

Euroxenomys minutus minutus (Rodentia, Castoridae) from Gratkorn (Austria, Styria)

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Abstract A large sample of microvertebrates from the Sarmatian s. str. of Gratkorn (Austria, Styria) has recently been recovered. The recovered rodent fauna is diverse and includes a few castorid remains that are described here. Such remains comprise isolated teeth, a palate and a fragmentary skull that are ascribed to the small-sized beaver *Euroxenomys minutus minutus* (Von Meyer, 1838). These finds are discussed with regard to the Austrian Miocene castorid record.

Keywords Beavers · Rodents · Late Middle Miocene · Sarmatian s. str

Introduction

The Austrian locality Gratkorn (late Middle Miocene, Sarmatian s. str.; see situation in Gross et al. 2007) is remarkable for the diverse array of recovered fossil vertebrates (fishes, amphibians, reptiles, birds, mammals) and the exceptional quality of conservation of the specimens (Gross et al. 2011). A large sample that includes both micro- and macromammals has been recently collected and prepared. As far as the small

mammals are concerned, the first studies on the insectivores, rodents and lagomorphs (Sciuridae, Eomyidae, Gliridae: Daxner-Höck 2010; Cricetidae: Prieto et al. 2010a; Lagomorpha: Prieto et al. 2012; Angelone et al. 2014, this issue; insectivores: Prieto et al. 2010b) have outlined the importance of Gratkorn for a better understanding of Middle Miocene European biochronology and palaeobiogeography.

Gross et al. (2011) reported an indeterminate Castoridae in the locality, but this family is the only rodent group that has not yet been described. In this work, we provide a description of the castorid remains from Gratkorn and discuss their relationship with the Austrian Miocene fossil record of this family.

Materials and methods

The fossils from Gratkorn are housed in the collections of the Universalmuseum Joanneum in Graz (Geology & Palaeontology). The nomenclature of the dental elements follows Stirton (1935; see also Korth 2001: fig. 1).

Tooth measurements: The maximum length and width are measured at both the occlusal surface and the crown basis. Daxner-Höck and Bernor (2009) use the distal and mesial width of cheek teeth, whereas here only the maximum width will be measured. The measurements (in mm) are given as follows: occlusal length – crown basis length × occlusal width – crown basis width.

Abbreviations

UMJGP	Universalmuseum Joanneum in Graz
NAFB	North Alpine Foreland Basin
P50	Petersbuch 50

Systematic palaeontology

Family Castoridae Hemprich, 1820
Genus *Euroxenomys* Samson and Rădulesco, 1973

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Fig. 1 *Euroxenomys minutus minutus* (Von Meyer, 1838) from Gratkom (UMJGP 210912)

Taxonomical remarks: The (sub)generic assignment of this small-sized castorid is a matter of debate since its first description in the early part of the nineteenth century (see Giersch et al. 2010: 237; Huguéney and Duranthon 2012: 96). In the last decades, most scholars have agreed to recognise the subgenus *Euroxenomys* (Samson and Radulesco 1973) as, for instance, Huguéney (1999) in her overview of the European Miocene castorids. In contrast, Korth (2001) ranked *Euroxenomys* at the genus level. This proposal has been followed by Huguéney and Duranthon (2012), on the basis of both morphologic and phylogenetic arguments, but the debate on the generic assignment continues (e.g. as *Trongotherium* (*E.*) in Giersch et al. 2010). The overview of the evolution of Tertiary beavers by Stefen (2011) outlined the difficulties to provide an accurate taxonomy for the small castorid, and considered that both *Trongotherium* and a small-sized *Steneofiber* might co-occur.

Here, we follow Huguéney and Duranthon (2012) in ranking *Euroxenomys* to the genus level.

Type species: *Chalicomys minutus* von Meyer, 1838

Type locality: Elgg (Switzerland), Middle Miocene.

