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The second record of *Borsodia* (Arvicolidae, Rodentia) from the Pliocene of the Netherlands

Mayhew, D.F. 2008 - The second record of *Borsodia* (Arvicolidae, Rodentia) from the Pliocene of the Netherlands - DEINSEA 12: 11 - 15 [ISSN 0923-9308]. Published online 10 January 2008.

This note describes a tooth of the extinct lagurine vole genus *Borsodia* (Arvicolidae, Rodentia) from a borehole at Eindhoven in the Netherlands. *Borsodia* was previously reported for the first time from the Netherlands on the basis of a tooth dredged from the Oosterschelde (Reumer *et al.* 2005). Attention is drawn to the use of *Borsodia* for stratigraphic correlation and climatic interpretation.

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Keywords: Arvicolidae, Pliocene, taxonomy, *Borsodia*, the Netherlands

INTRODUCTION

The genus *Borsodia* was introduced (as subgenus of *Mimomys*) by Janossy & van der Meulen (1975) who studied the voles of the Pliocene/Early Pleistocene locality of Ostramos 3, Hungary. They recognised that the specimens from Villany 3 called *Mimomys newtoni hungaricus* by Kormos (1938) lacked crown cement and had reversed enamel differentiation. In the Hungarian literature such material was later called *Mimomys hungaricus* (see e.g. Kretzoi 1956). Janossy and van der Meulen proposed to place this species in a separate subgenus. The close relationship between this species, with rooted teeth, and the later lagurines with unrooted teeth was already recognised by Kormos (1938).

As clarified by Mayhew & Stuart (1986), the separation of *Mimomys hungaricus* from *Mimomys newtoni* was based on misunderstanding. Hinton (1926) did not correctly describe *Mimomys newtoni* on the basis of the type specimen, but used referred material which had crown cement now referred to *Mimomys tiglicensis* TESAKOV, 1998. In fact *Mimomys hungaricus* is a junior synonym of *Mimomys newtoni*.

The separation of *Borsodia* from *Mimomys* at generic level seems now to be preferable since *Mimomys*, certainly in the sense as originally defined by Major (1902), appears to include certain stages of evolution of separate clades, and *Borsodia* is clearly part of the clade of lagurine voles. Undoubtedly, the lagurine voles represent an early split in the arvicolid evolution, perhaps being the sister group of the clade including the living genera *Arvicola*, *Microtus* and *Clethrionomys* (=Myodes).

The majority of *Borsodia* remains come from eastern Europe and Asia, and several species have been defined. It can also be noted here that due to the unclarity of the original description of the genus *Villanyia* KRETZOI, 1956, many remains which are actually *Borsodia* have been described under the genus *Villanyia* in the Russian literature.

Until recently the genus *Borsodia* was not reported from the Netherlands. However, two years ago it has been recognised for the first time (a single upper second molar) in material dredged from the Oosterschelde (Reumer *et al.* 2005, under the name *Mimomys* (*Borsodia*)).

newtoni MAJOR, 1902). A second occurrence of *Borsodia* from the Netherlands is noted here.

DESCRIPTION

Order Rodentia BOWDICH, 1821
 Family Arvicolidae GRAY, 1821
 Genus *Borsodia* JANOSSY & VAN DER MEULEN, 1975

Borsodia cf. *newtoni* MAJOR, 1902

Mimomys pusillus, SCHREUDER, 1933, fig.10

Material Upper right first molar, RGM 86163, collection Naturalis, Leiden, the Netherlands. (Figure 1 A, D)

Locality The Netherlands, Noord Brabant, Borehole Eindhoven (#51D/24). Depth 152-158m. The deposits at this level were formerly assigned to the Tegelen Formation, currently the Waalre Formation and are considered to be of Late Pliocene age. In this borehole deposits of the Kiezeloölite Formation (Late Miocene-Late Pliocene) are situated below a depth of 203.50m.

Description The tooth consists of the enamel crown and lacks dentine roots. The crown is well preserved, with no cement in the enamel folds (some sediment is present). The tooth has deep re-entrant folds and stronger, less abraded, enamel on the posterior margins of the triangles. The thickness of the enamel is however rather similar on the anterior and posterior parts of the triangles. [As noted by Tesakov (1993), strong enamel differentiation is found only in most highly evolved *Borsodia* species.]

Measurements Since its discovery and original description, the tooth appears to have become damaged, therefore the dimensions given in Table 1 are all estimates.

