** | | | | | | | | | |
| Zuurland *minutus* | 3 | 1.35 | **1.36** | 1.37 | 3 | 0.75 | **0.79** | 0.82 | this study |
| Recent *minutus* | 12 | 1.16 | **1.27** | 1.38 | 12 | 0.69 | **0.73** | 0.80 | We |
| Sète *praeminutus* | 2 | 1.38 | **1.46** | 1.53 | 2 | 0.81 | **0.85** | 0.89 | Mi |

Table 1.- Sizes of upper and lower first molars of *Micromys minutus* and *M.*cf. *M. praeminutus* from Zuurland and of some comparative samples. We: VAN DE WEERD, 1979. Sto: STORCH *ET AL*., 1973. Mi: MICHAUX, 1969.
*Tabla 1.- Talla de los primeros molares inferiores y superiores de* Micromys minutus *y* M. *cf*. M. praeminutus *de Zuurland y otras muestras de comparación*.

uted two *Micromys* M1's from the Early Pleistocene of Hohensülzen to *M. minutus*. These have indeed small sizes (Table 1). MICHAUX (1969) and VAN DE WEERD (1979, figs. 2 and 3) demonstrated a size difference between the teeth of the two species, which were retained.

Genus *Apodemus* KAUP, 1829
*Apodemus sylvaticus* (LINNAEUS, 1758)
(Plate 1e,f,g,h,j,k,l,m)

MATERIAL AND MEASUREMENTS

Available are 40 teeth from the levels between 42 and 93 m depth, with emphasis on the 42-44 m interval; measurements see Tables 2 and 3.

DESCRIPTION

M1. The upper M1's originate from the levels 38-39 m (1 specimen), 42-44 m (6), 50-54 m (1) and 64-65 (1); all show considerable uniformity in size and in morphology. The only variation lies in the presence or absence of a t3bis, which is well developed in 2 specimens, vestigially developed as an undulation of the enamel rim in 4 specimens (e.g. Plate 1f), and absent in 4 specimens (e.g. Plate 1j). The specimen depicted in Plate 1f, from Z4/50.70-54.50, possesses a small accessory cuspule halfway between the t1 and the t4 in the valley lingually of the t1-t5 connection. Most specimens have a small t12, although this cusp is never more than a vestigial heel (e.g., Plate 1j). In one specimen the t4 and t7 are connected by a narrow crest, in all other specimens these two cusps are separated, sometimes even widely so.

M2. We have 12 M2's, all except one from the 42-44 m levels (the exception comes from the 92-93 m level, see Plate 1e). The t1 is well developed, the t3 is small and sometimes only a small cuspule (Plate 1e). There is no t4-t7 connection. The t7 is a narrow heel in some of the specimens but a considerable cusp in others. The t9 is present, in worn specimens as an undulation of the buccal enamel edge; in one specimen however, it is hardly distinguishable. Two specimens possess a small and vestigial t12 (Plate 1e). Two of the M2's have aberrant root-patterns: in one specimen the two lingual roots are fused into a spade-shaped large root, another specimen is 6-rooted: it has two smaller roots between the four larger roots.

M3. There is one M3 from the 43-44 m level (plate 1g). The complex consisting of the t1, the t3, and the t4-6 is fused into an n-shaped structure. The t8 is comma-shaped and connected to the t4 by a narrow crest.

