Ann. Naturhist. Mus. Wien, Serie A	113	167–208	Wien, Mai 2011

Complex faunal mixing in the early Pannonian palaeo-Danube Delta (Late Miocene, Gaweinstal, Lower Austria)

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(With 9 figures)

Manuscript submitted on June 1st 2010,
the revised manuscript on November 10th 2010

Abstract

A small artificial road-construction outcrop at Gaweinstal in Lower Austria yielded an unusual assemblage of molluscs and vertebrates in Lower Pannonian fluvial deposits of the Hollabrunn-Mistelbach Formation. The composition of the mollusc fauna reveals a very complex mixing from at least three older strata resulting in a biostratigraphically condensed assemblage. Marine Sarmatian shells from the upper *Ervilia* Zone (~12.0 Ma) and the *Sarmatimactra* Zone (~11.8 Ma) and Lake Pannon related shells from the lower Pannonian *Mytilopsis ornithopsis* Zone (~11.4 Ma) are intermixed in fluvial sediments corresponding to the *Mytilopsis hoernesi* Zone (~11.2–11.1 Ma). This dating is supported by the vertebrate fauna which corresponds to the Late Miocene mammal zone MN9. The parautochthonous faunal elements reveal a multi-habitat assemblage from lotic, lentic and terrestrial habitats of the palaeo-Danube delta. The process of reworking and faunal mixing was supported by the palaeogeographic position and depositional history of the Mistelbach Block which is covered by various Miocene shallow water sediments which formed the river beds and catchment area of the palaeo-Danube delta. The section is thus an extraordinary example for the difficulties for biostratigraphic datings along such flat basin margins.

Keywords: molluscs, small mammals, Pannonian, Late Miocene, MN9, palaeo-Danube, Lake Pannon, Hollabrunn-Mistelbach Formation, biostratigraphically condensed assemblage.

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Zusammenfassung

Im Zuge von Straßenbauarbeiten bei Gaweinstal in Niederösterreich konnte eine ungewöhnliche Vergesellschaftung aus Mollusken und Wirbeltierresten in fluviatilen Ablagerungen der unterpannonen Hollabrunn-Mistelbach-Formation geborgen werden. Die Zusammensetzung der Molluskenfauna deutet auf Umlagerungen aus mindestens drei älteren Einheiten, die zu einer biostratigraphisch kondensierten Vergesellschaftung führten.

Sarmatische marine Fossilien der oberen *Ervilia* Zone (~12,0 Mio. Jahre) und der *Sarmatimactra* Zone (~11,8 Mio. Jahre) und Schalen aus der *Mytilopsis ornithopsis* Zone (~11,4 Mio. Jahre) des Pannon-Sees finden sich in fluviatilen Sedimenten der *Mytilopsis hoernesi* Zone (~11,2–11,1 Mio. Jahre). Die Alterseinstufung wird auch durch die Vertebratenfaunen bestätigt, die der Säugetier-Zone MN 9 entsprechen. Selbst die parautochthonen Mollusken liegen in Form einer „multi-habitat Vergesellschaftung" aus verschiedensten Lebensräumen des Paläo-Donaudeltas vor. Die intensive Faunenmischung erklärt sich aus der paläogeographischen Position und der wechselvollen Ablagerungsgeschichte der Mistelbacher Hochscholle. Miozäne Seichtwasser-Sedimente, die mehrfach während des Miozäns hier abgelagert wurden, bildeten im Pannonium das Flussbett der Paläodonau und waren das Einzugsgebiet für das Delta. Der Fundort ist somit ein gutes Beispiel für die Schwierigkeiten bei der korrekten biostratigraphischen Einstufung entlang flacher Beckenränder.

Schlüsselwörter: Mollusken, Kleinsäuger, Pannonium, Ober-Miozän, MN9, Paläodonau, Pannon-See, Hollabrunn-Mistelbach-Formation, biostratigraphisch kondensierte Vergesellschaftung.

Introduction

Numerous short-lived outcrops appeared in Lower Austria during the A5–highway constructions in the years 2008 and 2009. One of these sections exposed fluvial deposits of the Hollabrunn-Mistelbach Formation at Gaweinstal. This formation is widespread on the Mistelbach Block, which formed the basement rocks of the palaeo-Danube delta between the Zaya Gate in the west and the Steinberg fault in the east (Grill 1968; Wessely 2006; Harzhauser 2009). Several roughly coeval localities in this formation yielded remains of the equid *Hippotherium*, which are considered to be the geologically oldest representatives of this genus in the Old World (Bernor et al. 1988; Woodburne 2009). Thus, a better understanding of the taphonomic processes and a refined chronology of the depositional history in this area are of importance to constrain this European vertebrate immigration.

Throughout the Middle and Late Miocene, this area was a junction between the Central Paratethys Sea and later Lake Pannon in the Vienna Basin and the various riverine systems coming from the west via the North Alpine Foreland Basin. Thus, depending on relative sea level and regional geodynamic history, the area experienced an outstanding rapid succession of marine/lacustrine ingressions from the east alternating with prograding fluvial systems from the west. This rapid environmental change caused constant reworking of older sediments. Similar reworking of older strata into lower Pannonian formations and

the redeposition of usually quite well preserved Sarmatian shells, which show nearly no abrasion, is a characteristic feature in the entire Vienna and the Eisenstadt Sopron Basin. This mixing deduced many geologists such as FUCHS (1875) and JEKELIUS (1935; 1943) to assume so-called "transitional beds" with co-existing Sarmatian and Pannonian taxa. Early opponents of that theory were HOERNES (1898), FRIEDL (1936) and PAPP (1951).

Geographic and geological setting

The village Gaweinstal lies in the middle of the Mistelbach Block c. 34 km NE of Vienna (Fig. 1). This tectonic unit forms an uplifted block at the western margin of the Vienna Basin and is covered by marine and fluvial Badenian, Sarmatian and Pannonian deposits (GRILL 1968). In the following summary, we use the biostratigraphic scheme of MAGYAR et al. (1999) and the age model of HARZHAUSER et al. (2004) (Fig. 2).

