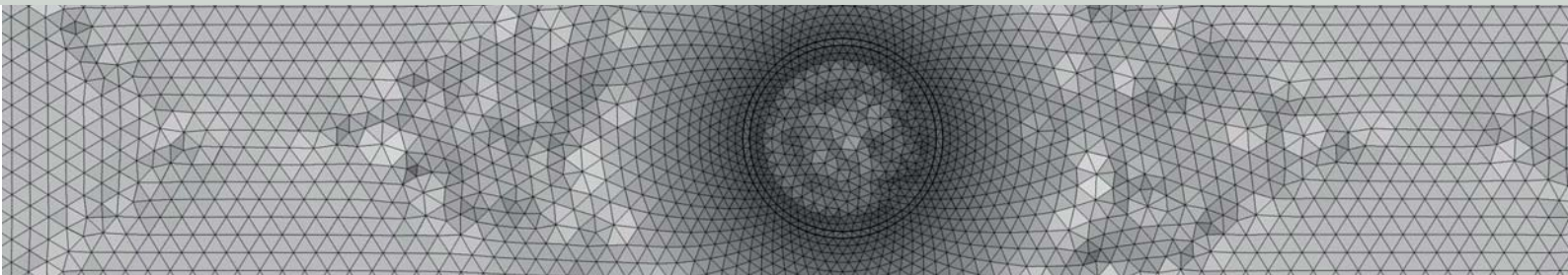




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The Pleistocene small mammals from Irchel, Switzerland – A taxonomic and biostratigraphic revision

Expertenbericht

im Rahmen der Beurteilung des Vorschlags von mindestens zwei geologischen Standortgebieten pro Lagertyp, Etappe 2, Sachplan geologische Tiefenlager

G. Cuenca-Bescós

University of Zaragoza, Spain

Dezember 2015

Disclaimer:

Die im Bericht dokumentierten Ansichten und Schlussfolgerungen sind diejenigen der Autoren und stimmen nicht notwendigerweise mit denen des ENSI überein.

Vorwort des ENSI

Bei der Beurteilung der Langzeitsicherheit geologischer Tiefenlager spielt der Prozess der Erosion, d. h. der Abtrag von Gesteinsmaterial und somit die Reduktion der geologischen Barriere eine zentrale Rolle. Zur Abschätzung des zu erwartenden Ausmasses an Erosion wurden von der Nagra für den sicherheitstechnischen Vergleich in Etappe 2 des Sachplan geologische Tiefenlager (SGT) verschiedenen Erosionsszenarien entwickelt. Diese Szenarien basieren auf Rekonstruktionen der langfristigen Landschaftsentwicklung.

Die geologisch jüngsten Gesteinsablagerungen der Nordschweiz sind überwiegend eiszeitlich geprägte Lockersedimente. Sie lassen sich aufgrund ihrer morphologischen Ausprägung vereinfachend in vier Einheiten unterteilen: Höhere und Tiefere Deckenschotter sowie Hoch- und Niederterrasse. Die Höheren Deckenschotter stellen das älteste und höchstgelegene Höhenniveau ehemaliger Flussläufe dar und liegen stellenweise 200 bis 300 m über dem Niveau der heutigen Flüsse. Sofern das Ablagerungsalter bekannt ist, lässt sich aus dem beobachtbaren Niveauunterschied (Basis Deckenschotter gegenüber heutiges Flussniveau) die seit der Ablagerung stattgefundene Erosion bemessen. Unter der Annahme vergleichbar wirkender Erosionsprozesse lässt sich der zukünftig zu erwartende Erosionsbetrag abschätzen.

Der zur Bestimmung der Erosionsraten notwendige Unterschied zwischen heutigem Flussniveau und dem Niveau der Vergangenheit lässt sich zuverlässig durch Höhenmessungen bestimmen. Die Bestimmung des Ablagerungsalters ist deutlich aufwendiger, da hierfür absolute (numerische) Ablagerungsalter benötigt werden. Im Fall der Deckenschotter lag zum Zeitpunkt der Ausarbeitung der Nagra-Unterlagen (2014) eine einzige Angabe zu den Höheren Deckenschottern vor. Bolliger et al. (1996) dokumentieren Funde von fossilen Tier- und Pflanzenresten (u. a. Nagetierzähne) innerhalb der Höheren Deckenschotter des Irchel im Kanton Zürich (Abbildung 1). Mittels biostratigraphischer Methoden wurden die Zahnreste aus diesen Funden auf ein Alter von 1.8 bis 2.6 Millionen Jahre datiert. Die Erosionsszenarien der Nagra - insbesondere die für die geologischen Standortgebiete mit einem Lager für hochaktive Abfälle - beziehen sich stark auf diese Altersangabe zu den Höheren Deckenschotter des Irchel.

Aus diesem Grund wurde vom ENSI eine unabhängige Überprüfung der in Bolliger et al. (1996) dokumentierten taxonomische Einordnung und biostratigraphische Zuordnung der fossilen Zahnreste veranlasst. Der vorliegende Expertenbericht «The Pleistocene small mammals from Irchel, Switzerland - A taxonomic and biostratigraphic revision» dokumentiert die Arbeiten, welche im Auftrag des ENSI von Prof. Dr. G. Cuenca-Bescós an der Universität Zaragoza durchgeführt wurden.

Beim analysierten Probenmaterial handelt es sich um Säugetierzähne, welche mittels Schlämmung von mehreren hundert Kilogramm feinkörnigem Material aus der Hasli-Formation (Abbildung 1) im Jahr 1994 gewonnen wurden. Es ist identisch zu dem in Bolliger et al. (1996) verwendeten Material.

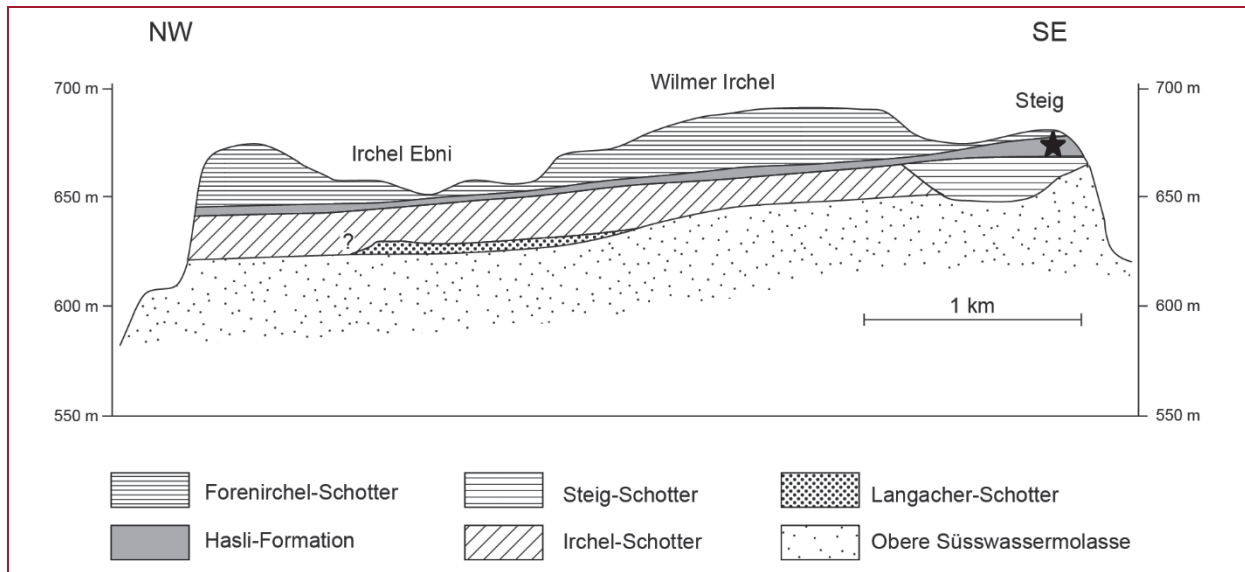


Abbildung 1: Längsprofil durch die Höheren Deckenschotter des Irchel (modifiziert nach Graf (1993)). Die Kleinsäuger-Fundstelle «Steig» (schwarzer Stern; Swiss Grid LV95: 2'688'960 / 1'265'560) befindet sich am südöstlichen Ausläufer des Irchel-Plateaus in der Hasli-Formation. Neben Säugetierresten sind auch zahlreiche Schneckenschalen sowie pflanzliche Reste in Bolliger et al. (1996) dokumentiert.

Für die vorliegende Studie wurden 15 intakte Zahnindividuen aus mehreren paläontologischen Sammlungen durch D. Kälin (swisstopo) zusammengetragen und dokumentiert (Vermessung, Zeichnung, Foto). Diese Dokumentation wurde anschliessend an G. Cuenca-Bescós übermittelt. Auf die Zusendung der Originalstücke wurde unter Berücksichtigung ihrer Zerbrechlichkeit verzichtet. Abweichend von der ersten biostratigraphischen Zuordnung durch O. Fejfar (Karls-Universität Prag) in Bolliger et al. (1996), wurden in der vorliegenden Studie keine Zahnfragmente berücksichtigt, sondern nur intaktes Material.

Referenzen

- Bolliger T., Fejfar O., Graf H., Kälin D. (1996): Vorläufige Mitteilung über Funde von pliozänen Kleinsäugetern aus den höheren Deckenschottern des Irchels (Kt. Zürich). *Eclogae Geologicae Helvetiae* 89, 1043-1048.
- Graf H.R. (1993): Die Deckenschotter der zentralen Nordschweiz, Dissertation Diss. ETH Nr: 10205, ETH Zürich, Zürich.

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THE PLEISTOCENE SMALL MAMMALS FROM IRCHEL,
SWITZERLAND.

A TAXONOMIC AND BIOSTRATIGRAPHIC REVISION

Gloria Cuenca-Bescós

19/12/2015

The fossils of small mammals from Irchel (Zürich, Switzerland) are reviewed here. The faunal list includes: the arvicolines, Mimomys pliocaenicus, M. reidi, primitive Pliomys sp. Or Pliomys cf. simplicior, Clethrionomys cf. kretzoi, and the murine Apodemus sp. The Irchel age is the unit MN17, or the rodent zone Mimomys pliocaenicus. It is part of the Gelasian stage, the earliest subdivision of the Quaternary period and Pleistocene epoch spanning the time between 2.6 and 1.8 Ma. The faunal assemblage points toward the end of this epoch.

THE PLEISTOCENE SMALL MAMMALS FROM IRCHEL, SWITZERLAND. A TAXONOMIC AND BIOSTRATIGRAPHIC REVISION

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THE PLEISTOCENE SMALL MAMMALS FROM IRCHEL, SWITZERLAND. A TAXONOMIC AND BIOSTRATIGRAPHIC REVISION

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<http://www.aragosaurus.com/>; <http://wzar.unizar.es/acad/fac/geolo/index.html>;
<http://www.atapuerca.tv/equipo/ficha.php?miembro=24>

ABSTRACT

A collection of fossils of small mammals from Irchel (Zürich, Switzerland) is reviewed here. Former studies revealed a fauna composed by arvicoline rodents. The new revision here adds new rodent species and novel diagnostic elements. The faunal list of the revised Irchel fauna is: the arvicolines *Mimomys pliocaenicus*, *M. reidi*, primitive *Pliomys* sp. or *Pliomys* cf. *simplicior*, *Clethrionomys kretzoi*, and the murine *Apodemus* sp. We do not see *Borsodia*, *Lagurodon*, and Lemmini indet. cited in previous studies. Despite the differences of species identified in previous work in relation to those identified in this study, the proposed Irchel age is almost the same, the unit MN17, or the rodent zone *Mimomys pliocaenicus*. It matches the Gelasian stage, which is the earliest subdivision of the Quaternary period and Pleistocene epoch spanning the time between 2.6 and 1.8 Ma.