Species and subspecies included in *Euroxenomys*: *E. minutus minutus* (von Meyer, 1838), *E. minutus rhenanus* (Franzen and Storch, 1975), *E. inconnexus* Korth, 1995, *E. wilsoni* Korth, 2001. *E. minutus ozansoyi* (Ünay, 1977) might be a junior synonym of *E. minutus minutus* (Huguéney and Duranthon 2012: 111)

Euroxenomys minutus (Von Meyer, 1838)

Euroxenomys minutus minutus (Von Meyer, 1838)

Figures 1, 2, and 3

Other references: 2011 Castoridae indet.- (Gross et al. 2011, table 1)

Diagnosis: See diagnosis of the genus *Euroxenomys* in Samson and Radulesco (1973), which at that time was considered to be monospecific.

In addition, Huguéney (1999: 291) and Daxner-Höck and Bernor (2009: 574) provide a detailed account of the dental

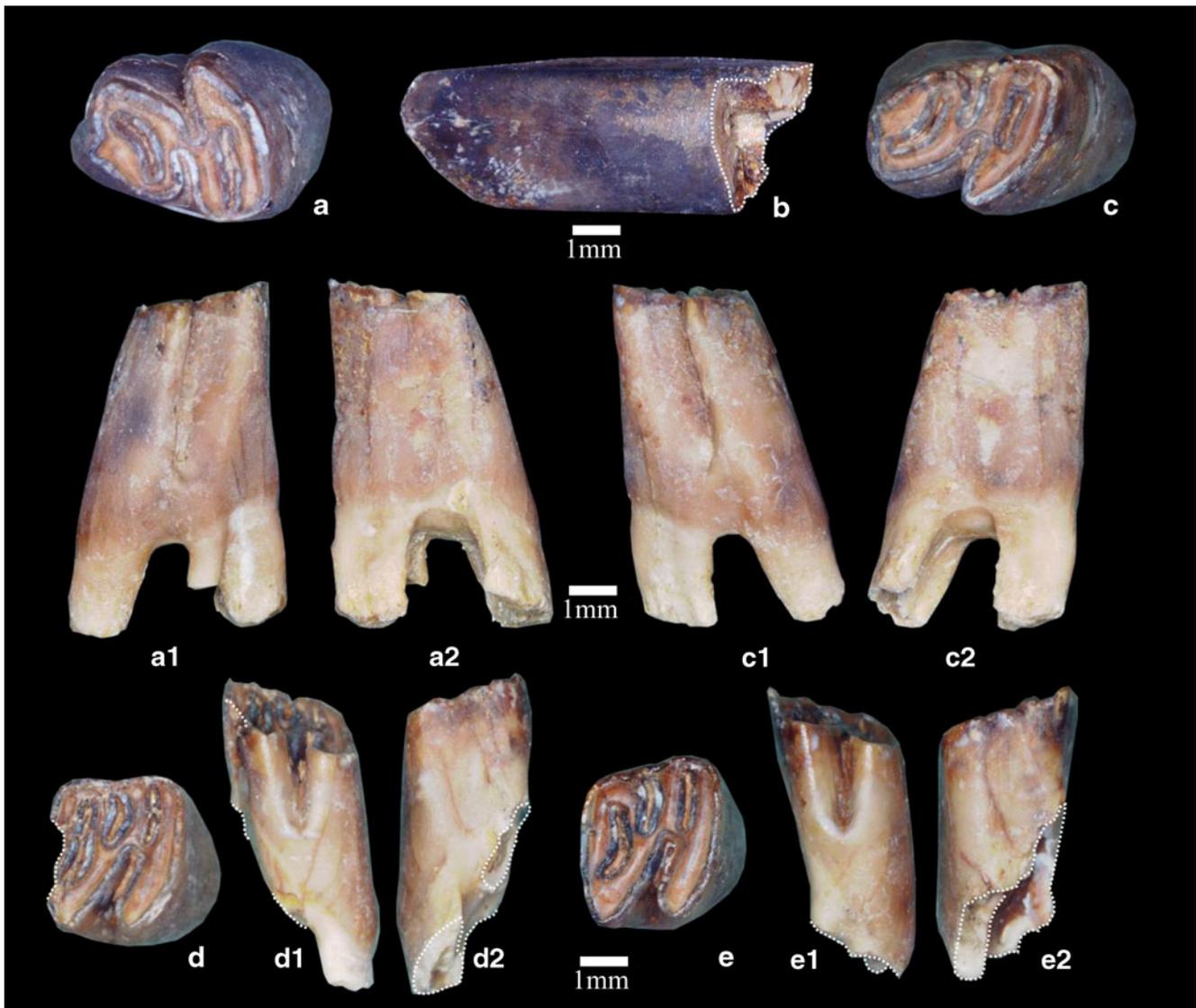


Fig. 2 *Euroxenomys minutus minutus* (Von Meyer, 1838) from Gratkorn, lower dentition: **a** right p4, **a1** labial view, **a2** lingual view, **b** fragment of right lower incisor, **c** left p4, **c1** labial view, **c2** lingual view, **d** left m1/2, **d1**