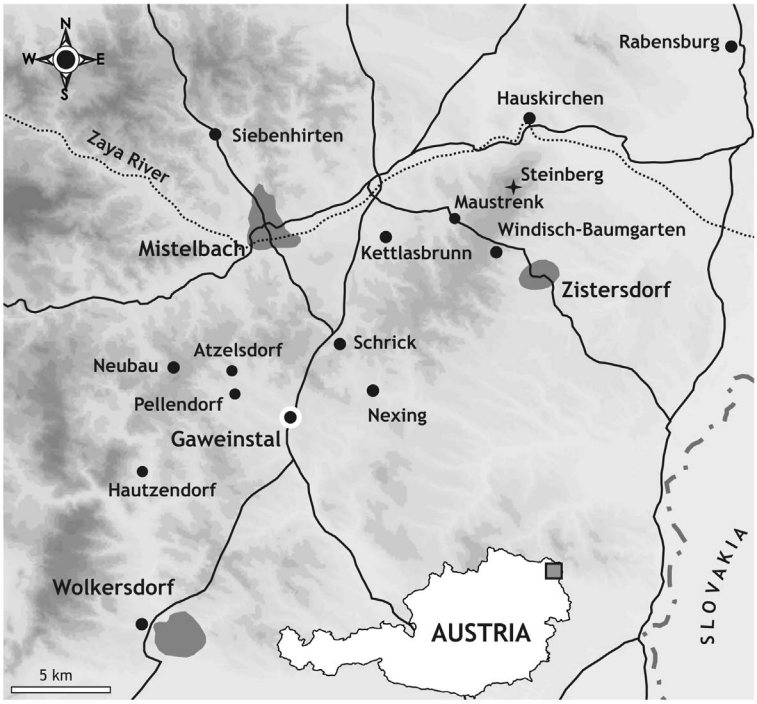


Fig. 1. Location map and digital elevation model of the investigated area on the Mistelbach Block along the western margin of the Vienna Basin.

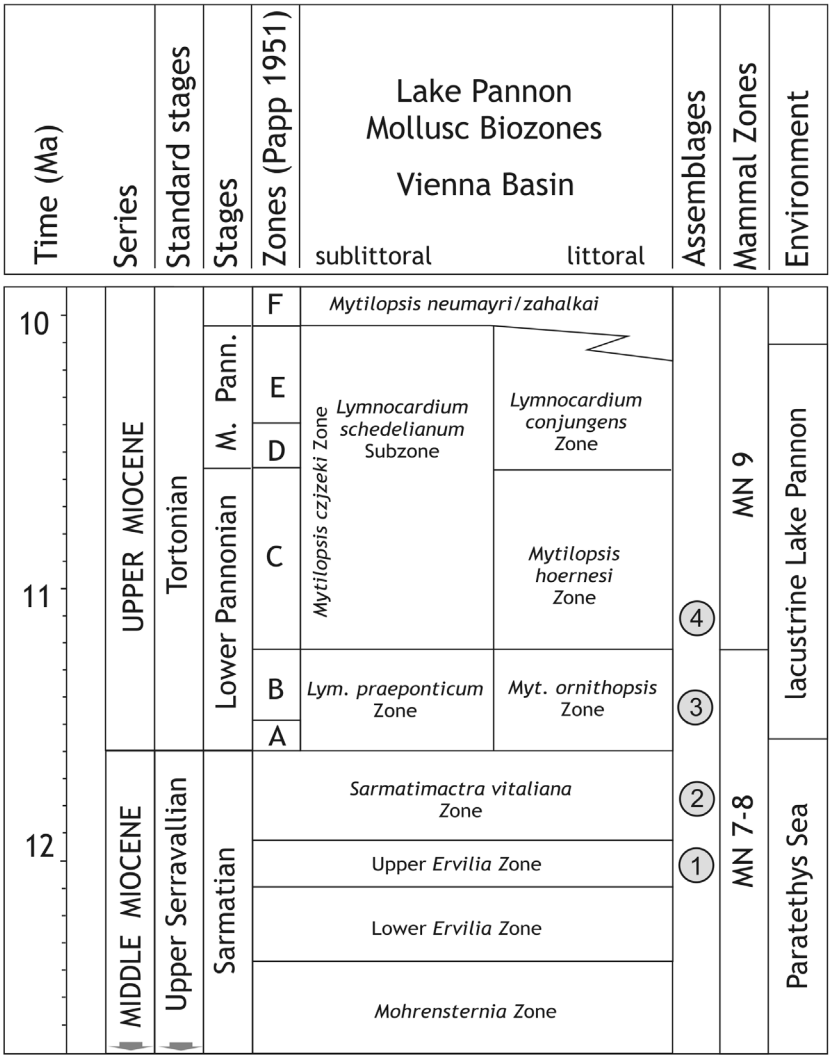


Fig. 2. Chronostratigraphy and biostratigraphy of the Sarmatian and Pannonian in the Vienna Basin (modified from HARZHAUSER et al. 2004 and HARZHAUSER & PILLER 2004). The circles indicate the stratigraphic position of the various mollusc assemblages detected in the biostratigraphically condensed assemblage from Gaweinstal.