m1. There are 7 m1's, all from the 42-44 m levels. The teeth all are typical for *Apodemus*. There is great variation in the number of accessory cuspules: 1 specimen has one cuspule, 1 specimen has two cuspules, 4 teeth have three cuspules (e.g. Plate 1m) and 1 tooth has four cuspules. The connection between the anterolingual/anterolabial cusps and the proto-

| element | borehole / level | length | width |
|---|---|---|---|
| M1 sin. | Z6/38-39 | 1.85 | 1.24 |
| M1 dex. | Z3/42-43 | 1.92 | 1.17 |
| M1 dex. | Z5/42-43 | 1.89 | 1.18 |
| M1 sin. | Z7/42.75-43.10 | 1.85 | 1.17 |
| M1 dex. | Z7/42.75-43.10 | 1.89 | 1.16 |
| M1 dex. | Z3/43-44 | 1.99 | 1.21 |
| M1 dex. | Z4/43-44 | -- | 1.15 |
| M1 dex. | Z4/50.70-54.50 | 1.94 | 1.14 |
| M1 sin. | Z6/64.25-65 | -- | 1.22 |
| M2 sin. | Z3/42-43 | 1.33 | 1.13 |
| M2 dex. | Z7/42.75-43.10 | 1.21 | 1.11 |
| M2 dex. | Z7/42.75-43.10 | 1.32 | 1.09 |
| M2 dex. | Z4/43-44 | 1.32 | 1.13 |
| M2 dex. | Z5/43.65-44.20 | 1.33 | 1.15 |
| M2 sin. | Z7/43.70-44.25 | 1.39 | 1.11 |
| M2 sin. | Z7/43.70-44.25 | 1.24 | 1.17 |
| M2 sin. | Z7/43.70-44.25 | 1.34 | 1.16 |
| M2 dex. | Z7/43.70-44.25 | 1.32 | 1.09 |
| M2 dex. | Z7/43.70-44.25 | 1.32 | 1.16 |
| M2 sin. | Z7/43.70-44.25 | 1.30 | 1.06 |
| M2 dex. | Z2/92-93 | 1.25 | 1.12 |
| M3 dex. | Z2/43-44 | 0.92 | 0.83 |
| m1 sin. | Z3/42-43 | 1.79 | 1.10 |
| m1 dex. | Z7/42.75-43.10 | 1.71 | 1.04 |
| m1 dex. | Z4/43-44 | 1.75 | 1.05 |
| m1 sin. | Z7/43.70-44.25 | 1.70 | 1.07 |
| m1 dex. | Z7/43.70-44.25 | 1.71 | 1.09 |
| m1 dex | Z7/43.70-44.25 | 1.65 | 1.04 |
| m1 sin | Z7/43.70-44.25 | 1.71 | 1.05 |
| m2 dex. | Z3/42-43 | 1.32 | 1.10 |
| m2 sin. | Z3/42-43 | 1.22 | 1.04 |
| m2 dex. | Z5/42-43 | 1.22 | 1.09 |
| m2 sin. | Z5/42-43 | 1.28 | 1.09 |
| m2 dex. | Z7/42.75-43.10 | 1.21 | 1.15 |
| m2 dex. | Z7/42.75-43.10 | 1.25 | 1.08 |
| m2 sin. | Z7/42.75-43.10 | 1.24 | 1.01 |
| m2 sin. | Z7/43.70-44.25 | 1.19 | 1.07 |
| m2 sin. | Z7/43.70-44.25 | 1.22 | 1.09 |
| m2 sin. | Z2/91-92 | 1.21 | 1.02 |
| m2 dex. | Z2/92-93 | 1.26 | 1.09 |

Table 2.- Available material and measurements of *Apodemus sylvaticus* from the Zuurland boreholes.
*Tabla 2.- Material disponible de* Apodemus sylvaticus *de los sondeos de Zuurland*