labial view, **d2** lingual view, **e** left m1/2, **e1** labial view, **e2** lingual view (all specimens: UMJGP 204747)

characters of *Euroxenomys minutus*, although neither of these authors provided an emended diagnosis.

Emended diagnosis: After Aldana Carrasco (1992, translated from Spanish; Aldana Carrasco considered the European *Euroxenomys* as a synonym of the North American genus *Monosaulax*).

Small-sized *Monosaulax*. The anterior face of the upper incisors is semi-flattened and in the lower ones is rounded; subhypodont teeth; basal section of the P4/subtriangular, with three external striae, the parastria being longer (it runs throughout less than the height of the molar) the mesostria and the metastria are very short. The M1–2 with three labial striae which are very short. M3 with one labial stria, the mesostria, which is very short. With wear, the length and width of the M1–2 and the length of the P4 show few variations, in contrast the length of the P4 varies considerably. AL1 variable, however, it

can be remarked that the mean of AL1 of the P4 is higher than in the rest of the upper teeth, that is the hypostria is shorter. DP4 and P4 have a triangular section. P4 with very short mesostriid and a hypostriid that runs throughout 2/3 of the crown height. M1–2 and M3 with two or three lingual striids. P4 longer and wider than the upper molars. P4 longer and similar in width to the lower molars. M3 longer than M1–2 but of similar width.

Remarks: AL1 is the distance from the base of the tooth to the base of the hypostria or hypostriid (Aldana Carrasco 1992: 100).

Differential diagnosis: Aldana Carrasco (1992, translated from Spanish; the author wrongly synonymized *Steneofiber* and *Chalicomys* with *Palaeomys*). The size of the lower teeth of *M. minutus* is higher than that of *M. curtis* and lower than *M. tungurensis* and *M. changpeiensis*. It further differs from *M. tungurensis* because this species shows a hypostriid that