Already during the middle Badenian, when the North Alpine Foreland Basin (NAFB) turned into wetlands, a first fluvial system covered the area ending in the huge delta of Kleinhadersdorf bearing important vertebrate remains (Grill 1968). The sea covered the area again during the late Badenian and after a short interruption again during the early Sarmatian (Mandic et al. 2008). After this strong transgression, which allowed the establishment of sublittoral soft bottom conditions on the Mistelbach Block, the area turned into an extremely shallow ooid shoal, protected from the open sea by several islands in the Steinberg area. The mixed-siliciclastic carbonatic deposits, with shell coquinas, oolites and oolitic sands are united in the Skalica Formation and bear a rich mollusc fauna (Harzhauser & Piller 2004). At the Sarmatian/Pannonian transition at c. 11.6–11.5 Ma., the Mistelbach Block became dry land until a first rise of Lake Pannon during the *Mytilopsis ornithopsis* Zone at ca. 11.4–11.3 Ma. This short period ended with the retreat of the lake's coastline and the huge delta of the palaeo-Danube River prograded far into the basin (Harzhauser et al. 2004). The associated deposits are united in the mainly coarse siliciclastic deposits of the Hollabrunn-Mistelbach Formation (Nehyba & Roetzel 2004). The palaeo-Danube river entered as gravel-bed river at the Zaya Gate and expanded as braid-delta system on the Mistelbach Block up to the Steinberg fault in the west, indicating the transition into the delta slope. Towards the east, the delta lobes reached far into the Vienna Basin (Harzhauser et al. 2003; Nehyba & Roetzel 2004; Wessely 2006). Another short transgression of Lake Pannon at c. 11.1–11.0 Ma into the wetlands of the palaeo-Danube caused a flooding of the Mistelbach Block and pelitic lacustrine sediments of the Bzenec Formation were deposited (Grill 1968; Harzhauser et al. 2003, 2004; Harzhauser 2009). This last lacustrine phase is indicated by clay and silt with Lake Pannon molluscs of the *Mytilopsis hoernesi* Zone and the lower *Lymnocardium conjungens* Zone. Finally, fluvial-deltaic conditions became re-established during the late Pannonian, when the coast of Lake Pannon was already situated in the area of western Hungary.

Although Grill (1954; 1961; 1968) indicates only Sarmatian strata in the area of Gaweinstal, the new outcrops show that fluvial-deltaic deposits of the palaeo-Danube are still preserved there. These sands and gravels of the Hollabrunn-Mistelbach Formation were exposed during the years 2008 and 2009 due to construction for the A5–highway. At that time, the private collector Peter Schebeczek (Mistelbach) collected the rich mollusc faunas and Gudrun Daxner-Höck and Franz Topka (NHMW) took bulk samples for micro-mammals.

The mollusc assemblage

Both collection campaigns resulted in an assemblage of 35 mostly very well-preserved mollusc species. The composition, however, documents a strong mixing of at least four different sources.

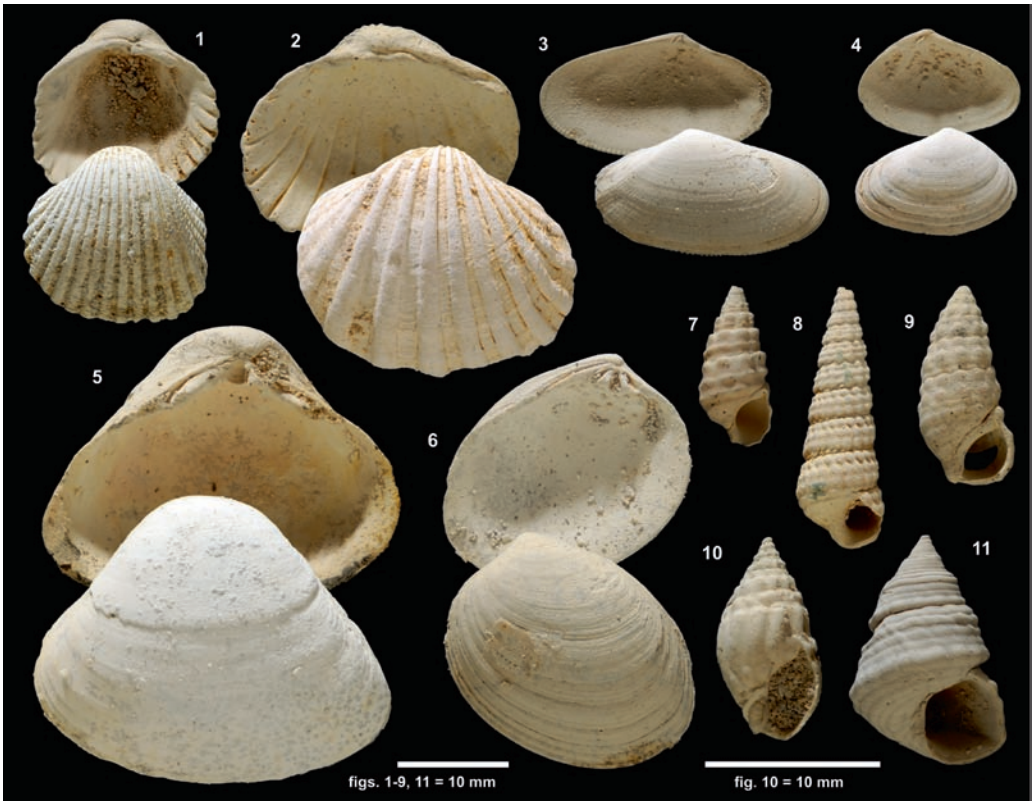


Fig. 3. Reworked Sarmatian marine molluscs from the Upper *Ervilia* Zone.
1. *Obsoletiforma vindobonensis* (Laskarew, 1903), NHMW 2009z0161/0008.
2. *Plicatiforma latisulca* (Münster in Goldfuss, 1837), NHMW 2009z0161/0009.
3. *Donax dentiger* Eichwald, 1830, Schebeczek collection.
4. *Ervilia dissita* (Eichwald, 1830), NHMW 2009z0161/0012.
5. *Sarmatimactra eichwaldi* (Laskarev, 1914), NHMW 2009z0161/0010.
6. *Venerupis tricuspis* (Eichwald, 1830), NHMW 2009z0161/0013.
7. *Granulolabium bicinctum* (Brocchi, 1814), NHMW 2009z0161/0002.
8. *Potamides disjunctus* (Sowerby, 1831), NHMW 2009z0161/0003.
9. *Cerithium rubiginosum* Eichwald, 1830, NHMW 2009z0161/0005.
10. *Duplicata duplicata* (Sowerby, 1831), NHMW 2009z0161/0006.
11. *Gibbula podolica* (Dubois, 1831), this shell could also derive from the *Sarmatimactra* Zone; NHMW 2009z0161/0001.