INTRODUCTION

THE FOSSILS OF SMALL MAMMALS FROM IRCHEL, TOOLS FOR RELATIVE DATING

Previous paleontological studies from Irchel revealed a fauna composed by arvicoline rodents (Bolliger et al., 1996). Indeed, the fossil assemblage from Irchel studied here is composed exclusively by small mammals or the order Rodentia, though there are arvicoline and murine rodents. From now on we will call Irchel fauna, which we will review in this paper. Despite some differences in the species classification in the previous work of Bolliger et al. (1996), in relation to those identified in the present study, the proposed Irchel age is almost the same, the unit MN17. Fossil assemblages are traditionally used to designate the duration of periods of time, and the Irchel fauna has fossils characteristic of the MN17 unit of the European Land Mammals Zones or ELMA (Mein, 1975, Bolliger et al., 1996, Lindsay, 1997). Although the biostratigraphy does not provide actual numerical dates for the rocks; usually the correlation demonstrates that a particular horizon in one geological section represents the same period of time as another horizon at some other section. Unit MN17 is correlated with the rodent zone *Borsodia-Villanya*, subzone *Mimomys pliocaenicus* and spans the time between 2.6 and 1.8 Ma (Horacek, 1979, Bosak et al., 1982, Bolliger et al., 1996, Agustí et al., 2001, Reumer et al., 2005, Minwer-Barakat et al., 2012, Mayhew, 2013).

In the present work we examine the fossils from the locality of Irchel. They are represented by the drawings and photographs of the molars of the fossil rodents, provided by Daniel Kalin.

Our aim is to analyze the size and morphology of the molars of Irchel. At that point we will proceed with the identification of the species of rodents from Irchel. Then we will compare the species assemblage from Irchel with similar faunal assemblages. To finish, the faunal assemblage from Irchel will serve for the proposition of a relative age for the Irchel fauna.

MATERIAL, TERMINOLOGY AND METHODS

From the pictures we can determine that the fossils are composed exclusively by isolated teeth which fit into the mammals of the Order Rodentia, more precisely they belong to arvicoline (voles) and murine (mice) rodents. The Irchel collection studied here consists of 15 fossils of teeth in moderate to regular state of preservation; voles are more abundant (Table 1) (Figs. 1-15), than mice (Fig. 16).

The terminology and measurement parameters for the descriptions of the fossil rodents from Irchel are described below.

| TABLE 1 | | | | | |
|---------------|---------|------|-------|-------|--|
| Label | Element | L | W | plobe | Species |
| Irchel A | M1d sup | 3 | 1,8 | | <i>Mimomys pliocaenicus</i> |
| Irchel B | M1s sup | 2,72 | 1,6 | | <i>Mimomys reidi</i> |
| Irchel C | M1d sup | 2,28 | 1,3 | | <i>Mimomys reidi</i> |
| Irchel D | M3d sup | 2,1 | 1 | 1,25 | <i>Mimomys reidi</i> |
| Irchel J | M3s sup | 2,1 | 1 | | <i>Mimomys reidi</i> |
| Irchel E | m1d inf | 2,48 | 1,097 | | <i>Pliomys</i> sp. or <i>P.</i> cf. <i>simplicior?</i> |
| Irchel F | m1d inf | 2,5 | 1,07 | | <i>Mimomys reidi</i> |
| Irchel G | m3d inf | 1,36 | 0,87 | | <i>Clethrionomys</i> cf. <i>kretzoii?</i> |
| Irchel H | m2s inf | 2,12 | 1,3 | | <i>Mimomys pliocaenicus</i> |
| Irchel I | m2d inf | 2,12 | 1,19 | | <i>Mimomys pliocaenicus</i> |
| Irchel murine | m1, m2 | | | | <i>Apodemus</i> cf. <i>sylvaticus</i> |

Table 1. The collection of fossil rodents from the locality of Irchel, canton Zurich, Switzerland. Material and measurements. The labels are partially from D. Kalin, partially this work. See also the figures 2-3. The material is arranged by element. Sizes, length (L),width (W),and posterior lobe (plobe), in mm.

DESCRIPTION AND CLASSIFICATION OF THE MATERIAL

ORDER RODENTIA

FAMILY CRICETIDAE FISCHER, 1817

SUBFAMILY ARVICOLINAE GRAY, 1821

Like the fingerprints, the patterns of the occlusal surface of the molars of voles (arvicolines) are the best tool for the fossil identification and classification of the species of this subfamily of the rodent family Cricetidae, which comprises the new world rats and mice, voles, hamsters, and relatives (Michaux et al., 2001). The arvicolines are classified in the Grade D of tooth crown

morphology: longitudinal chewing and non-cusp interlocking associated with flattened tooth crown and cricetine dental plan (Lazzari et al., 2008).

Descriptions and measurements of the occlusal and labio-lingual surfaces of the molars of the voles from Irchel are based, as said above, on the drawings and photographs provided by Daniel Kalin, one of the authors of the first study of the fossils from the site (Bolliger et al., 1996). Some parameters of the crowns of the molars were measured using the scales and dimensions provided by Kalin in his figures. All measurements are given in millimeters (Table 1).

The terminology and measurement parameters (Figure 1) follow the works of Meulen (1973); Agustí (1993); Tesakov (1998); Fahlbusch and Moser (2004), Cuenca-Bescós et al., 1995, 2010; see also Tesakov and Kolfschoten, 2011, for root and hypsodont terminology). Some terms follow the work of Rabeder (1981).

There are four species of arvicoline rodents in the Irchel fauna (Table 1), two species of *Mimomys*, which represent larger and medium to small sized *Mimomys* lineages of the early Pleistocene from Europe. Also, the species *Pliomys simplicior* and the species *Clethrionomys kretzoi*, which are so scarce that we will classify them in open nomenclature as species “compare with” or confer (“*cf.*”). The molars are rhizodont, meaning they have roots, though in diverse states of development. In the Daniel Kalin graphic documents we do not found *Borsodia*, nor the arhizodont arvicolines *Lagurodon* sp. and Lemmini indet., mentioned in the previous work of Bolliger et al. (1996) (see discussion about *Clethrionomys* below).

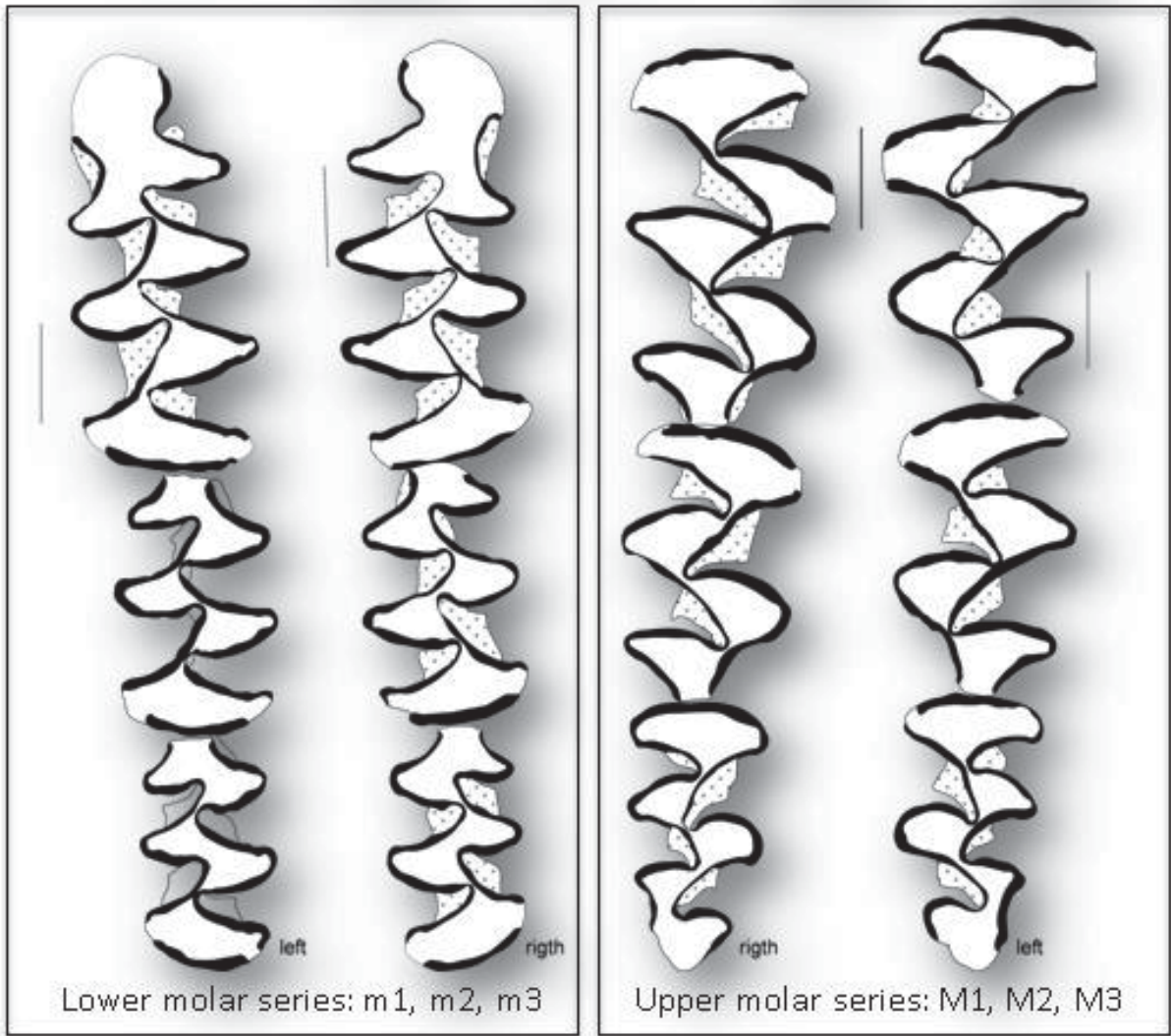
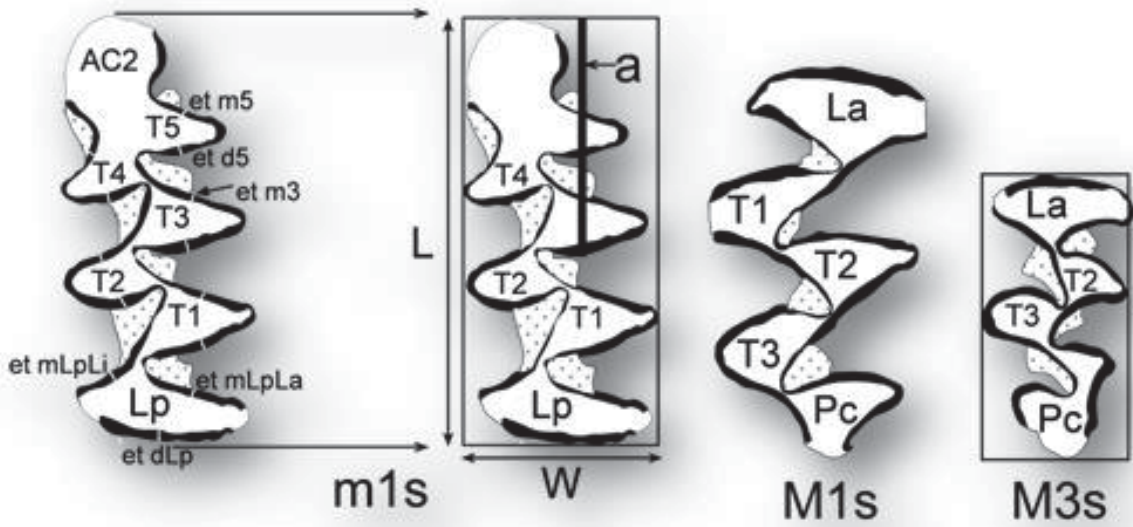


Figure 1. Patterns of the occlusal surface of the molars, nomenclature and measurements of extant arvicoline rodents (voles). Example, the south water vole *Arvicola sapidus*, from *Bubo bubo* pellets from Sobradriel, Zaragoza, Spain. Top: from left to right nomenclature and measurements of left (s) side molars m1, M1, and M3. Below: lower and upper molar series. a, anteroconid complex and length; AC2, anterior cap 2; d, distal; et d, enamel thickness in distal side of a triangle; et m, enamel thickness in mesial or anterior side of a triangle; L, length; La, anterior lobe; Lp, posterior lobe; M1,M2,M3, upper molars; m1, m2, m3 lower molars; T1...T5, dentine fields, triangles in white, surrounded by enamel walls, in black; m, mesial; W, width. Dotted, cementum between salient angles.