| | Length | | | | Width | | | | Reference |
|---|---|---|---|---|---|---|---|---|---|
| | n | min | **mean** | max | n | min | **mean** | max | |
| **M1** | | | | | | | | | |
| Zuurland 42-44 m | 7 | 1.85 | **1.90** | 1.99 | 9 | 1.14 | **1.18** | 1.24 | this study |
| Rhenen (NL, Saalian) | 5 | 1.62 | **1.72** | 1.86 | 5 | 0.97 | **1.07** | 1.18 | Ko |
| Recent: | | | | | | | | | |
| Northern France | 168 | 1.52 | **1.74** | 2.12 | 168 | 1.09 | **1.20** | 1.34 | Pa |
| Le Claux (France) | 56 | 1.58 | **1.85** | 2.07 | 56 | 1.12 | **1.22** | 1.38 | Pa |
| Burgos (Spain) | 30 | 1.71 | **1.90** | 2.08 | 30 | 1.17 | **1.27** | 1.38 | Pa |
| Bonn (Germany | 22 | 1.73 | **1.81** | 1.95 | -- | | | | Ni |
| Brünen (Germany) | 8 | 1.64 | **1.77** | 1.85 | -- | | | | Ni |
| **M2** | | | | | | | | | |
| Zuurland 42-44 m | 11 | 1.21 | **1.31** | 1.39 | 11 | 1.06 | **1.12** | 1.17 | this study |
| Zuurland 92-93 m | 1 | | **1.25** | | 1 | | **1.12** | | this study |
| Rhenen (NL, Saalian) | 5 | 1.19 | **1.29** | 1.37 | 5 | 1.19 | **1.20** | 1.22 | Ko |
| Recent: | | | | | | | | | |
| Northern France | 168 | 0.95 | **1.15** | 1.30 | 168 | 0.91 | **1.14** | 1.28 | Pa |
| Le Claux (France) | 56 | 1.01 | **1.21** | 1.35 | 56 | 0.91 | **1.15** | 1.29 | Pa |
| Burgos (Spain) | 30 | 1.09 | **1.22** | 1.32 | 30 | 1.06 | **1.20** | 1.30 | Pa |
| **m1** | | | | | | | | | |
| Zuurland 42-43 m | 7 | 1.65 | **1.72** | 1.79 | 7 | 1.04 | **1.06** | 1.10 | this study |
| Rhenen (NL, Saalian) | 4 | 1.75 | **1.85** | 1.94 | 4 | 1.03 | **1.06** | 1.09 | Ko |
| Recent: | | | | | | | | | |
| Northern France | 88 | 1.53 | **1.70** | 1.84 | 88 | 0.94 | **1.06** | 1.18 | Pa |
| Le Claux (France) | 55 | 1.58 | **1.75** | 2.01 | 55 | 0.99 | **1.10** | 1.21 | Pa |
| Burgos (Spain) | 30 | 1.71 | **1.80** | 1.93 | 30 | 1.09 | **1.16** | 1.26 | Pa |
| Bonn (Germany) | 22 | 1.65 | **1.73** | 1.80 | -- | | | | Ni |
| Brünen (Germany) | 8 | 1.60 | **1.72** | 1.80 | -- | | | | Ni |
| **m2** | | | | | | | | | |
| Zuurland 42-44 m | 9 | 1.19 | **1.24** | 1.32 | 9 | 1.01 | **1.08** | 1.15 | this study |
| Zuurland 91-93 m | 2 | 1.21 | **1.24** | 1.26 | 2 | 1.02 | **1.06** | 1.09 | this study |
| Rhenen (NL, Saalian) | 5 | 1.15 | **1.23** | 1.27 | 5 | 1.02 | **1.11** | 1.19 | Ko |
| Recent: | | | | | | | | | |
| Northern France | 88 | 0.90 | **1.11** | 1.23 | 88 | 0.95 | **1.06** | 1.18 | Pa |
| Le Claux (France) | 55 | 1.06 | **1.16** | 1.29 | 55 | 0.98 | **1.09** | 1.25 | Pa |
| Burgos (Spain) | 30 | 1.07 | **1.18** | 1.27 | 30 | 1.05 | **1.13** | 1.26 | Pa |