1. Middle Sarmatian (Figs 3.1–3.11): The majority of the shells are Sarmatian molluscs which are clearly reworked from sand and oolithic sand of the Skalica Formation. These deposits are frequently outcropping along the entire Mistelbach Block and especially along the Steinberg elevation (Friedl 1936; Grill 1968). The excellent preservation is no contradiction, as the short transport of the shells by the tributaries of the palaeo-Danube did not necessarily damage the shells. A comparable occurrence of reworked

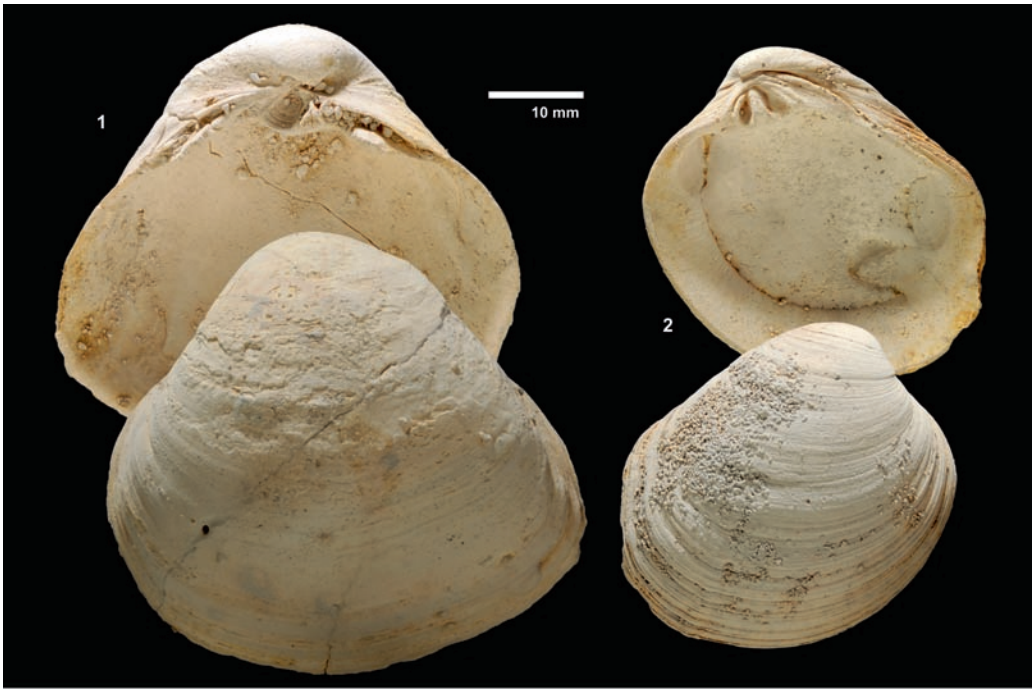


Fig. 4. Reworked Sarmatian marine bivalves from the *Sarmatimactra* Zone.
1. *Sarmatimactra vitaliana* D'ORBIGNY, 1844, NHMW 2009z0161/0011.
2. *Venerupis tricuspis ponderosus* (D'ORBIGNY, 1844), NHMW 2009z0161/0014.

Sarmatian shells in lower Pannonian deposits was documented by HARZHAUSER (2009) from the Atzelsdorf section only 3.5 km WNW of Gaweinstal. The overall composition of this reworked fauna corresponds fully to the assemblages of the upper *Ervilia* Zone as typically outcropping at Nexing. Potamidid [*Potamides disjunctus* (SOWERBY, 1831), *P. hartbergensis* (HILBER, 1891)] and batillariid [*Granulolabium bicinctum* (BROCCHI, 1814), *G. nodosoplicatum* (HÖRNES, 1856)] gastropods are predominating. Cerithiids [*Cerithium rubiginosum* EICHWALD, 1830] are less frequent, followed by less common nassariids [*Duplicata duplicata* (SOWERBY, 1831)] and muricids [*Ocenebra striata* (EICHWALD, 1830)]. Among the bivalves, which are always disarticulated, dominate cardiids [*Obsoletiforma vindobonensis* (LASKAREW, 1903), *Plicatiforma latisulca* (MÜNSTER in GOLDFUSS, 1837)] and venerids [*Venerupis tricuspis* (EICHWALD, 1830)]; mactrids [*Sarmatimactra eichwaldi* (LASKAREV, 1914)], mesodesmatids [*Ervilia dissita* (EICHWALD, 1830)] and donacids [*Donax dentiger* EICHWALD, 1830] are rare.