COMPARISON

The tooth is refigured here (Fig. 1 A, D) together with a tooth from Thorpe (Norwich Crag) and another from later Crag deposits at West Runton, UK [both figured in Mayhew & Stuart (1986) as *Mimomys (Borsodia) newtoni*]. Compared with *Borsodia* from the Norwich crag of Thorpe, the tooth from Eindhoven has slightly higher lingual and posterior enamel free areas. The re-entrant folds are curving and lack the development of an extra fold as found in *Lagurus*. The *Borsodia* tooth from the 'Weybourne crag' of West Runton has a slightly different form of the posterior labial re-entrant fold, hinting at development of the lagurine fold, has higher enamel free areas, and appears more evolved than the Eindhoven tooth.

DISCUSSION

The tooth was recognised as *Borsodia* on seeing Schreuders (1933) figure, since it was similar to a tooth from Thorpe (Mayhew & Stuart 1986, fig 12 part 12b, refigured here). This resemblance was also noted by Schreuder (1933), referring to Hintons figure (1926, text fig.100, fig.21) of the same Thorpe specimen. Schreuder suggested that both teeth could be assigned to *Mimomys pusillus* (MEHELY, 1914). However, it is clear that they belong to *Borsodia* in view of the absence of crown cement and the structure of the dentine. Surprisingly, up to now *Borsodia* was not reported from the very extensive collections from Tegelen (Tesakov 1998). Neither was it identified up to now in publications on the extensive material from Zuurland, Brielle (van Kolfshoten 1988). It is rather striking that the two largest Netherlands collections of material of Late Pliocene age do not appear to contain this species (although a full report on the Zuurland material is awaited), whereas it has now been found in other very small samples.

A further check of the collections held by Naturalis, Leiden, (including additional Tegelen material, not seen by Tesakov, as well as material from many boreholes) did not, however, reveal any other specimens of

Table 1 Estimated measurements (in mm) of *Borsodia* cf. *newtoni* M1 RGM 86163, borehole Eindhoven 51D/24, depth 152-158m .

measured unit	mm
crown height enamel	4.11
wear surface length	2.32 *
wear surface width	1.30
height of anterior lingual enamel free area	2.82
height of anterior labial enamel free area	4.11
height of medial lingual enamel free area	3.38
height of posterior enamel free area	3.40

* 2.2 mm according to Schreuder (1933)

Borsodia. The absence of the genus in the Tegelen collection appears in view of the considerable sample size to be significant.

In the UK, *Borsodia* occurs at several localities (Mayhew & Stuart 1986; Mayhew 1990;

Mayhew & Gibbard 1998), although it is not abundant. In these publications it was demonstrated that there were differences between the teeth of *Borsodia* from earlier localities (Bramerton, Bulcamp, Thorpe,) and later localities (East Runton, West Runton Crag, Weybourne). The earlier localities have teeth with lower crown height, lower enamel free areas, and an anterior loop of the lower first molar which is asymmetric and has a more posteriorly situated 'Miomys ridge'.

The differences between samples interpreted in Mayhew & Stuart (1986) as evolutionary trends within a lineage of *Borsodia* are those which have been used elsewhere in the literature to define separate species, leading to a large synonymy for the group *Borsodia*. For example the earlier forms are described in the literature as *Miomys petenyii* MEHELY,