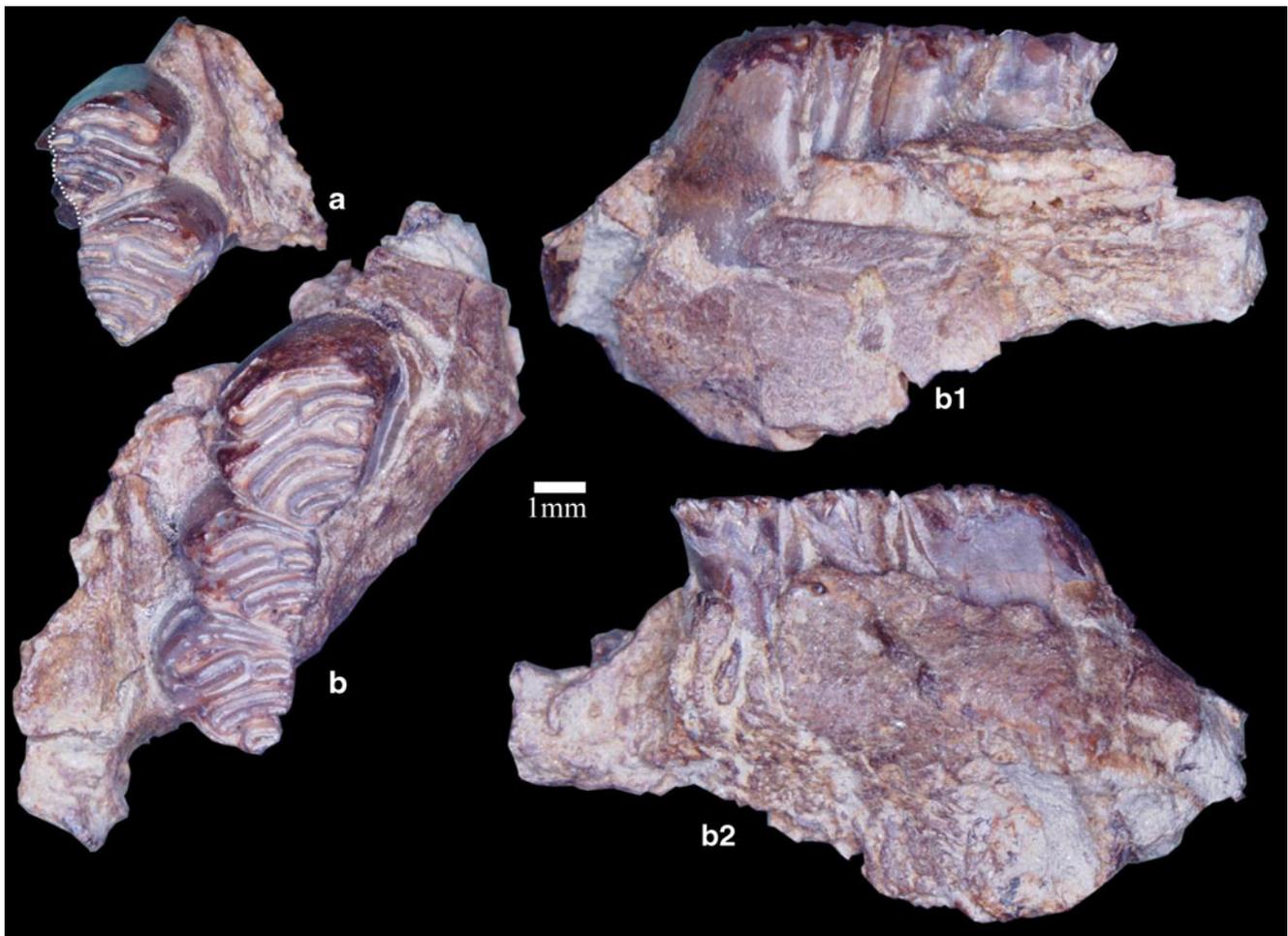


Fig. 3 *Euroxenomys minutus minutus* (Von Meyer, 1838) from Gratkorn, upper dentition: **a** right maxillary fragment with M1–M2, **b** left maxillary fragment with P4–M2, **b1** lingual view, **b2** labial view (all elements belong to specimen: UMJGP 204006)

reaches the base of the crown and the parafossetid is longer and narrower. It differs from *M. pansus* because in this species the P4 and lower molars are longer and wider and the M1–2 are more rounded, *M. complexus* and *M. hesperus* are larger and show a promesofossetid. Furthermore, *M. complexus* presents a more-developed hypostriid and in *M. hesperus* the parafossetid and metafossetid are longer and narrower.

Material

UMJGP 204006: Left maxillary fragment with P4–M2. Right maxillary fragment with M1–M2. Both fragments likely belong to the same individual. Measurements: P4: 3.58–4.41 × 3.32–3.89; M1: 2.71–3.18 × 2.46–2.76; ca 3.03–ca3.57 × 2.68–3.04; M2: 2.83–3.12 × 2.71–2.95.

UMJGP 204747: Right p4. Left p4. Left m1/2. Left m1/2, 4 incisor fragments. All fragments likely belong to the same individual. Measurements: p4: 3.98–5.36 × 5.36–4.16; 3.70–5.72 × 3.42–3.95. m1/2: * × 3.62–4.15; 3.14–4.32 × 3.5–3.84.

UMJGP 210912: Crushed skull with associated mandibles.

Description

Skull: UMJGP 210912 includes a partial skull and two associated mandibles. This specimen has been prepared in a block in order to preserve the original association of the bones. The skull is very fragmentary. The two upper incisors are preserved, but the bone material from their sockets has almost completely disappeared and they show numerous transverse cracks. The anterior surface of the incisor enamel is mostly smooth, without ridges or rugosities (Fig. 1e). Above the left mandible, there is a remnant of the left maxillary with the P4 and M1. The right maxillary preserves the full upper postincisor series (P4–M3).