2. Upper Sarmatian (Figs 4.1–4.2): Whilst the assemblage above is explained easily by reworking and transport from the underlying and adjacent mid-Sarmatian strata, the occurrence of the huge mactrid *Sarmatimactra vitaliana* (D'ORBIGNY, 1844), the thick-shelled venerid *Venerupis tricuspis ponderosus* (D'ORBIGNY, 1844) and the large and strongly ornamented nassariid *Duplicata dissita* (EICHWALD, 1830) needs another

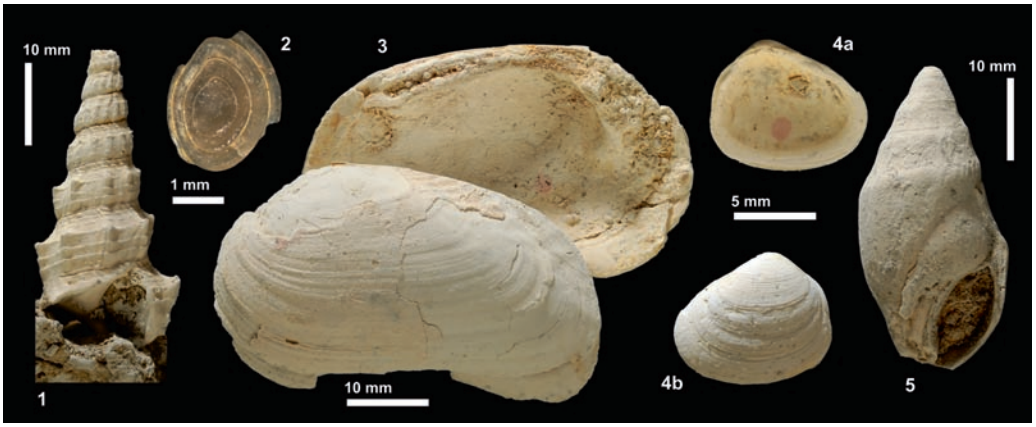


Fig. 5. 1–4: Parautochthonous Early Pannonian freshwater molluscs from the Hollabrunn-Mistelbach Formation; 5: Reworked shell from the early Pannonian *Mytilopsis ornithopsis* Zone.
1. *Tinnyea escheri* (Brongniart in Cuvier & Brongniart, 1822), Schebeczek collection.
2. *Bithynia jurinaci* (Brusina, 1884), NHMW 2009z0162/0004.
3. *Margaritifera flabellatiformis* (Grigorowitch-Beresowski, 1915), NHMW 2009z0162/0011.
4. *Pisidium* sp., NHMW 2009z0162/0012.
5. *Melanopsis impressa* phenotype *pseudonarzolina* Papp, 1953, Schebeczek collection.

source. These taxa are typical elements of the late Sarmatian *Sarmatimactra* Zone (Papp 1954; Harzhauser & Piller 2004). The frequent trochid *Gibbula podolica* (Dubois, 1831) might also derive from that zone, as the strongly sculptured morphotype is typical for the late Sarmatian (Papp 1974).

3. Lower Pannonian *Mytilopsis ornithopsis* Zone (Lake Pannon assemblage: Fig. 5.5): The large sized, typically Pannonian *Melanopsis impressa* phenotype *pseudonarzolina* Papp, 1953 appears surprisingly rare and the preservation is poor (Fig. 5.5). The melanopsids of the *Melanopsis impressa-fossilis*-complex are always restricted to deltaic and coastal areas of Lake Pannon and do never occur upstream in fluvial settings. Moreover, the morphology of the specimens is typical for shells described by Papp (1953) from the older Pannonian Zone B (= *Mytilopsis ornithopsis* Zone). Therefore, these shells are interpreted to be reworked from the lowermost Pannonian deposits treated as "Zone mit *Melanopsis impressa*" by Grill (1968).

4a. Lower Pannonian (aquatic assemblages; Figs 5.1–5.4): In contrast to the rich Sarmatian assemblage, the Pannonian fauna is distinctly less numerous and differs also in the often fragmentary preservation. Elements from the lotic environments of the deltaplain are represented by the unionid *Margaritifera flabellatiformis* (Grigorowitch-Beresowski, 1915) which is interpreted to be indicative for fast-flowing, oligotrophic, calcium-deficient rivers and streams (Harzhauser & Tempfer 2004). Less agitated environments such as ox-bows, lakes, ponds and slowly running rivulets were inhabited by *Bithynia jurinaci* (Brusina, 1884),

Fig. 6. Early Pannonian terrestrial gastropods
1. *Gastrocopta* (*Sinalbinula*) *nouletiana* (DUPUY, 1850), NHMW 2009z0162/0003.
2. *Mastus* nov. sp., NHMW 2009z0162/0005.
3. *Discus* aff. *pleuradrus* (BOURGUIGNAT, 1881), NHMW 2009z0162/0002.
4. *Aegopinella reussi* (SCHLOSSER, 1907), NHMW 2009z0162/0009.
5. *Pseudochlorites gigas* (PFEFFER, 1929), NHMW 2009z0162/0001.
6. *Cepaea etelkae* (HALAVÁTS, 1923), NHMW 2009z0162/0010.

Planorbarius mantelli (DUNKER, 1848), and *Pisidium* sp. Downstream, close to the intersection with Lake Pannon occurred dreissenids such as *Mytilopsis martonfii* (LÖRENTHEY, 1893) and *Mytilopsis gitneri* (BRUSINA, 1892) and the gastropod *Tinnyea escheri* (BRONGNIART, 1822).

4b. Lower Pannonian (terrestrial assemblages; Figs 6.1–6.6): A rare fraction of the assemblage consists of terrestrial gastropods from the Pannonian wetlands. The most frequent taxa are the large *Pseudochlorites gigas* (PFEFFER, 1929) and the slightly smaller *Cepaea etelkae* (HALAVÁTS, 1923). All other species such as *Gastrocopta* (*Sinalbinula*) *nouletiana* (DUPUY, 1850), *Abida* sp., *Mastus* nov. sp., *Pseudidyla* sp., *Discus* aff. *pleuradrus* (BOURGUIGNAT, 1881), *Aegopinella reussi* (SCHLOSSER, 1907) and *Klikia planispira* LUEGER, 1981 are very rare. All of these rare and thin-shelled species display some fragmentation due transport. The composition is very similar to the coeval faunas from Hauskirchen, Mistelbach and Lanzendorf (LUEGER, 1981). These have been interpreted by LUEGER (1981) to have lived in rather open and dry woodland with narrow moist areas, fringing rivulets and ponds.