Table 3.- Sizes of molars of *Apodemus sylvaticus* from the Zuurland boreholes and some comparative Recent samples from the literature. Ko: VAN KOLFSCHOTEN, 1981. Pa: PASQUIER, 1974. Ni: NIETHAMMER, 1978b.
*Tabla 3.- Talla de los molares de* Apodemus sylvaticus *de los sondeos de Zuurland y algunas muestras recientes de comparación de la literatura.*

conid/metaconid is absent in one specimen (Plate 1m) but present in the others, albeit sometimes very weakly so.

m2. There are 9 m2's from the 42-44 m levels and two m2's from 91-93 m. In size and morphology there is little difference. The variation in the second lower molars is restricted to the labial cingulum, which may be absent, present as a narrow ridge only, or bear one or two accessory cuspules. The posterior accessory cuspule is present in all specimens. One

specimen (Plate 1k) has its terminal heel split into a larger and a smaller cuspule, which gives it an 8-shaped pattern.

*Apodemus flavicollis* (MELCHIOR, 1834)
(Plate 1n)

MATERIAL AND MEASUREMENTS

1 m1 sin. from Z2/20-21 m; L = 1.92; W = 1.16.

DESCRIPTION

The only *Apodemus* tooth from Holocene levels is considerably larger than the presumably Eburonian or Waalian specimens from the 42-44 m interval. Morphologically, there is no difference of any importance between this tooth and the ones of *A. sylvaticus*. There is a connection between the anterolabial/anterolingual cusps (anteroconid complex) and the protoconid/metaconid complex. The terminal heel is low and there are two accessory cuspules on the labial cingulum, in addition to the posterior accessory cusp. This appears to be the predominant morphology in recent specimens of *A. flavicollis*, see PASQUIER, 1974: 92.

REMARK

Fossil *Apodemus flavicollis* is here reported for the first time from the Netherlands. This species is known to occur in the Recent fauna in the southernmost tip of the province of Limburg only, some 200 km from the locality of the Zuurland boreholes. Table 4 shows some measurements of the m1 of *A. flavicollis* from several other fossil samples and from some Recent samples. The Zuurland tooth falls nicely within the size range of *A. flavicollis*. The table shows that rather stable size of *A. flavicollis* from different localities and ages. This uniformity and the morphology support the identification of the single Holocene Zuurland m1.

## GENERAL DISCUSSION

The teeth of *A. sylvaticus* do not come from the levels uniformily. There is 1 tooth from 38-39 m, 34 teeth from 42-44 m, 1 tooth from 50-55 m, 1 tooth from 64-65 m, and 3 teeth from 91-93 m. This result comes as a surprise, if it is realised how much material Mr Hordijk collected from the 62-66 m interval in particular. This means that the wood mouse is extremely rare in the 62-66 m association, and relatively rather common in the 42-44 m interval. In ear-

| | **Length** | | | | **Width** | | | | **Reference** |
|---|---|---|---|---|---|---|---|---|---|
| | n | min | **mean** | max | n | min | **mean** | max | |
| **Fossil samples** | | | | | | | | | |
| Zuurland 20-21 m | 1 | | **1.92** | | 1 | | **1.16** | | this study |
| Chios (Holocene) | -- | | | | 17 | 1.10 | **1.17** | 1.20 | Be |
| Voigtstedt (E. Pleist.) | 3 | | **1.88** | | 3 | | **1.10** | | Ma |
| Pirro Nord 1 (E. Pleist.) | 17 | 1.82 | **1.88** | 1.98 | 17 | 1.07 | **1.14** | 1.20 | Gi |
| **Recent samples** | | | | | | | | | |
| "France" | 38 | 1.71 | **1.85** | 1.99 | 38 | 1.03 | **1.13** | 1.29 | Pa |
| Kirchdorf (Austria) | 57 | 1.53 | **1.80** | 2.00 | 57 | 0.96 | **1.11** | 1.26 | Pa |
| Berlin (Germany) | 24 | 1.68 | **1.82** | 1.84 | 24 | 1.04 | **1.12*** | 1.19 | Pa |
| Bonn (Germany) | 30 | 1.73 | **1.90** | 2.05 | -- | | | | Ni |