Mandibles: Although specimen UMJGP 210912 preserves two partial mandibles, they are placed on top of one another, the left covering the ventral margin of the right one. Additionally, part of the skull and other cranial fragments also cover most of the right mandible, including the ramus, so few details of that element can be described. One cannot tell if the incisor

Table 1 Miocene castorid record from Austria

Locality	Basin	Dating	<i>Euroxeromys minutus</i>	<i>Chalicomys jaegeri</i>	<i>Steneofiber</i>	Castoridae indet.	Reference
Eichkogel	Vienna	Pannonian, H		x			Daxner-Höck 1980, 1996; Daxner-Höck and Bernor 2009
Kohfidisch	Styrian (fissure filling)	Pannonian, H		cf.			Huguency 1999; Daxner-Höck and Bernor 2009
Schernham	NAFB	Pannonian, G	x	x			Bauer 2009; Daxner-Höck and Bernor 2009
Götzendorf	Vienna	Pannonian, F	x	x			Rögl et al. 1993; Daxner-Höck and Bernor 2009
Richardhof-Golfplatz	Vienna	Pannonian, E	x				Bauer 2009
Vösendorf	Vienna	Pannonian, E	x				Huguency 1999
Inzersdorf	Vienna	Pannonian, E	x				Huguency 1999
Atzelsdorf	Vienna	Pannonian, C	x		?		Daxner-Höck and Bernor 2009
Brunn-Vösendorf	Vienna	Pannonian, C	x				Huguency 1999
Gaweinstal	Vienna	Pannonian, C	x				Harzhauser et al. 2011
Mataschen	Styrian	Pannonian, B	x	x			Daxner-Höck 2004; Daxner-Höck and Bernor 2009
Gratkorn	Styrian	Sarmatian	x				This paper
Göriach	Styrian	Badenian	x	x			Mottl 1970; Rabeder 1985; Huguency 1999
Leoben (Seegraben)	Leoben	Badenian		x			Mottl 1970; Huguency 1999
Feisternitz	Styrian	Badenian		x			Mottl 1970; Huguency 1999
Wies	Styrian	Badenian		x			Huguency 1999
Eibiswald	Styrian	Badenian		x			Mottl 1970; Huguency 1999
Kalkgrub bei Schwanberg	Styrian	Badenian		x			Mottl 1970
Leoben (Münzenberg)	Leoben	Badenian		x			Mottl 1970; Huguency 1999
Teiritzberg (T2/5)	Korneuburg	Karpatian				x	Daxner-Höck 1998
Obergänserndorf (OGI)	Korneuburg	Karpatian				x	Daxner-Höck 1998
Voitsberg	Styrian	Ottományian		x			Mottl 1970; Huguency 1999

and the p4 are still present since that area is covered. Most of the posterior part of the m1 is visible, as well as the m2 and m3. The left mandible lies on its lingual part and preserves the full lower series (tooth row length: 15.01 mm; tip of the smooth incisor p4: 16.06 mm), but the m3 has detached because the distal part of the jaw, including all the ascending ramus, is missing. The angular apophysis starts just below the anterior root of the m1. The mental foramen is positioned slightly in front of the anterior root of the p4, being placed quite ventrally. The diastema is relatively short (5.48 mm), deep and asymmetric. The height of the mandible under the diastema is 8.48 mm, the maximum height (below the p4) is 12.35 mm, while the corpus becomes thinner as we move distally measuring only 9.10 mm below the posterior root of the m2. The teeth are relatively worn (stage 4 of Crusafont Pairó et al. 1948),

indicating an advanced age. The dental elements are described in the following.

Incisors: Both upper and lower incisors are robust and show a smooth enamel surface (Figs. 1f, 2b).

Lower cheek teeth: The p4 is by far the largest tooth in the lower series. The hypoflexid ends 1.86 mm above the alveolus in specimen UMJGP 210912. The two isolated p4s (Fig. 2a, c) are very close in size and morphology, and moderately worn. The mesoflexid is lingually open. The mesostriids are less than 1 mm high. The parafossettid is wide and curved, with its buccal end markedly pointing forward. The metaconid defines a small ‘bump’ in the anterior margin of the tooth. The hypoflexid ends 1.8–2.0 mm above the enamel–dentine junction. The metafossettid is almost as wide as the parafossettid, but it is transverse and slightly shorter. In the right p4 (Fig. 2a), the metafossettid is weakly open in the lingual side of the tooth, while this connection has closed in the left premolar (Fig. 2c).