The vertebrate assemblage

The composition of the vertebrate assemblage is characterized by species-richness but extremely low individual numbers. It displays rare fossil remains of fishes, reptiles, birds and mammals, which are not investigated in detail yet, except for the small mammals (see below). The vertebrate fossils from Gaweinstal lack any traces of abrasion indicating a rather short transport. The entire collection comprises more than 35 vertebrate taxa.

Birds are very rare and only allow the identification of an anseriform. Fish remains are quite abundant and comprise different Osteichthyes, of which Sparidae (porgies), Cyprinidae (carps and minnows) and Centropomidae (snooks) are identifiable so far. The reptiles are dominated by aquatic and terrestrial testudines and are represented by about 50 isolated carapace and plastron elements and a few limb bone fragments of different taxa, such as the tortoise *Testudo* sp., the pond turtle *Mauremys* sp. and the softshell turtle *Trionyx* sp.

The mammal community is composed of large and small mammals. The large mammal fauna consists of perissodactyles, artiodactyls and carnivores. Perissodactyles are a minor component and are represented only by very few postcranial elements and one lower cheek tooth of the rhinoceros *Aceratherium incisivum* Kaup, 1832 and one lower molar of the chalicothere *Chalicotherium goldfussi* Kaup, 1833. Ruminants are the most abundant large mammal fossils recovered at Gaweinstal. Identifiable by both teeth and postcranial bones are the tragulid *Dorcatherium naui* Kaup & Scholl, 1834, the small sized moschid *Micromeryx flourensianus* Lartet, 1851, and a bovid that represents *Miotragocerus* sp. or *Tethytragus* sp. Based on a single tooth also the presence of the palaeomerycid *Palaeomeryx eminens* von Mayer, 1847 is confirmed. Furthermore, few dental remains of undetermined suoids and one incisor representing the three-toed horse *Anchitherium*, have been recovered.

Few remains of Carnivora were found at Gaweistal. Mustelidae are represented by only two mandibles of *Proputorius pusillus* (Viret, 1951) and the Viverridae are documented by a right mandible of *Semigenetta* sp. A single left astragalus of a hyaenid falls into the size-group of *Ictitherium* sp.

Thirteen small mammal species could be identified on the basis of isolated cheek teeth, some incisors and two fragmentary mandibles, i.e. *Amphilagus fontannesi* (Deperet, 1887), *Prolagus oeningensis* (König, 1825) (Lagomorpha), *Spermophilinus bredai* (von Meyer, 1848), *Megacricetodon minutus* Daxner, 1967, *Democricetodon* sp., *Hispanomys* cf. *bijugatus* Mein & Freudenthal, 1971, *Anomalomys* cf. *rudabanyensis* Kordos, 1989, *Trogontherium* (*Euroxenomys*) *minutum* (von Meyer, 1838) (Rodentia) and *Plesiodimylus* cf. *chantrei* Gaillard, 1897, cf. *Archaeodesmana* sp., *Schizogalerix voesendorfensis* (Rabeder, 1973), *Paenelimnoecus repenningi* (Bachmayer & Wilson, 1970) and *Crusafontina exculta* (Mayr & Fahlbusch, 1975) (Insectivora/Lipotyphla).

The ruminant taxa identified from Gaweinstal are all taxa, which persisted at least from the Middle Miocene into the Late Miocene. Two perissodactyle taxa, however, allow a more precise correlation of the Gaweinstal fauna: The first occurrence (FOD) of the rhino *Aceratherium incisivum* overlaps with the last occurrence (LOD) of *Anchitherium* in the early Late Miocene during the European Land Mammal Zone MN9 (for MN-Zones see Steininger 1999). None of the vertebrate taxa indicate a marine origin that might point to an intermixture with reworked Sarmatian taxa.

The small mammal community is composed of three overlapping range groups:

- Advanced Middle Miocene holdovers with the LOD in the early Late Miocene (MN9 or basal MN10): *A. fontannesi*, *P. oeningensis*, *S. bredai*, *M. minutus*, *H. bijugatus* and *Democricetodon* sp.
- Species/genera with the FOD in the early Late Miocene (MN9): *A*. cf. *rudabanyensis*, *S. voesendorfensis*, *P. repenningi*, *C. exculta* and cf. *Archaeodesmana* sp. Three out of them are limited to MN9 (*A.* cf. *rudabanyensis*, *C. exculta*, *S. voesendorfensis*).
- Only *T.* (*E.*) *minutum* and *P.* cf. *chantrei* are long lived species with range from the Early to the Late Miocene.

Consequently, the mammal assemblage is most likely isochronous because the ranges of all taxa overlap within the Mammal Zone MN9 (early Vallesian). Thus, the mammalian assemblage can be correlated with the mollusc assemblages 4a and 4b from the early Pannonian.

The vertebrates represent inhabitants of various environments provided by the braided-delta system of the palaeo-Danube: different families of bony fish and the softshell turtle (*Trionyx*) represent the aquatic assemblage while the pond turtle (*Mauremys*), the waterfowl (Anseriformes), the beavers (*Trogontherium*) and desmans (*Archaeodesmana*) are known for their semiaquatic life style. The documented ruminants *Micromeryx*, *Miotragocerus* vel *Tethytragus* and *Palaeomeryx*, as well as the rhino *Aceratherium* and the chalicothere *Chalicotherium* are forest dwellers, while the tragulid *Dorcatherium* is a humid forest dweller. The presence of these ungulates and of the carnivores *Semigenetta* and *Proputorius* implies areas of forested habitats. Ground dwelling hamsters (*Democricetodon*, *Megacricetodon* and *Hispanomys*), ground squirrels (*Spermophilinus*) and lagomorphs (*Amphilagus*, *Prolagus*) inhabited more dry and open areas. Arboreal small mammals are absent most probably due to taphonomic processes.