In both, arvicoline and murine rodents, the lower molars are denoted here in lower case letters (m1–3), and the upper molars in upper case letters (M1–3).

GENUS *MIMOMYS* F. MAJOR, 1902

The genus *Mimomys* comprises large to medium size vole species. Their molars are rooted and have cement in the re-entrant angles (LRA or BRA of Meulen 1973), that is the Synclinal Zement of Rabeder (1981: Fig. 9), which varies from little to abundant. The lower m1 has an enamel islet in the anteroconid complex, which may be reduced to absent in hypsodont forms. This is a primitive character that disappears in advanced forms of the *Mimomys*—*Arvicola* and of the *Mimomys*—*Microtus* lineages such as in the m1 of the Fig. 1, representing the molar series of the extant species of the genus *Arvicola*. Also, in the adult stages of advanced species of the genus *Mimomys*, an enamel fold, or *Mimomys*-ridge (Meulen, 1973), or *Mimomys*kante (Rabeder, 1981), may be present. There are species with both, the enamel islet and the *Mimomys*-ridge in a single specimen (see examples in

Rabeder, 1981, Agustí et al., 1993, Reumer et al., 2005, among others). The posterior lobe of the M3 has also an enamel islet, which disappears in the adult stages of advanced forms.

MIMOMYS PLIOCAENICUS F. MAJOR, 1902

Available material: **Irchel A**, M1d; **Irchel H**, m2s; **Irchel I**, m2d (table 1; figs. 2, 3, 4, 5, 6).

Measurements: see table 1

DESCRIPTION

This is the largest vole in the Irchel fauna (Figs. 2A, 2I, 2H; 4, 5, 6). The fields of dentine (triangles) are closed to slightly open in the upper and in the lower molars. The enamel wall is of “*Mimomys*” type. In the upper, as well in the lower molars the amount of crown cement is little. Roots are formed, though the molars are hypsodont. The M1 has a third root, though poorly developed (Figs. 2, 3, 5). In the m2, the enamel-dentine boundary, at the base of the crown tends to form high dentine tracts (Figures 2H, 2I), having being developed enamel free areas in the occlusal surface of the posterior lobe of the molar.

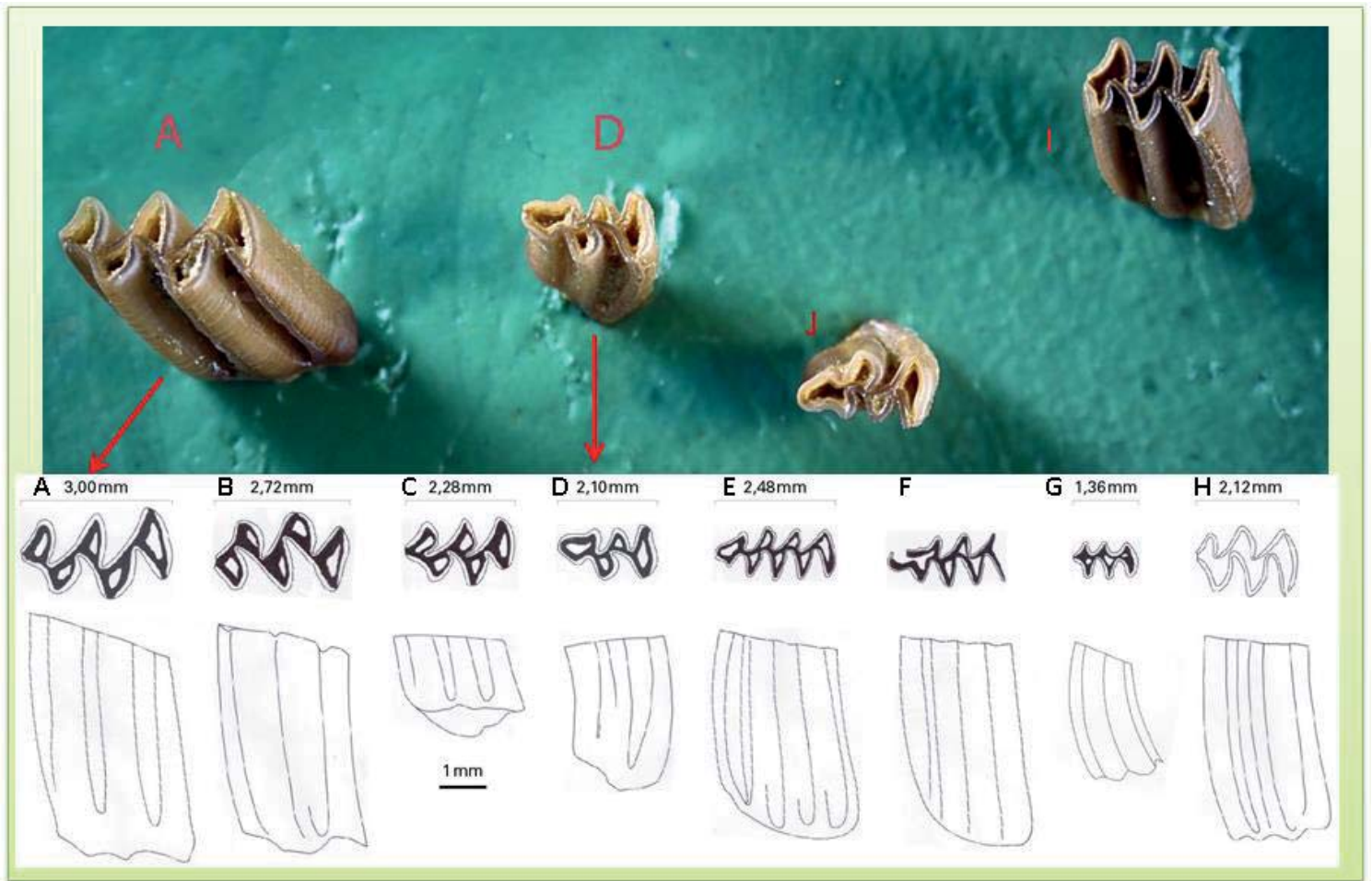


Figure 2. Pictures and drawings of the occlusal surface of the molars of Arvicoline rodents from Irchel, canton Zurich, Switzerland. *Mimomys pliocaenicus* A, Irchel A, M1d; H, Irchel H, m2s, I, Irchel I, m2d; *Mimomys reidi* B, C, Irchel B M1s and Irchel C M1d; D, J, Irchel D M3d and Irchel J M3s; F, Irchel F, m1d; *Pliomys cf. simplicior* E, Irchel E, m1d; *Clethrionomys cf. kretzoi* G, Irchel G, m3d.

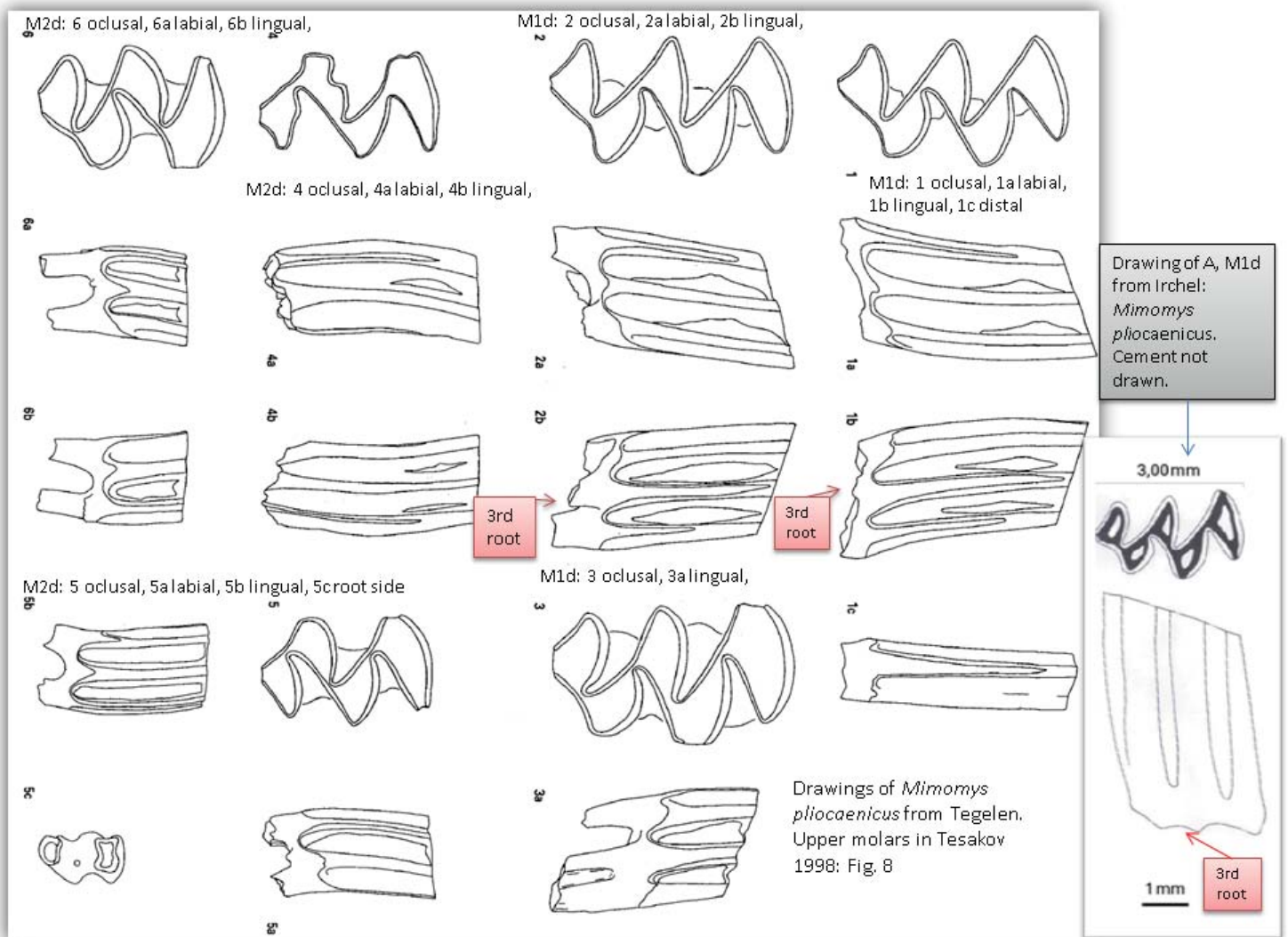


Figure 3. Drawings of the occlusal surface of the upper molars of *Mimomys pliocaenicus* from Tegelen (Tesakov 1998: Fig. 8) in comparison with the M1 (A) from Irchel, canton Zurich, Switzerland. Note the third root, though poorly developed in the M1 from Irchel (Irchel A).

Discussion and comparison

Mimomys pliocaenicus. We are aware that the drawback of the lack of the molars M3, and m1 in the Irchel assemblage, with their distinctive enamel

islet and/or *Mimomys*-ridge, typical of the species *Mimomys pliocaenicus*, is a handicap in the identification of this species in the Irchel fauna. Nevertheless, the rest of the molars attributed to *M. pliocaenicus* from Irchel, resemble this species in size and morphology. The species *Mimomys pliocaenicus* described from Tegelen (Tesakov, 1998), differs slightly from *M. pliocaenicus* from Irchel in that the species from Tegelen has somewhat more cement, it is somewhat larger in size, and the third root in the upper molars is more conspicuous (Fig. 3, drawing of A). Also, dentine tracks are lower, and the enamel-free areas are visible in worn molars, while in Irchel they are visible in less worn specimens (Figs. 2I, 2H, 4H). There is a broad similarity, morphological and metrical, though.

Mimomys polonicus. The ancestor of *M. pliocaenicus*, the species *M. polonicus*, is somewhat smaller and differs, among other characters, in its more developed third root in the upper molars.

M. medasensis. According to the opinion of several authors (Michaux, 1971, Esteban Aenlle and López Martínez, 1987; Martín Suárez, 1988; Minwer-Barakat, 2004, 2008), *M. medasensis* Michaux, 1971 is an Iberian endemic parallel of the European species *M. pliocaenicus*, from which it differs in some features. One of the most conspicuous is the presence of two roots instead of three in the M1, and the abundant cement. This species, being similar in size, differs in the disappearance of the third root in the M1 (Minwer-Barakat et al., 2004).