Table 4.- Sizes of m1 of fossil and Recent *Apodemus flavicollis*, and the specimen from the Zuurland 20-21 m level. Be: BESENECKER *ET AL.*, 1972. Ma: MAUL, 1990. Gi: DE GIULI & TORRE, 1984. Pa: PASQUIER, 1974. Ni : NIETHAMMER, 1978a. *: erroneously given as 1.22 by PASQUIER, 1974.
*Tabla 4.- talla de los m1 de* Apodemus flavicollis *recentes y fósiles, y de especímenes del nivel 20-21 m de Zuurland.*

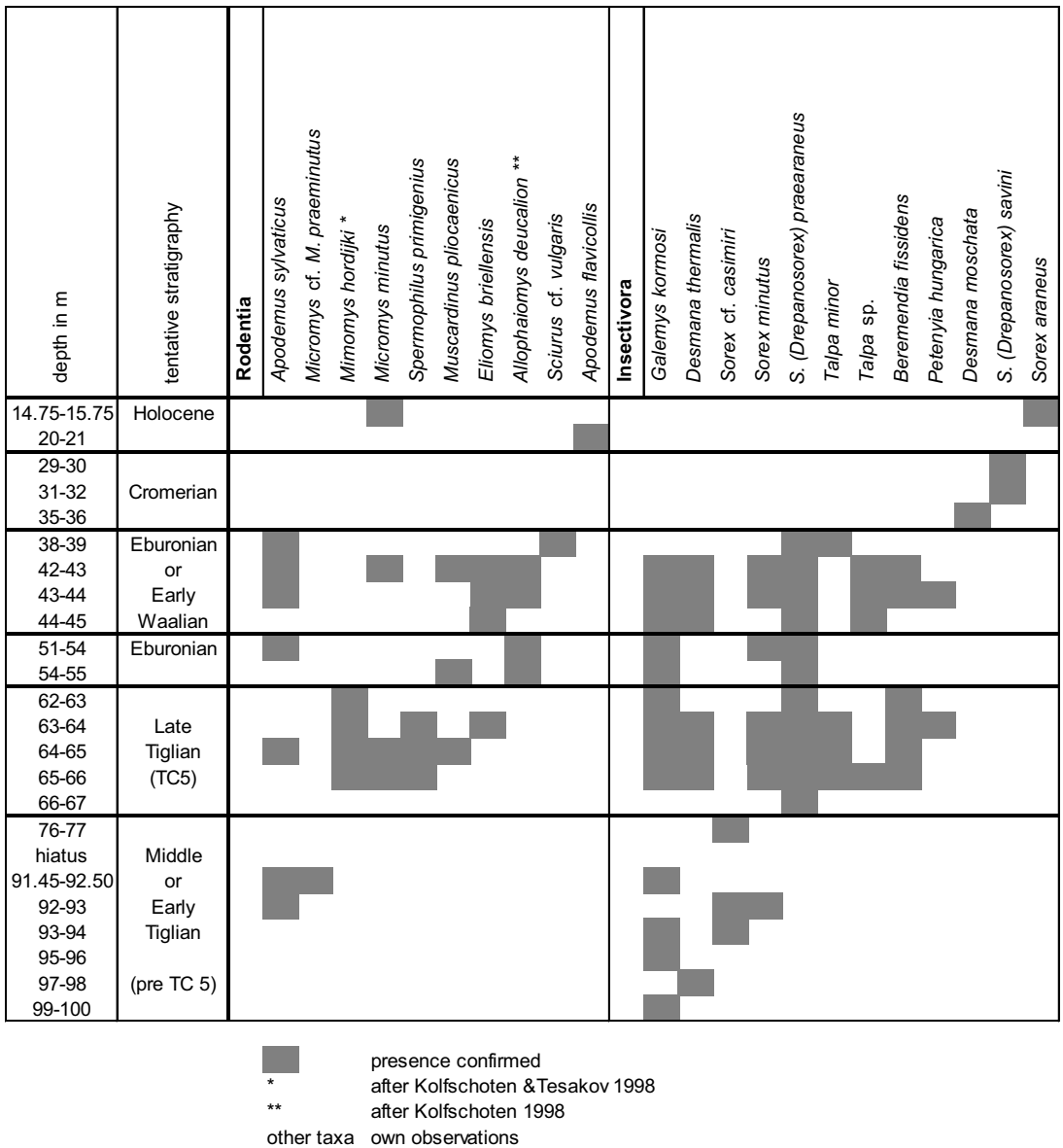


Figure 1.- Range chart of the known small mammals from the Zuurland boreholes.
*Figura 1.- Distribución de los micromamíferos de los sondeos de Zuurland.*

lier publications (REUMER & HORDIJK, 1999; REUMER, 2001) we have suggested that the entire range between 42-66 m shows faunistic uniformity. We now want to add some nuance to this conclusion, not as far as the qualitative faunal composition is concerned (*A. sylvaticus* is present in both the 42-44 and the 62-66 m interval, Figure 1), but for the quantitative composition. We suggest an ecological differentiation, in that the 42-44 m interval represents an environment in this region with a somewhat more forested and/or shrubby aspect when compared to the environment of the 62-66 m interval. So far, all species we encountered in the 42-44 m interval were with one exception also found in the 62-66 m inter-

val; the ground squirrel *Spermophilus primigenius* is exclusively found in the 63-66 m interval (Figure 1, after REUMER & VAN DEN HOEK OSTENDE, in press). Recent ground squirrels in Europe (*S. suslicus* and *S. citellus*) prefer open landscapes and are even known to avoid forest, so the presence of *S. primigenius* in the 63-66 m interval means that the biotope represented in this interval showed a more or less open landscape. The presence of ground squirrels in 63-66 m and their absence in the 42-44 m