The vertebrate fauna from Gaweinstal closely resembles that of Atzelsdorf (Lower Austria, early Late Miocene, Pannonian C), a locality only 3.5 km WNW of Gaweinstal (see Daxner-Höck & Göhlich 2009). In contrast to Gaweinstal, the fauna of Atzelsdorf lacks almost entirely the micromammals – probably due to higher energetic depositional conditions of the latter locality. On the other hand, in the fauna of Gaweinstal no proboscideans, no cervids and no *Hippotherium* have been identified, so far. The lack of these taxa is most probably just a gap of documentation and amount of sample material and not a question of ecological conditions.

The extension of the Paratethys on the Mistelbach Block during the *Sarmatimactra* Zone

Reworking of Sarmatian molluscs in Pannonian fluvial or lacustrine deposits is a common feature on the entire Mistelbach Block. Such occurrences are known from Wolkersdorf, where gastropods and bivalves of the Upper *Ervilia* Zone are found in silty sand of the Pannonian Zone D, associated with parautochthonous shells of *Melanopsis vindobonensis* Fuchs, 1870 and large-sized species of *Congeria* sp. (own data, evaluated during road constructions in 1999). Similarly, molluscs of the Upper *Ervilia* Zone were deposited in silty lacustrine clay at Atzelsdorf during the transgression of Lake Pannon into the delta plain (Harzhauser 2009). In both cases, the reworking did not damage the shells and even slight abrasion is absent. At the Pellendorf section, Sarmatian molluscs within lithified Sarmatian oolites of the Upper *Ervilia* Zone have been documented from fluvial gravel of a large tributary of the palaeo-Danube (Harzhauser et al. 2003). This predominance of shells from the Upper *Ervilia* Zone is an expression of the still widespread occurrence of deposits of that zone on the Mistelbach Block (see map in Grill 1968). It is little surprising that the channels of the palaeo-Danube did frequently cut the – at that time about 400 ky old – Sarmatian marine strata. The occurrence of few shells reworked from the *Sarmatimactra* Zone, however, indicates the presence of deposits of that zone in the area as well. Generally, deposits of this latest Sarmatian time are restricted to basinal settings in the northern Vienna Basin, whereas several outcrops are documented from the southern Vienna Basin and the Eisenstadt Sopron Basin (Harzhauser & Piller 2004).

An exception on the Mistelbach Block is a Sarmatian erosional relic in the uppermost part of the Nexing section (Harzhauser & Piller 2010). An additional hint to the former presence of that zone in the area are decimetre-large pebbles consisting of nubecularia-foraminifera-buildups at the base of lacustrine Pannonian clay at Maustrenk resting on strongly altered mudstones and oolites of the uppermost *Ervilia* Zone (Harzhauser & Piller unpublished field data). The shells from Gaweinstal are now the third section where the *Sarmatimactra* Zone can be traced at least indirectly. The near absence of *Sarmatimactra* Zone deposits on the Mistelbach Block and the scarceness even of reworked shells seem to reflect a very restricted original distribution. The Mistelbach Block was an extremely shallow lagoon and shoal already during the time when the oolites of the Upper *Ervilia* Zone were deposited. Most outcrops on the Mistelbach Block, such as Hauskirchen, Kettlasbrunn, Maustrenk, Nexing, and Windischbaumgarten, suggest a ceasing accomodation space and sedimentation close to the zero-water line at that time (see Friedl 1936; Grill 1968; Harzhauser & Piller 2004, 2010 for outcrop descriptions). Even emersion, paleosol formation and short progradations of fluvial systems are documented (Harzhauser & Piller 2010). In addition, highstand systems tract (HST) conditions became established during the Latest Sarmatian coinciding with the progradation of the coast line (Kosi et al. 2003; Harzhauser & Piller 2010; Schreilechner & Sachsenhofer 2007). Thus, the Paratethys could not flood the elevated block fully during the *Sarmatimactra* Zone aside from very few incised inlets. These seem to follow

the modern Zaya valley, which might have been formed already during the Badenian and was reactivated during the early Sarmatian (Mandic et al. 2008). As the palaeo-Danube followed this palaeo-valley also during the Pannonian, most of the patchy uppermost Sarmatian deposits became destroyed.

Systematic palaeontology

The Sarmatian mollusc fauna is excellently described in numerous monographs (Svagrovský 1971; Papp 1954, Schultz 2001, 2003, 2005). Therefore, only some selected Pannonian taxa will be discussed and illustrated in the following chapter. The identifications follow largely Lueger (1981) and Harzhauser & Binder (2004) and are not intended to represent revisions. The systematics follows the MOLLBASE recommendations (http://www.mollbase.de/list/) and the CLECOM-project (Bank et al. 2001; Falkner et al. 2001). For classification of mammals we follow Mc Kenna & Bell (1997) and Wilson & Reeder (2005).

The investigated material is stored in the Museum of Natural History in Vienna (NHMW) and the private collection of Peter Schebeczek (Mistelbach). Abbreviations: d.: diameter, h.: height, l.: length, w.: width. To facilitate easier comparisons all right side teeth of small mammals are figured as mirror images (invers), and their figure numbers are underlined, e.g. Figs 5a-c (= right P4/M1).

Class Gastropoda Cuvier, 1797

Order Neotaenioglossa Haller, 1892

Superfamily Cerithioidea Férussac, 1822

Family Melanopsidae Adams & Adams, 1854

Genus *Melanopsis* Férussac, 1807

Melanopsis impressa phenotype *pseudonarzolina* Papp, 1953
(Fig. 5.5)

1953 *Melanopsis impressa bonellii* Manzoni – Papp: 131, Pl. 9, Figs 9–11
[non *Melanopsis Bonellii* Manzoni, 1870].
1953 *Melanopsis impressa carinatissima* Sacco – Papp: 131, Pl. 9, Figs 12–13
[non *Melanopsis impressa* var. *carinatissima* Sacco, 1895].
1953 *Melanopsis impressa pseudonarzolina* n. ssp. Papp: 132, Pl. 9, Figs 14–18.
1953 *Melanopsis marzolina doderleini* Pantanelli – Papp: 132, Pl. 9, Figs 5–8
[non "*Melanopsis Matheroni* var. *Doderleini* Pantanelli, 1886"].
1985 *Melanopsis impressa bonellii* Manzoni – Papp: 284, Pl. 32, Figs 1–5
[non "*Melanopsis bonellii* Manzoni, 1870"].