Kislangia. Other large arvicoline species in the Quaternary assemblages such as *Kislangia*, more specifically during the early Pleistocene (late Villanyian), are superior in size, have more cement, and the labio-lingual triangles are

more asymmetrical (see for instance the descriptions of *Kislangia gusii* of Agustí et al., 1993).

Borsodia. Being somewhat smaller in size, the genus *Borsodia* lacks crown cementum in the reentrant angles, and there is always an enamel interruption in the *Mimomys*-ridge of the m1 (Rabeder, 1981, Tesakov, 1998, Popov, 2001).



Figure 4. Kalin Pictures of the occlusal surface of the molars of Arvicoline rodents from Irchel, canton Zurich, Switzerland. *Mimomys reidi* B, C, F, Irchel B, M1s, Irchel C, M1d, Irchel F, m1d; *Pliomys cf. simplicior* E, Irchel E, m1d; *Clethrionomys cf. kretzoi* G, Irchel G, m3d.

MIMOMYS CF. REIDI HINTON, 1910

DESCRIPTION

Material: **Irchel B** M1s; **Irchel C**, M1d; **Irchel D** M3d; **Irchel F** m1; **Irchel J** M3s; (table 1, figs. 2, 4, 5, 6).

According to Tesakov (1998) we consider that this species represents the primitive stage of the small *Mimomys* lineage leading to the Biharian *M. pusillus*. The species *M. reidi* is smaller than *M. pliocaenicus* (Fig. 5), and similar in size to *M. tigliensis* Tesakov 1998.

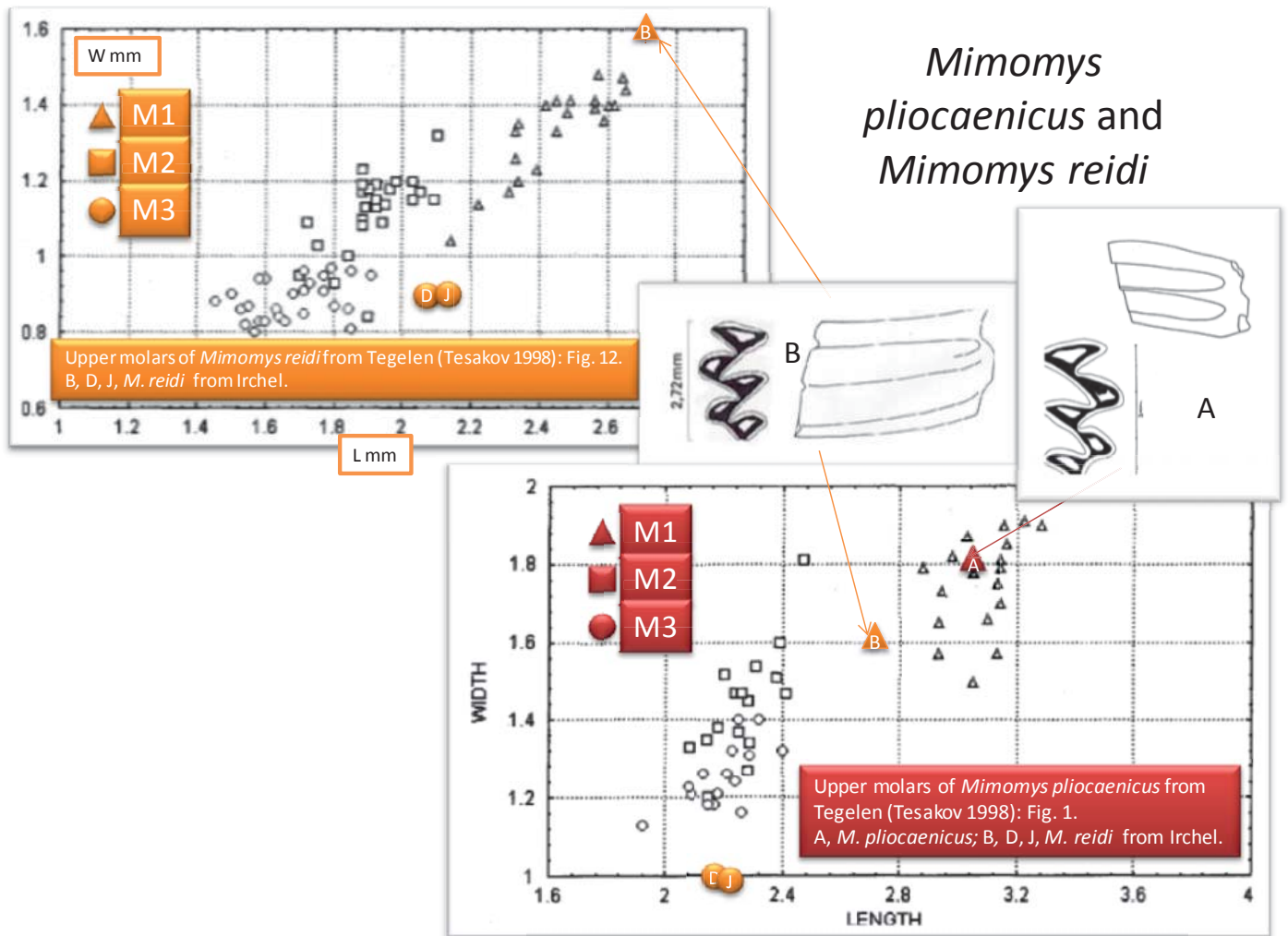


Figure 5. Comparison of the size of the upper molars of *Mimomys pliocaenicus* (in red) and of *M. reidi* (in yellow) from Irchel, with the size of these species in the bivariate diagrams, Length and Width (LxW), of the upper molars of *M. pliocaenicus* and *M. reidi* described by Tesakov (1998: Figs. 1 and 12 respectively). Uppercase letters refer to the labels given in Table 1. Measurements are given in mm.

The *M. reidi* from Irchel is a species of medium size, smaller than *M. pliocaenicus* (Fig. 5), and hypsodont. The m1 has moderate to scarce cement in the re-entrant angles (see the M3 in Fig. 2D), and lacks an enamel islet. Nevertheless it has a conspicuous *Mimomys*-ridge in a young stage of wear (Fig. 2F, 4F). The position of the *Mimomys* ridge of the m1 is posterior in relation to *Mimomys tigliensis*. It has rounded anterior cap of the anteroconid. The triangles in the occlusal surface of the m1 are slightly confluent while in the upper M1 are nearly closed (Figs. 2B, F, 4B, F).

The M3 has also moderate to scarce cement in the re-entrant angles has three dentine fields; one is formed by the anterior loop slightly confluent with T2, the T2 and the posterior lobe complex. The re-entrants are slightly verging to distal (Figs. 2D, 2J). The size of the M3 fits in between *M. pliocaenicus* and *M. reidi*, though they do not have the enamel islet typical of the latter species. Therefore, we classify the M3 as the *M. reidi*.

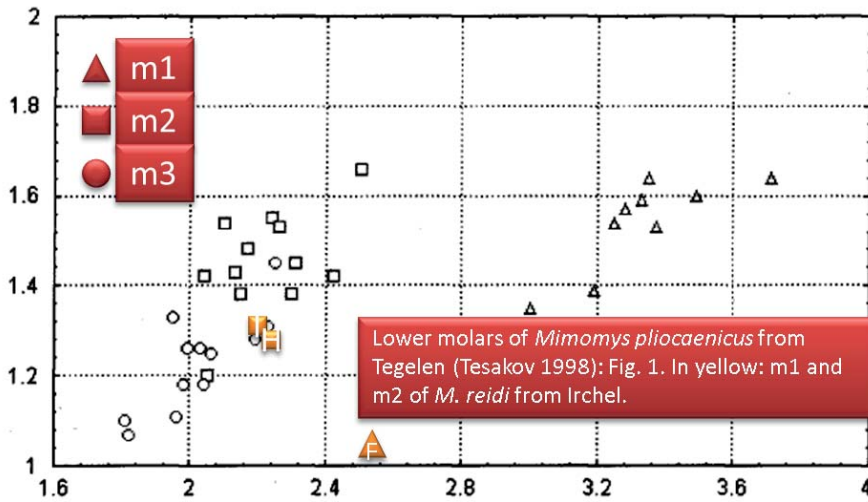
DISCUSSION AND COMPARISON

THE CLASSIFICATION OF THE M3 FROM IRCHEL

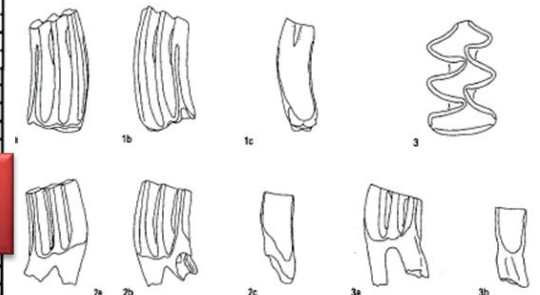
The size of M3 fits in between *M. pliocaenicus* and *M. reidi*, they could belong to *M. pliocaenicus* (Figure 5), and however they do not have the enamel islet typical of the latter species. In Tegelen though, the enamel islet tends to disappear in adult specimens (Fig. 11a, b). The M3 of *M. pliocaenicus* from Kadzielnia has also a conspicuous enamel islet (Kowalski 1958: Fig. 18).

Mimomys horkijki has a M3 similar to that of Irchel; the occlusal surface consists of an AL, T2, T3, T4 plus posterior cap. The occlusal elements are more confluent than in Irchel. There is not enamel islet (Tesakov and Kolfshoten 2011).

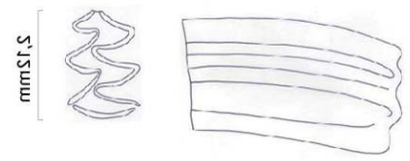
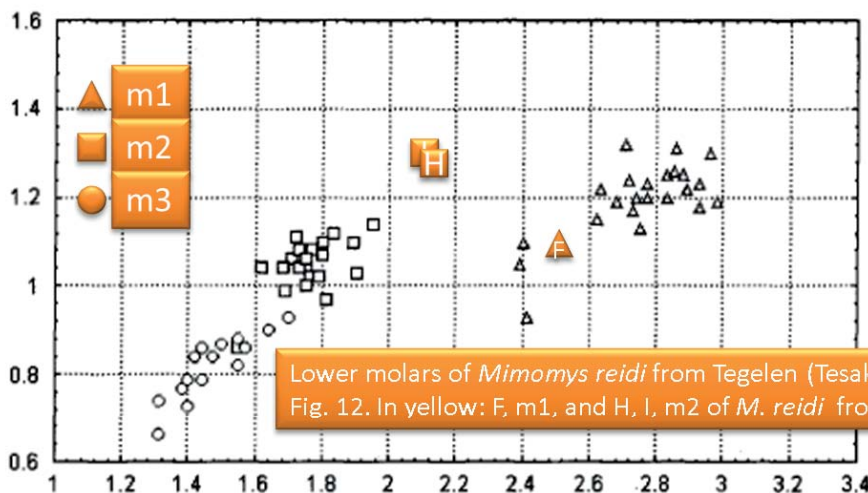
Mimomys reidi. This species has a conspicuous *Mimomys*-ridge in younger stages of wear as in the m1 from Irchel. The triangles are slightly confluent, as in Tegelen (Tesakov, 1998). It differs from the material from Tegelen in being the M1 somewhat larger and in having less cement in the reentrant angles (Fig. 5). The M3 is more similar to the M3 in *Mimomys tigliensis* Tesakov 1998, in its because has narrow anterior confluence and poorly to slightly divergent re-entrants (Figs. 2D, 2J).