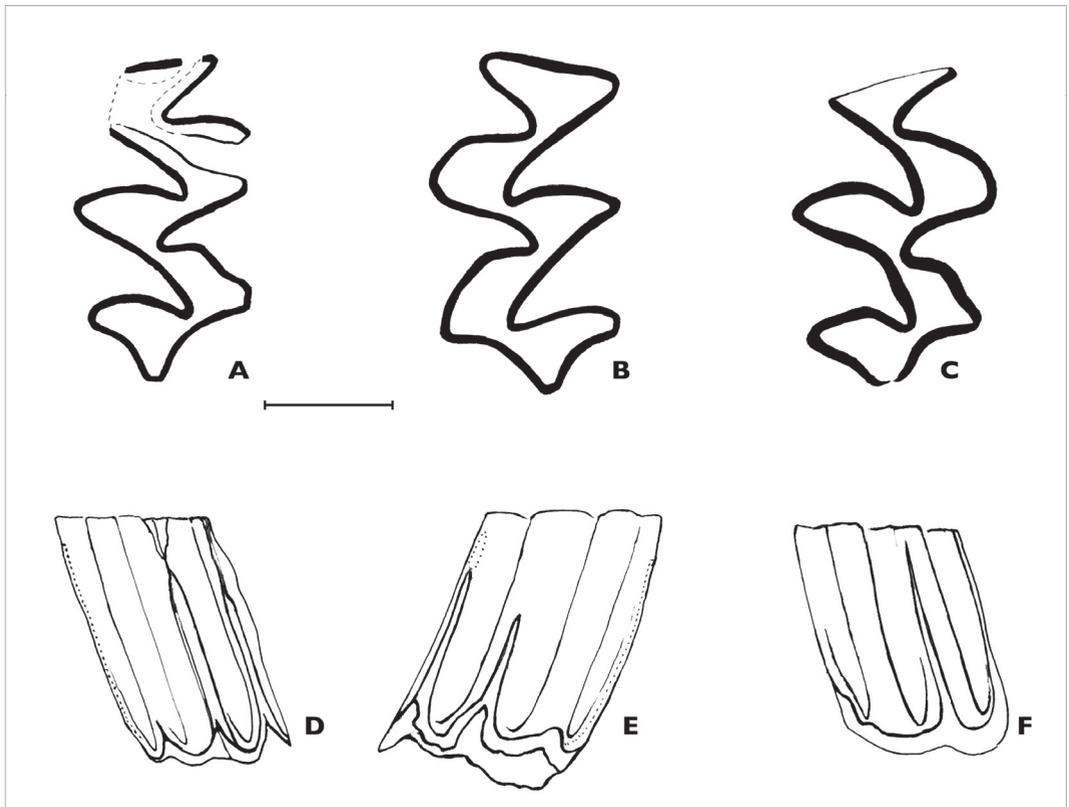


Figure 1 *Borsodia* cf. *newtoni* from borehole Eindhoven 51D/24 compared with Thorpe and West Runton Crag *Borsodia* specimens. **A, D** RGM 86163 Eindhoven; **B, E** NCM 971c Thorpe; **C, F** UMZC WRC561. Scale line (wear surface view) 1 mm. (NCM = Norwich Castle Museum; UMZC = University Museum of Zoology, Cambridge). [artwork by the author]

1914, but there is confusion about this species as it is now clear that the original description by Mehely was based on composite material coming from different species (Mayhew, pers. obs.). As noted above, there was also confusion about *Mimomys newtoni* MAJOR, 1902 due to Hinton (1926) not basing his redescription on the type specimen. Added to this is the unclarity about *Villanyia* which has resulted in *Borsodia* material being referred to that genus in much of the literature. Therefore a revision of the *Borsodia* clade as a whole is required, but this falls outside the scope of this paper.

Rabeder (1981) distinguished in material from successive loess layers at Stranzendorf, Austria, the species *B. parvisinuosa*, *B. aequisinuosa* and *B. altisinuosa*, which differed in the height of the enamel free areas on the sides of the molars, demonstrating the evolution of hypsodonty. In respect of crown height, the tooth from Eindhoven appears to be closest to *B. altisinuosa* RABEDER. It is a question of individual approach whether every demonstrable difference between samples should be used for taxonomic distinction. For stratigraphic purposes, assigning separate names to distinguishable entities leads to easier tabulation of significant concepts. (The significance of these concepts in itself can only demonstrated once we have a clear understanding of intra- and interspecific variation.) On the other hand, evolutionary relationships can be obscured, and ultimately it becomes difficult to assign individual specimens to a species. Therefore I prefer a more conservative approach and at present assign the Eindhoven tooth to *Borsodia* cf. *newtoni*.

The levels of evolution within *Borsodia*, and the nomenclatural solutions used to document those stages have been usefully reviewed by Tesakov (1993). *Borsodia* is potentially very useful for stratigraphic correlation because of the changes in the Late Pliocene and Early Pleistocene, and because it can be directly linked to the origin in the Early Pleistocene of voles of the extant genus *Lagurus*. Tesakov shows that the evolutionary trends presumed on the basis of very limited material from the UK (Mayhew & Stuart 1986; Mayhew 1990; Mayhew & Gibbard 1998) reflect those demonstrated by the very abundant material from Eastern European and Asian localities. We can expect this also to apply to the Netherlands when more material is recovered.

A final point of interest is the potential relevance of *Borsodia* as ecological indicator. As pointed out by Tesakov (1993), *Borsodia* species appear to be associated with a steppe zone extending from Asia into Europe. It appears that during the Late Pliocene and Early Pleistocene there was strong selection for hypsodonty due to increasing aridity, a tendency found in multiple lineages. The Tegelen channel-fill fauna is dominated by *Apodemus*, and is interpreted as indicating locally forested conditions, so perhaps we should not expect it to contain *Borsodia*. Reumer & Van den Hoek Ostende (2003) suggested on the basis of the squirrels from Tegelen and Zuurland that different palaeoenvironments existed at these localities. The presence of *Borsodia* in the Netherlands and the UK reminds us that there were periods (possibly rather many) in the Pliocene and Pleistocene during which open steppe vegetation extended to Western Europe.

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Received 1 July 2007

Accepted 3 september 2007

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