In the latter, there is an additional minute circular fossettid between the end of the metafossettid and the lingual border of the p4. The right p4 has 3 roots, the left 2. The p4 of the left mandible of the specimen UMJGP 210912 (Fig. 1c) does not differ significantly from the isolated p4s just described.

The two lower m1/m2 UMJGP 204747 (Fig. 2d, e) are also very similar. One molar is slightly damaged anteriorly (Fig. 2d). These molars are approximately square and not elongated as the p4. The wear stage is slightly more advanced than that of the p4s, since the lingual connexion of the mesoflexid is already closing. All fossettids are of similar width and roughly parallel to one another. However, the parafossettid is slightly wider. This fossettid is somewhat shorter and more curved in the second specimen (Fig. 2e). The mesofossettid is open to the lingual side in one specimen (Fig. 2e) while in the second one (Fig. 2d), wear has already closed this connection. The hypoflexid faces the metafossettid, and are only separated by a thin dentine bridge. The roots of the m1/2 s are broken but there appears to have been only a wide and long posterior root and probably two shorter anterior ones (Fig. 2d). The m1 of the left mandible UMJGP 210912 (Fig. 1c) shows a long hypofossettid, but the remaining morphological characters cannot be observed. On the contrary, the m2 is free from sediment. It shows a less curved hypofossettid than the m1 as well as a transverse parafossettid. The mesofossettid is already closed. Clearly, the wear stage of the lower series of specimen UMJGP 210912 is more advanced than that of the isolated cheek teeth from the same site.

The only recovered m3 (UPMJGP 210912) is damaged antero-labially (Fig. 1c). All fossettids are closed. The parafossettid is wider than the remaining fossettids and strongly curved. The hypofossettid faces the metafossettid and is separated from it by a thin enamel bridge.

Upper cheek teeth: The P4 is larger and more triangular than the M1 and M2 (Fig. 3b). The upper cheek teeth of specimen UMJGP 204006 show an advanced wear stage, with all the flexi but the hypoflexus being closed into fossetes (stage 4 of Crusafont Pairó et al. 1948). In the P4, the hypoflexus faces the parafossette, although it is slightly more anterior. Both flexi are separated by a thin enamel bridge. The parafossette is oblique, with its lingual end pointing distally. The mesofossette curves postero-lingually and occupies the whole width of the premolar. A small and round subparafossette is developed on the lingual side of the second loph. The metafossette is parallel to and almost as long as the parafossette.

The M1s and M2s (Fig. 3a, b) are very similar to one another. They are basically smaller and with a squarer outline than the P4. Furthermore, they lack the subparafossette. The mesofossette is shorter than in the P4 and not curved, being roughly parallel to all other fossetes.

In specimen UMJGP 210912, only the occlusal surface of the M3 is visible (Fig. 1d). The M3 is highly elongated and becomes markedly narrower towards its distal end, which is

pointed. The specimen is highly worn, with all the flexi closed into fossetes (stage 5 of Crusafont Pairó et al. 1948). In this specimen, the hypoflexus occupies the lingual part of the tooth, and a smaller and curved parafossette is present labially. The strongly curved mesofossette crosses the whole central part of the M3. Posteriorly, two backward-directed fossetes run parallel, the lingual one being clearly smaller. The estimated length of this molar is ca. 4.2 to ca. 5.1 mm (occlusal length – crown length).

Discussion

The Gratkorn material shows a number of diagnostic features of *Euroxenomys minutus* after Hugueney (1999) and Daxner-Höck and Bernor (2009). These include:

- 1) Small size
- 2) Synclines(ids) run parallel
- 3) Hypostriae(ids) do not reach the base of the crown
- 4) Enlarged P4/p4
- 5) Smooth mesial surface of incisor, with triangular or rounded transversal section.