Mimomys pliocaenicus
and *M. reidi*



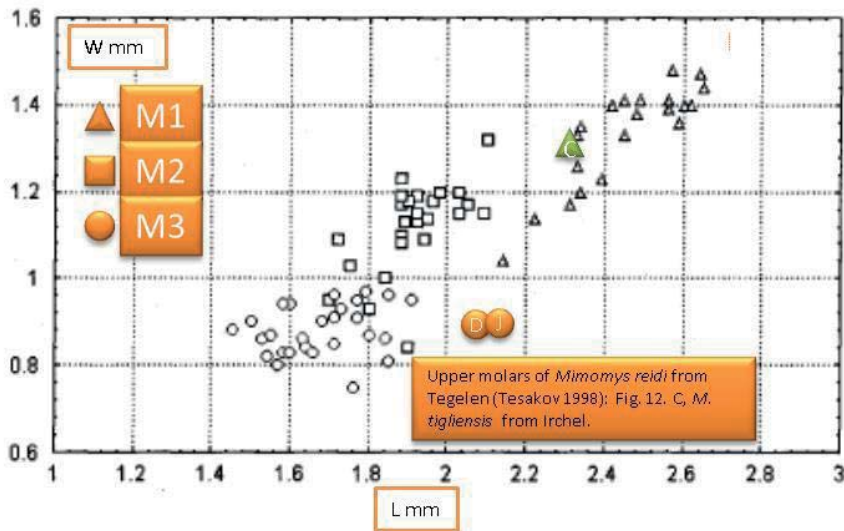
m2 of *M. reidi*, Tegelen, Tesakov (1998): Fig. 19.
a, labial, b, lingual



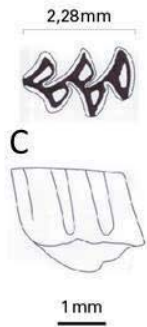
H. m2s of Irchel. Occlusal and labial

Figure 6. The **Irchel H** specimen, the m2 of *Mimomys pliocaenicus*. Comparison of the size of the lower molars of *M. reidi* (in orange labels) from Irchel, with the size of the species in the bivariate diagrams, Length and Width (LxW), of the lower molars of *M. pliocaenicus* and *M. reidi* described by Tesakov (1998: Figs. 1 and 12 respectively). Uppercase letters in the orange labels refer to the labels given in Table 1. Measurements are given in mm.

***Mimomys tigliensis* Tesakov 1998 vs. *Mimomys reidi* Hinton, 1910.** Following Tesakov (1998) *M. tigliensis* differs from *M. reidi* in its much more abundant cement, much higher hypsodonty, absence of enamel islets in the anteroconid of m1, two-rooted M1, while they are three-rooted in *M. reidi* as in the M1 (Fig. 2B) from Irchel (Figs. 6, 7, 8, 9, 10).



Mimomys tigliensis and *Mimomys reidi*



C. M1d of *M. reidi* from Irchel

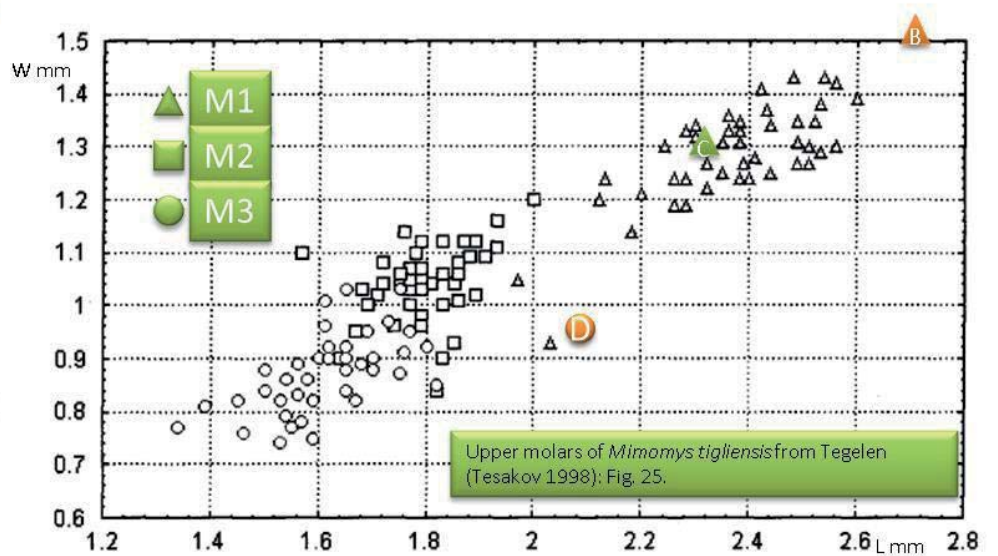
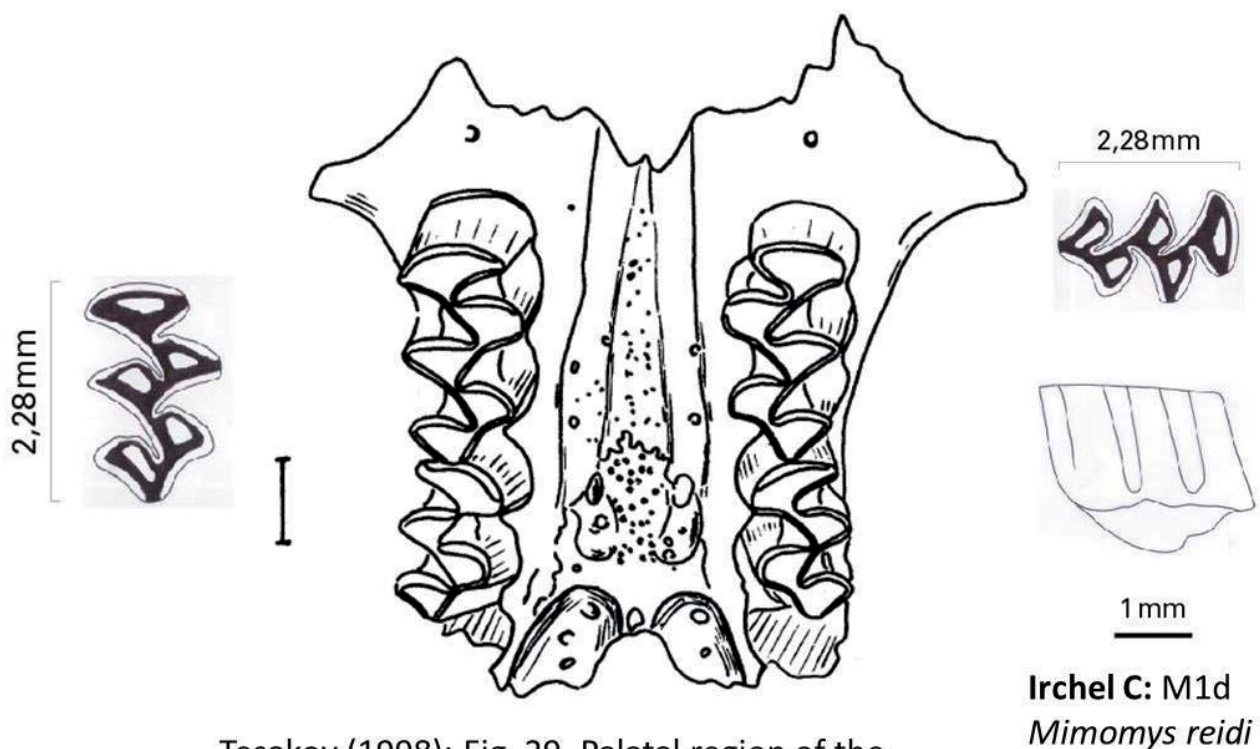


Figure 7. The **Irchel C** specimen, the M1 of *Mimomys reidi*. Comparison of the size of the upper molars of *M. reidi* (in orange labels) from Irchel, with the size of the species *M. tigliensis* in the bivariate diagrams, Length and Width (LxW), of the upper molars of *M. tigliensis* (in green) and *M. reidi* (in orange) described by Tesakov (1998: Figs. 12 and 25 respectively). Uppercase letters in the orange labels refer to the labels given in Table 1. Measurements are given in mm.

The position of the *Mimomys*-ridge of the m1 of *M. reidi* is posterior in relation to *Mimomys tigliensis* (see Fig. 2F) described by Tesakov (1998).

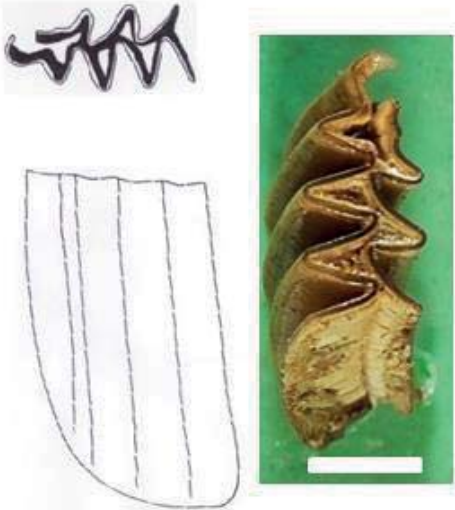
Mimomys tigliensis vs. *Mimomys reidi*



Tesakov (1998): Fig. 29. Palatal region of the skull of *M. tcharinomys tigliensis* from Tegelen*.

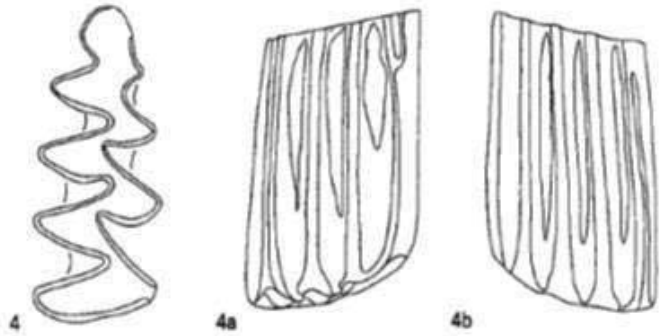
Figure 8. The **Irchel C** specimen, the M1 of *Mimomys reidi*. Comparison with the M1 of the maxilar of *M. tigliensis* from Tegelen (in Tesakov, 1998: Fig. 29). Note the similar size between both species (also in Figure 7). Note the abundant cement in the re-entrants of *M. tigliensis* in relation with the lesser amount in *M. reidi*.

Irchel F



Irchel F: m1d
Mimomys
reidi

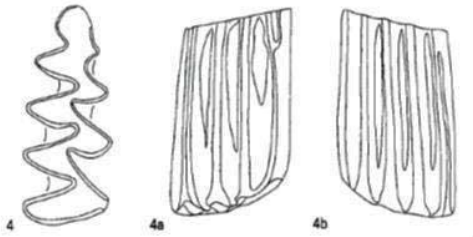
*Mimomys tigliensis**



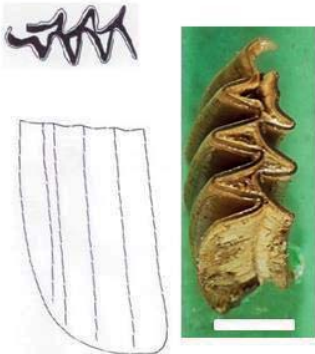
Tesakov (1998): Fig. 24. m1d of *M. tigliensis* from Tegelen *. Holotype. 4, occlusal, 4a, labial; 4b, lingual. There is slightly more cement in the re-entrant angles than in the m1 from Irchel.