levels, in combination with the abundance of wood mice in the 42-44 m levels and their near absence in the 62-66 m levels, are indicative for an ecological differentiation. As the 62-66 m levels are considered to correspond to the Tiglian TC5 stage (see TESAKOV, 1998), the 42-44 m levels will have to originate from a somewhat younger period. Given the presence of *Allophaiomys* (VAN KOLFSCHOTEN, 1998), these levels might be of Eburonian or Waalian age.

Figure 1 summarises the ranges of the taxa that have so far been encountered in the Zuurland boreholes (after VAN KOLFSCHOTEN, 1998; VAN KOLFSCHOTEN & TESAKOV, 1998; REUMER & HORDIJK, 1999; REUMER, 2001; REUMER & VAN DEN HOEK OSTENDE, in press; present paper) and indicates the present stratigraphical interpretation of the various levels.

We have here described four Muridae taxa from the Netherlands: *Micromys* cf. *M. praeminutus, M. minutus, Apodemus sylvaticus,* and *A. flavicollis*. One other fossil murid has so far been mentioned from Dutch territory: *Apodemus maastrichtiensis* van Kolfschoten, 1985, a taxon that was described as a new species from the Middle Pleistocene of Belvédère 4 (Maastricht), and which species has also been mentioned from Belvédère 3 and Fransche Kamp II (Saalian, the Netherlands; VAN KOLFSCHOTEN, 1990), Little Oakley and Boxgrove (early Middle Pleistocene, England; STUART & LISTER, 2001), Miesenheim I (Late Cromerian, Germany; VAN KOLFSCHOTEN, 1990; as *A.*aff. *maastrichtiensis*), and from Monte Peglia MP63 (Biharian, Italy; ARGENTI, 1998; as *A.* cf. *A. maastrichtiensis*). In the Zuurland boreholes, this small *Apodemus* was not encountered. This may be due to a large hiatus in the Zuurland sections or to the fact that some levels are not extremely fossiliferous.

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