Stefen and Rummel (2003) propose the presence of two lineages of a small-sized *Euroxenomys*-like beavers. This proposal is based on the comparison of a well-preserved skull from the south German fissure filling Petersbuch 50 (P50) and a palate from Weże in Poland. While both specimens are sharing skull characteristics, the Polish material is characterised by a M3 only slightly longer than the M2. The M3 from Gratkorn is, although hard to measure, clearly larger than the upper two first molars, and fits within the size range of the two molars from P50. It seems to be larger than *E. m. minutus* from Sansan (Hugueney and Duranthon 2012), and from Castell de Barberà (Aldana Carrasco 1992). The M1 from P50 is characterised by its small size, but is much worn, and this will affect measurements. Considering the above-mentioned characteristics, and the unsolved questions regarding the taxonomy of the small-sized European beavers at the end of the Middle Miocene (Stefen and Rummel 2003), the material from Gratkorn fits well with *Euroxenomys minutus minutus*.

The cranial material referred to *Euroxenomys* is most often very fragmentary. While mandibles, maxillaries (rarely with snout; Sulimski 1964) are available to science (e.g. Crusafont Pairó et al. 1948; Mayhew 1978; Hugueney 1999; Daxner-Höck 2004; Hugueney and Duranthon 2012), the only (nearly complete) skull of the genus was recently described from the late Middle Miocene fissure filling P50 (Bavaria; Stefen and Rummel 2003). The skull from Gratkorn is very damaged and it does not provide any additional information. On the other hand, the mandibles, although damaged are very similar in size and overall morphology to the figured specimens from P50

(Stefen and Rummel 2003), Sansan (Huguency and Duranthon 2012) and Castell de Barberà (Crusafont Pairó et al. 1948).

Conclusions and implications for the Austrian Miocene castorid record

A summary of the Austrian Miocene castorid record is presented in Table 1. It includes less than 20 sites that range from the Early Miocene (Ottangian) to the Late Miocene (Pannonian, MN11). *Euroxeonomys minutus* is present from the Badenian (Göriach) to the Pannonian zone G (Schernham), although it is more common during the Pannonian. The sparse Karpatian remains found at Körneuburger (Daxner-Höck 1998) cannot be assigned to *Euroxenomys minutus*. Besides this isolated record, the Ottangian–Badenian castorid record only includes a large-sized beaver currently identified as *Chalicomys jaegeri* (its taxonomy is in need of revision). However, these reports represent old finds in which no systematic screen-washing of sediments was undertaken, so it is likely that smaller-sized taxa such as *E. minutus* were overlooked and only larger-sized ones were collected. Not surprisingly, *E. minutus* has been recovered in the Badenian site of Göriach which was sampled using screen-washing. As said before, *Euroxenomys* is a common find in Pannonian sites. In most of these sites, it is the only beaver present, co-occurring with the larger *C. jaegeri* in Pannonian B (Mataschen), F (Götzendorf) and G (Schernham) sites. A *Steneofiber*-like beaver, smaller than the Austrian *Chalicomys*, co-occurs with *Euroxenomys* in the lower Pannonian (zone C) of Atzelsdorf (Daxner-Höck and Bernor 2009). The Mataschen collection deserves a special mention since it represents the most complete Austrian material of this species known to date (Daxner-Höck 2004). It consists of semi-articulated skeletal remains preserved in two different blocks. Although such specimens provide a great deal of information on the postcranial appearance of *E. minutus* and its palaeobiology (Daxner-Höck 2004), but, unfortunately, the skull is badly damaged, and only isolated bone fragments are preserved. At Gratkorn, it is exactly the opposite, where only cranial elements have been found thus far.

In general, beavers are relatively common in the Austrian Miocene, being sometimes abundant (e.g. Rögl et al. 1993 found 28 % of castorid among the rodent fauna from Götzendorf). They are only missing in a few localities (e.g. Oberdorf, Grund and Mühlbach; Daxner-Höck 1998, 2003). Thus, their presence in Gratkorn is not a surprise, although they are not particularly common at this site. *E. minutus* indicates the presence of permanent water masses near the site area, which is in general agreement with the palaeoenvironment reconstructed for the site (Gross et al. 2011; Böhme and Vasilyan 2014, this issue; Prieto et al. 2014, this issue).

However, *Euroxenomys* may have been more agile when moving on the ground than other beavers (Daxner-Höck 2004; Casanovas-Vilar et al. 2008), and may have ventured farther away from water.

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