Figure 9. *Mimomys reidi*: **Irchel F** specimen. Comparison with the m1 of *M. tigliensis* from Tegelen described by Tesakov (1998). See that the enamel fold in the m1, **Irchel F**, is more distal than it is in the m1 from Tegelen. It is more similar to that in m1 of *M. reidi*, as described from Kadzielnia by Kowalski (1958: Fig. 20)

*Mimomys tigliensis**

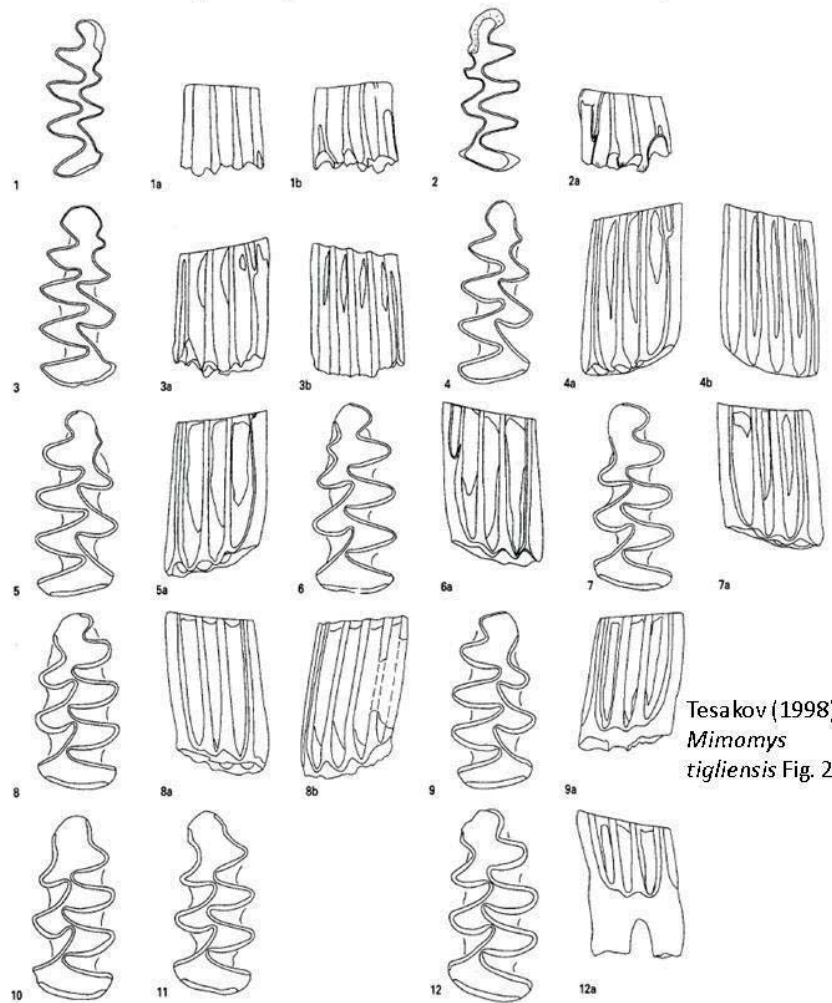


Tesakov (1998): Fig. 24. m1d of *M. tigliensis* from Tegelen *. Holotype. 4, occlusal, 4a, labial; 4b, lingual. There is slightly more cement in the re-entrant angles than in the m1 from Irchel.



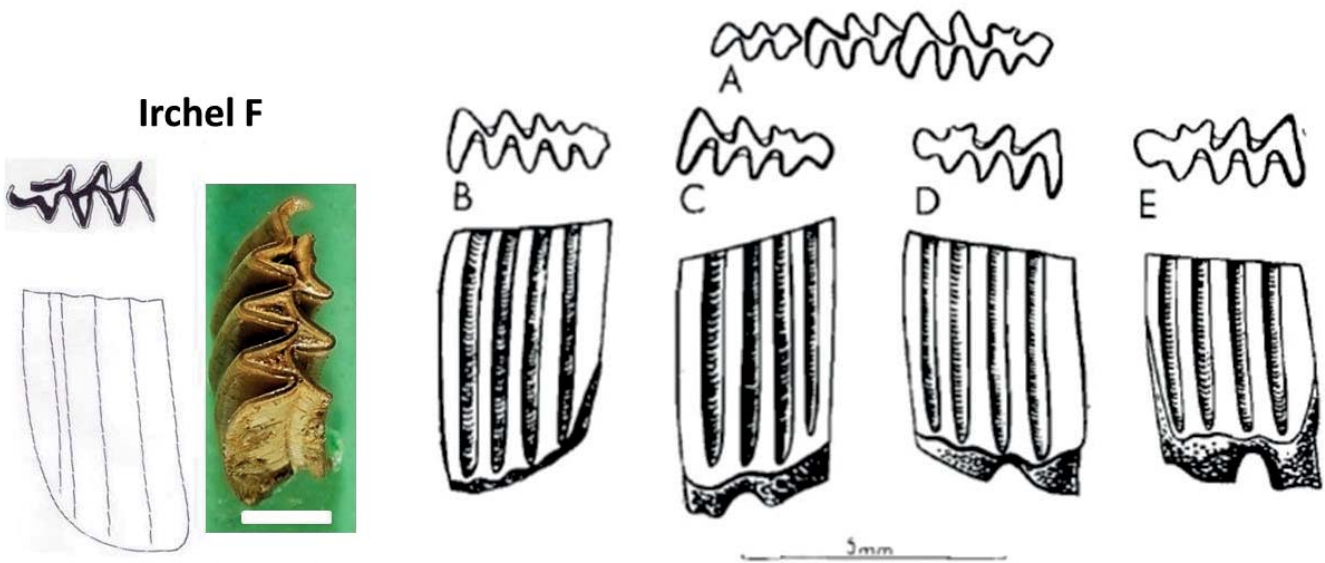
Irchel F: m1d *Mimomys reidi*

Mimomys tigliensis vs. *Mimomys reidi*



Tesakov (1998): *Mimomys tigliensis* Fig. 24.

Figure 10. *Mimomys reidi*: **Irchel F** specimen. **Irchel F**, m1d, from Irchel. Comparison with the m1 of *M. tigliensis* from Tegelen described by Tesakov (1998: Fig. 24).

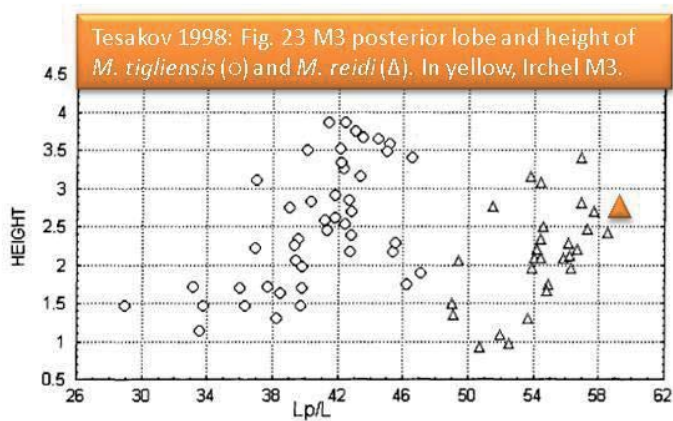


Irchel F: m1d
Mimomys
reidi?
tigliensis

Kadzielnia, Kowalski 1958: Fig. 20

Figure 11. **Irchel F**, m1d, from Irchel. Comparison with the m1 of *M. reidi*, as described from Kadzielnia by Kowalski (1958: Fig. 20).

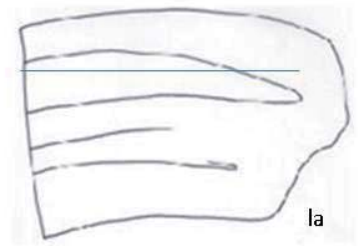
The M3 of the voles from Irchel (Fig. 5) are slightly larger and complex than *M. reidi* from Tegelen (see Fig. 20 of Tesakov, 1998). The M3 from Irchel has some similarity to the worn or older specimens from Tegelen (Fig. 10). The posterior lobe index (Lp/L) of Tesakov (1998) is a good distinction between the M3 of *M. reidi* and *M. tigliensis*. Both M3 from Irchel are in the area of *M. reidi* (Fig. 12).



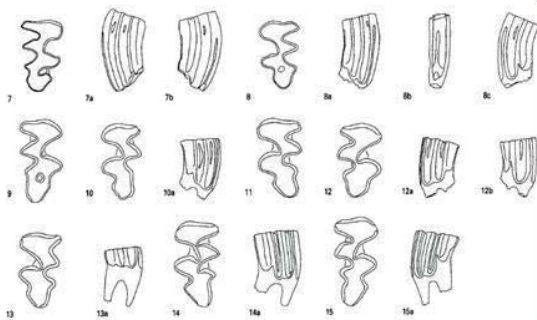
Mimomys reidi



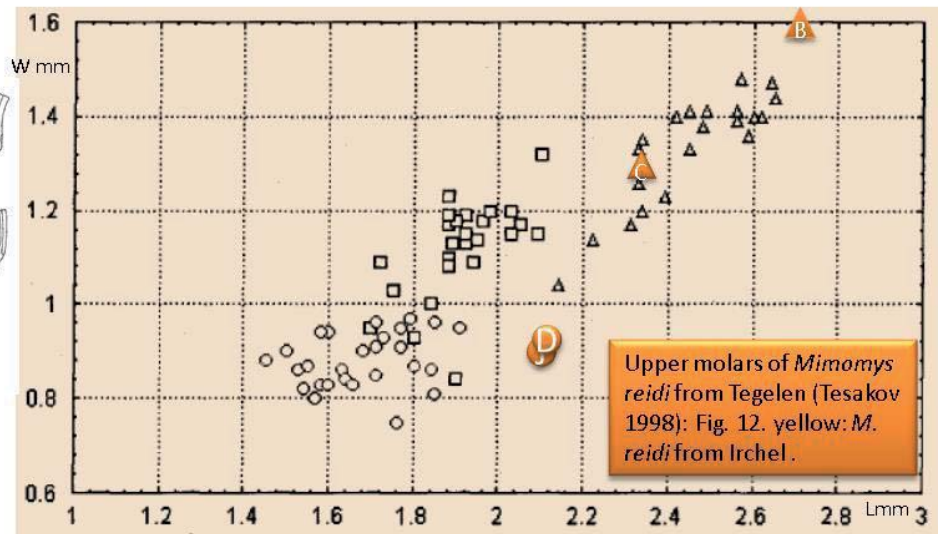
Irchel D: M3d
 $Lp/L * 100 = 1,25 / 2,1 * 100 = 59$
 Height = 2,71



Similar to *M. reidi* from Tegelen, though somewhat more complex



Mimomys reidi Tegelen. Upper M3 in Tesakov 1998: Fig. 20



Upper molars of *Mimomys reidi* from Tegelen (Tesakov 1998): Fig. 12. yellow: *M. reidi* from Irchel.

Figure 12. Comparison of specimens **Irchel D** and **Irchel J**, the M3 of *Mimomys reidi*, from Irchel, compared with the M3 from Tegelen. The values of the index Lp/L of the M3 fits better in the cluster of *M. reidi* (triangles) than in the cluster of *M. tigliensis* of the figure 23 of Tesakov (1998).

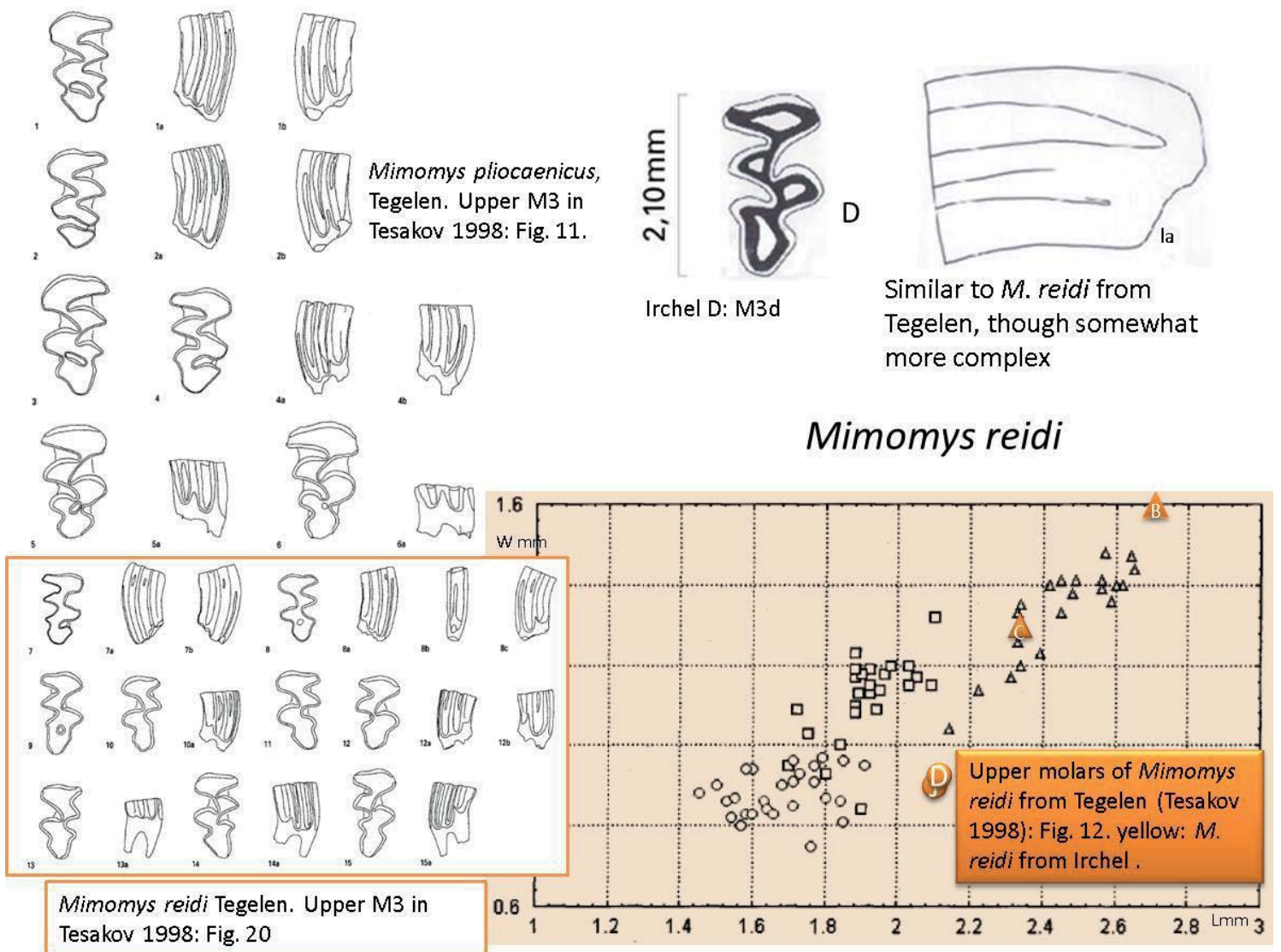


Figure 13. Comparison of specimens **Irchel D** the M3 of *Mimomys reidi*, from Irchel, compared with the M3 of *M. reidi* and *M. pliocaenicus* from Tegelen, described by Tesakov (1998). Note that the M3 of *M. pliocaenicus* are more complex than in *M. reidi*.

M. ostramosensis, from Osztramos 3 (also MN 17 in age, see FIGURE FINAL) is more advanced than *M. pliocaenicus* in the disappearance of enamel islets of M1 and M3 which occurs in young ontogenetic stages (Janossy and van der Meulen, 1975, Tesakov, 1998).

LAST COMMENTS

It is evident from the comparison among the species *M. reidi* and *M. tigliensis*, that it is difficult to evaluate differences between the small *Mimomys* species from Irchel. It could be *M. reidi* and/or *M. tigliensis*. The presence of two species of small *Mimomys* is not unusual in other localities of the MN 17 biozone in Europe such as Tegelen (Tesakov, 1998). Though, because of the scarcity of material, we classify it as *M. cf. reidi*. Also the position of the M3 seems difficult to fix up in between the large and the small *Mimomys* species.

CLETHRIONOMYS KRETZOII (KOWALSKI, 1958)

Available material: **Irchel G**, 1m3d, LxW: 1.36 x 0.87 (Table 1, Figs. 2G, 4G, 13).

It is represented by an m3 that belongs to a young individual. The molar has a posterior lobe and two pairs of widely confluent triangles. There is very little cement in the re-entrant angles. The enamel wall is almost continuous, except for the uppermost mesial side. Roots are undeveloped. The LRA is shallow in Irchel G, as in the m3 of *C. kretzoii* from Tegelen (Tesakov, 1998); see the figure 13 for comparison. Though the shape of the molar, same length, slightly wider.

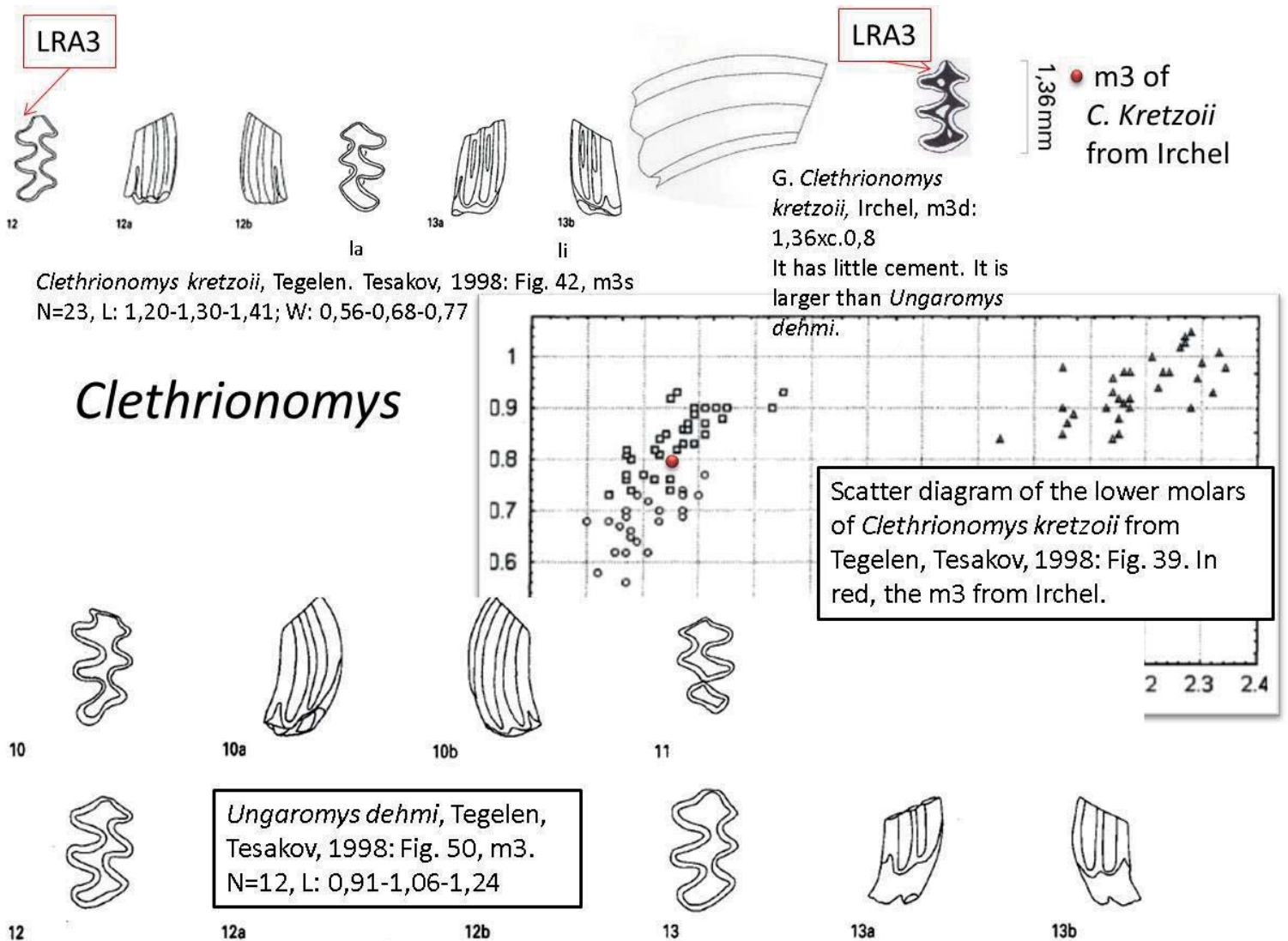


Figure 14. *Clethrionomys kretzoi*, specimen **Irchel G**, m3d. Comparison of the species *Clethrionomys kretzoi* and *Ungaromys dehmi*. Scatter diagram of the lower molars of *Clethrionomys kretzoi* from Tegelen, Tesakov, 1998: Fig. 39. In red, the m3 from Irchel. Note that *C. kretzoi* is larger than *U. dehmi* and the triangles are somewhat less confluent.

DISCUSSION AND COMPARISON

The **Irchel G**, m3d, is similar in length to the m3 of *Clethrionomys kretzoi* from Tegelen (Tesakov, 1998); it is slightly wider. As in the young individuals of Tegelen, the LRA3 is present (see Fig. 14).

It is wider than *Ungaromys* (see Figure 14) and more complex. Being confluent in both genera, the triangles of *Clethrionomys* are nearly parallel, while in *Ungaromys* they vary from alternating to parallel. Moreover, the genus *Ungaromys* lacks cement in the reentrant angles. The m3 from Irchel must be a very young specimen, though it has scarce cement and the molar base is still open. Also the LRA in the m3 of *Ungaromys* is deeper (Fig. 13, the *Ungaromys dehmi* from Tegelen).

PLYOMYS CF. SIMPLICIOR KRETZOI, 1956

DESCRIPTION

Available material: **Irchel E**, 1m1d LxW: 2.48 x 1.097 (Table 1, Figs. 2E, 4E).

The ancient *Pliomys* species has no cement in the re-entrant angles. Some old individuals and derived species such as *P. lenki* (Cuenca-Bescós et al., 2010) may have crown cement in the re-entrants. The m1 from Irchel E lacks crown cementum, and the occlusal dentine fields T2-T5 and with the anteroconid cap, communicates. It is a medium size *Pliomys* species of the dimensions of *P. simplicior* from Deutsch-Altenburg 2C₁ though it is slightly smaller. *P. episcopalis*, also from Deutsch-Altenburg 2C₁ is a bit larger (Rabeder, 1981). Triangle T6 is less developed than in *P. episcopalis*, while the T7 is conspicuous. The re-entrant angle BRA4 of the m1 is shallower than it is in *P. episcopalis*, and the anterior cap is more triangular shaped. The triangular

anteroconid cap distinguishes the species from Irchel from ancient *Pliomys* species, such as *P. destinatus*, described by Tesakov (2005), where it differs by a rounded anteroconid cap without additional triangles T6 and T7. It differs from *P. episcopalis* for its small size and the presence of T7.

The m1 from Irchel is smaller than *P. episcopalis* from Kadzielnia (Kowalski, 1958), Atapuerca TD3-4 (Cuenca-Bescós et al., 1995) and somewhat simpler (Figure 14).

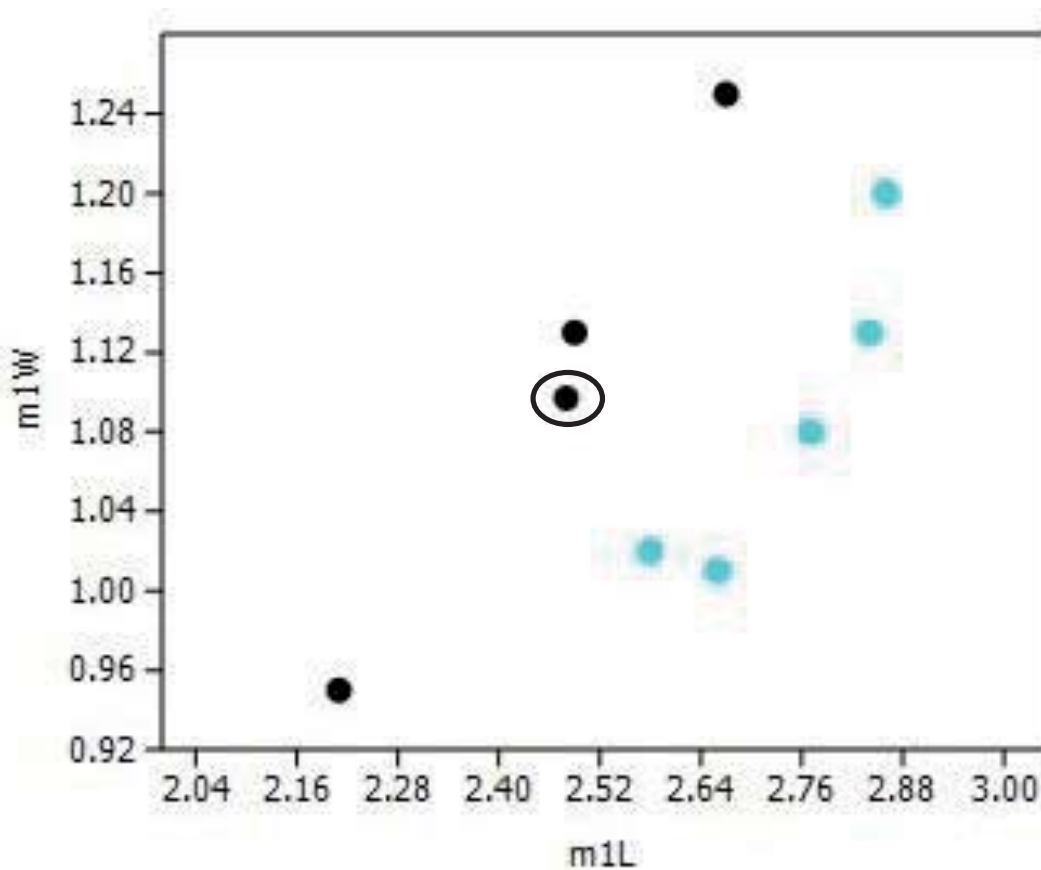


Figure 15. Scatter diagram (LxW in mm) of the m1 of the *Pliomys* species, *P. simplicior* (black dots) from Irchel and Deutsh Altenburg 2C (after Rabeder, 1981), and *P. episcopalis* (blue dots) from Atapuerca TD3-4 (Cuenca-Bescós et al., 1995). The m1 from Irchel is inside the black oval. It fits in the size of *P. simplicior*.

In the description of *P. simplicior*, from Nagyarsany, the author describes it as smaller than *P. episcopalis* though with a completely separated anteroconid cap (Heller, 1968). Heller indicates that both are morphologically similar species. Other author as Kowalski (1958) considers the species *P. simplicior* as nomen nudum; in his description of the specimens from Kadzielnia he declares that the character of being somewhat smaller is not sufficient.

In conclusion, and owing to the scarcity of material and nomenclatorial discussion we classify this specimen from Irchel as *P. cf. simplicior*.

SUBFAMILY MURINAE MURRAY 1866

As in arvicolines, rodents with a murine dental pattern were derived from ancestors with a cricetine pattern, and their origin is associated with important changes in cusp morphology and organization (Lazzari et al., 2008). In the description of the murines, we follow the cusp nomenclature of the molars proposed by van de Weerd (1976), modified by Aguilar et al. (2008) and Horacek et al. (2013). In the figure 16 we represent the molars of murines from Irchel.

APODEMUS CF. SYLVATICUS.

DESCRIPTION

Available material: **Irchel murines**, 1m1s, m2s (Table 1, Fig. 16).

The murines from Irchel are similar to the *Apodemus sylvaticus* described by the authors, see in example Anchelergues et al. (2015) although the posterior tubercles of the m1 (f, g, h in Weerd 1976) are elongated, not rounded as in *A. sylvaticus*. Therefore we classify the murine from Irchel as *A. cf. sylvaticus*.



Figure 16. The murines from Irchel, Switzerland. The lower, isolated, left m1 and m2 of *A. cf. sylvaticus*.

BIOSTRATIGRAPHIC REMARKS

FORMER PROPOSED CHRONOLOGY OF THE IRCHEL SITE

Bolliger et al. (1996) suggest a MN 17 age for the Irchel fauna; which would correspond to an age range of about 1.8 - 2.5 Ma. Nevertheless, the authors also note that from the magnetostratigraphic study, it results in a minimum of 0.91 Ma.

COMMENTS AGAINST AN AGE OF 0.91 MA

The claimed age of Irchel, around 0.9 Ma, is not supported by the biostratigraphy. The faunal assemblage has the primitive, large and small, *Miomys* species and lacks the rootless arvicoline rodent *Allophaiomys*. The date of 0.9 Ma is the upper limit of the Jaramillo magnetic reversal, which is a time range, comprised between roughly 1.2—0.9 Ma. In Europe we know well dated Early Pleistocene faunal sequences immediately prior, synchronous or younger to the Jaramillo magnetic reversal (Markova, 2007, Cuenca-Bescós et al., 2010, 2013, 2015, Minwer-Barakat et al., 2011, Duval et al., 2011, 2012). This time range is biochronologically characterized by the end of the Villafranchian and the beginning of the Galerian, a distinctive faunal turnover that took place during this time span in the western Palaeartic region (Kahlke et al., 2011), informally called Epivillafranchian. Some examples are the Cava Pirro fauna in Italy, with human—made lithic industries (Arzarello et al., 2009, Petronio & Marcolini, 2013), and the Atapuerca Faunal Unit 1, in Spain (Cuenca-Bescós and García, 2007, Cuenca-Bescós et al., 2010), notably with the oldest occurrence of *Homo*, together with the rodent association dominated by *Allophaiomys* species.

The fauna from Irchel is correlated with the MN17 zone, Gelasian or Tiglian (Villanyian, Epivillafranchian in terrestrial sequences, Tesakov, 1988, Kahlke et al., 2011). In Europe, the Villanyian is usually subdivided into the mammal Zones MN 16 and MN 17 where it can be defined as the *Borsodia-Villanyia* Superzone and subdivided into three rodent biozones based on arvicolines, from older to younger: the *Mimomys hassiacus* Zone; the *Mimomys polonicus* Zone and the *Mimomys pliocaenicus* Zone (Fejfar et al., 1997). We have shown that the *Mimomys* species from Irchel are *M. pliocaenicus* and *M. reidi*, both characteristics of the third biozone, *Mimomys pliocaenicus*, which means the upper part of the MN17 biozone.

The lack of the genus *Borsodia* in the Irchel fauna, characteristic of the MN 17 may be due to the arid character of the Irchel faunas, with few murids and diverse and large number of arvicolines. Following Mayhew et al. (2011), the extinct rooted genus *Borsodia* is an example of a clade with a range extending from Asia to the UK (evolutionary history shortened by Tesakov, 1993, 2004). The genus *Borsodia* is lacking in forest faunas (i.e. Tegelen, Tesakov, 1998), but present in other Early Pleistocene localities in the Netherlands (Mayhew, 2008), and the UK (Mayhew and Stuart, 1986), over a range of periods documenting recurring immigration during climatic conditions favouring arid/steppe faunas.

The Gelasian is an equivalent of the Praetiglian and Tiglian stages as defined in the Netherlands, which are commonly used in northwestern Europe (Rio et al., 1998, Gibbard et al., 2010). The Pastonian interglacial, called the Pastonian Stage (from Paston, Norfolk), is the name for an early Pleistocene

stage used in the British Isles. It precedes the Beestonian Stage and follows the Pre-Pastonian Stage. Unfortunately the precise age of this stage cannot yet be defined in terms of absolute dating or MIS stages. The Pre-Pastonian Stage is equivalent to the Tiglian C5-6 Stage of Europe and the Pre-Illinoian I glaciation of the early Pre-Illinoian Stage of North America (Cohen & Gibbard 2011).

LOWER LIMIT

The lower limit of the zone MN 17 is characterized by the apparition of the cemented *Mimomys* species such as the species from Irchel, as well as the genus *Pliomys*, *Clethrionomys*, *Borsodia*, *Villanya* (Fejfar et al., 2011).

UPPER LIMIT

The absence of the rootless vole *Allophaiomys pliocaenicus*, the index fossil of the nest biozone, the MQ1 in the Lower Biharian, as well as the absence of advanced *Mimomys* species such as *M. savini* and *M. pusillus* represents the key for stratigraphic interpretation of the upper limit of this faunal assemblage. The FAD – (first appearance datum) of *Allophaiomys pliocaenicus* defines the beginning of the Biharian (Bosak et al., 1982).

CONCLUSIONS

The faunal assemblage of Irchel consists of isolated teeth of rodents exclusively, four species of arvicolines (voles), *Mimomys pliocaenicus*, *M. reidi*, *Clethrionomys* cf. *kretzoi*, and primitive *Pliomys* sp. or *Pliomys* cf. *simplicior*; and one species of murines (mice), *Apodemus* cf. *sylvaticus*.

This faunal assemblage is correlated with the MN17 zone, which is the end of the Villanyian of the Mammal Zonation of Europe, Tiglian Stage. This stage is dated between 2.2 and 1.8 Ma (Figure 17).

We have shown that the *Mimomys* species from Irchel, *M. pliocaenicus* and *M. reidi*, are characteristic of the third biozone of the Villanyian, the *Mimomys pliocaenicus* biozone, which means the upper part of the MN17 biozone.

Thus, concluding, the association of the *Mimomys* species as well as the presence of primitive *Pliomys* species may indicate that the Irchel fauna is in the upper part of this biozone, probably around 1.8-2 Ma.

| Ma | Stages/Faunal Zones | Poland | Hungary | Romania | Croatia | Switzerland | Austria | Germany | Czech Republik |
|-----------|---------------------|-----------------------------|--|-------------|--|-------------|---|--|----------------------------|
| c. 0.6-c. | Early Brunhes | | Somssich 1 | | | | Hundsheim | Mosbach 2 Mauer Miesenheim Erpfinden 1 3 Husarenhof 4 | Mladeč 2,3 |
| 0.4 | Arvicola faunas | | | | | | | | |
| c. 0.8-c. | Early Brunhes | Kozi Grzbiet | Somssich 2 | | | | | Voigstedt Süßenborn Mahlis | Prezletice |
| 0.6 | Mimomys Faunas | | | | | | | | |
| c. 1.2-c. | Waalian- | Zalekiaki 1A | Villany 6 | | | | Deutsch- Altenburg 4A 4B | Untermaßfeld Neuleiningen 5 15 | Mladeč 1 |
| 0.8 | Cromerian | | | | | | | | |
| c. 1.8-c. | Eburonian- | Zamkova Dolna C Zabia | Osztramos 14-8 Nagyharsán yhegy Uppony | Betfia 7-13 | Podumci Tatinja draga Razvode | | Deutsch- Altenburg 2C1 10 | Neuleiningen 2 3 13 | Koneprusy Chlum |
| 1.2 | Waalian | | | | | | | | |
| c. 2.6-c. | Gelasian-Tiglian | Kamyk Kadzielnia | Osztramos 3 Villány 3-5 | Slatina 1-2 | Sandalja | Irchel | Deutsch- Altenburg 3 17 19 Stranzendorf f D F G I L | Schernfeld Neuleiningen 4 7 11 Schambach Deinsdorf Solnhofen 5 | Javoricko 1-5 Citineves |
| 1.8 | | | | | | | | | |

| Ma | Stages/Faunal Zones | Italy | France | Iberian Peninsula | | | The Netherlands | United Kingdom |
|-----------|---------------------|--|-----------------------------------|---------------------------------------|---|--|----------------------------------|---|
| c. 0.6-c. | Early Brunhes | Torre in Pietra | Arago G-K | Cueva del Agua Gran Dolina 10 | Sima de los Huesos Cúllar de Baza 1 | Galeria GII GIII Ambrona Aridos 1 | Nordbergum | Westbury-sub-Mendip 8- 20 |
| 0.4 | Arvicola faunas | | | | | | | |
| c. 0.8-c. | Early Brunhes | Slivia | Grace | Gran Dolina 8 | | | | West Runton a-g Sugworth |
| 0.6 | Mimomys Fauna: | | | | | | | |
| c. 1.2-c. | Waalian- | | Courterolles Le | Gran Dolina 3-7 | Puerto Lobo 1 4 | Huéscar 1* | Bavel Maasvlakte | Happisburgh 3 Pakefield |
| 0.8 | Cromerian | | | | | | | |
| c. 1.8-c. | Eburonian- | Monte la Mesa Monte Peglia Pirro Nord | Balaruc Mas Rambault | Cueva Victoria Orce2 3 | Fuente Nueva 3 Barranco León 3 Sima del Elefante 7-14 | | Brielle 1 Zuurland 9 | Westbury-sub-Mendip Siliceous Mb |
| 1.2 | Waalian | Pietrafitta | | Bagur 2 | Loma Quemada 1 | Muntanyeta dels Sants de la Pedra Venta Micena Orce 4 5 6 7 | | |
| | | | | Murcia 12 | Quibas | Almenara-Casablanca 3 | | |
| c. 2.6-c. | Gelasian-Tiglian | Montagnola Senese Rivoli Veronese | Senèze St.Vallier Montoussé | Incarcal 10B Almenara-Casablanca 1 | Alquería Galera 2 | G H Tollo de Chiclana 10 Islas Medas Fonelas P-1 Cañada Real | Tegelen Zuurland 61-65; 90-95 | Bramerton ButleyEast Runton Easton Wood Siderstrand |
| 1.8 | | | | | | | | |

Figure 17. Selected localities of the Early and Middle Pleistocene from Europe.

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