Material: Four shells in the Schebeczek collection; h.: 29 mm, d.: 16 mm.

Remarks: This phenotype of the *Melanopsis impressa*-complex was described as *Melanopsis impressa bonellii* Manzoni, 1870 by Papp (1953). This species, however, was described from the Late Miocene of Italy (Sacco, 1895) and it is therefore extremely unlikely, that it is conspecific with the endemics from Lake Pannon. The same problem arises for the slightly smaller or somewhat more sculptured shells referred to by Papp (1953) as *M. impressa carinatissima* Sacco, 1895 and *M. narzolina doderleini* Pantanelli, 1886. In addition, *M. impressa pseudonarzolina* was introduced by Papp (1953) as name for slender shells within that complex. Later, Papp (1985) doubted the validity of his *M. impressa pseudonarzolina* and considered it as a synonym of *M. impressa bonellii*. The only realistic available names for the phenotypes characteristic for the early Pannonian of Lake Pannon are *M. impressa pseudonarzolina* Papp, 1953 and *M. impressa posterior* Papp, 1953. As these shells are stratigraphical significant for the early Pannonian, it seems to be pragmatic to refer to these shells as phenotype or chronospecies *M. impressa pseudonarziola*. A similar solution was proposed by Harzhauser et al. (2002) for the *Melanopsis fossilis*-complex. *M. impressa posterior* Papp, 1953 may be only a bulky morphotype within the same group.

The shells are slightly corroded and their morphology is most characteristic for the early *Pannonian Mytilopsis ornithopsis* Zone (= Zone B of Papp 1953). Sediments containing melanopsids and dreissenids of that zone are quite common on the Mistelbach Block and have been mapped and described in detail by Grill (1968). Erosional relics close to Gaweinstal are documented from Pellendorf, Bogenneusiedl, Hautzendorf, and Nexing. The occurrence of this Lake-Pannon-related species suggests a first transgression of Lake Pannon onto the Mistelbach Block during the *Mytilopsis ornithopsis* Zone and the subsequent erosion by the fluvial system of the Hollabrunn-Mistelbach Formation.

Distribution: *Melanopsis impressa* phenotype *pseudonarzolina* Papp, 1953 is a characteristic element of the early Pannonian *Mytilopsis ornithopsis* Zone (= Pannonian Zone B) and lower parts of the *Mytilopsis hoernesi* Zone (lower part of Zone C).

Family Pachychilidae Troschel, 1857

Subfamily Melanatriinae Thiele, 1929

Genus *Tinnyea* Hantken, 1887

***Tinnyea escheri* (Brongniart in Cuvier & Brongniart, 1822)**
(Fig. 5.1)

1822 *melania Escheri* Brongniart in Cuvier & Brongniart: 117.
1985 *Brotia* (*Tinnyea*) *escheri escheri* (Brongniart) – Papp: 282, Pl. 30, Figs 21–22.
2000 *Brotia* (*Tinnyea*) *escheri* (Brongniart) – Mikuž & Pavšič: 44, Pl. 1, Figs 1–8 [cum syn.].

Material: Two shells in the Schebeczek collection; h.: c. 40 mm, d.: 18 mm

Remarks: *Tinnyea escheri* seems to be a very variable species which is described under numerous variation or subspecies names as summarized by Wenz (1929). In the material from the Pannonian of the Vienna Basin, the variability ranges from rather smooth shells referred to as *Tinnyea escheri escheri* by Papp (1953) to strongly sculptured spiny ones, which are referred to as *Tinnyea escheri auingeri* (Handmann, 1882) by Papp (1953). As the species was introduced by Brongniart in Cuvier and Brongniart (1822) with an insufficient description without illustration, it is difficult even to decide what is the type morphology. The only phenotype which may represent an endemic offshoot of that complex is *Tinnyea escheri vasarhelyii* Hantken, 1887. It differs consequently from all other representatives in its enormous size of more than 100 mm, the prominent sculpture and is restricted to a very short interval within the middle Pannonian (Harzhauser et al. 2003) whereas other phenotypes do not show any constant geographic or stratigraphic patterns as already recognized by Wenz (1929). The generic affiliation with *Tinnyea* Hantken, 1887 was discussed in detail by Harzhauser et al. (2003).

Distribution: An ubiquitous freshwater species from the Oligocene to Late Miocene; known from France in the west, via the North Alpine Foreland Basin, South- and Central Germany and the Pannonian basins complex to the Balkanids and as far east as Thracia in Turkey (Wenz 1929; Mikuž & Pavšič 2000; Kókay 2006; Islamoglu et al. 2008). The last occurrence of the *Tinnyea escheri*-complex is documented from the Pontian of Serbia (Stevanovic 1990).

Superfamily Rissooidea Gray, 1847

Family Bithyniidae Troschel, 1857

Genus *Bithynia* Leach, 1818

***Bithynia jurinaci* (Brusina, 1884)**
(Fig. 5.2)

1884 *Bythinia Jurinaci* Brusina: 31.
2004 *Bithynia jurinaci* Brusina – Harzhauser & Binder: 7, pl.2, Figs 8–11 [cum syn.].

Material: Two opercula in the NHMW collection (Inv. NHMW 2009z0162/0004); h.: c. 3 mm.

Remarks: In both specimens, the youngest growth increments are fractured and chipped. This points to some transport from the nearby freshwater ponds of the palaeo-Danube wetlands where it was very abundant (e.g. at Pellendorf; Harzhauser et al. 2003). Other lentic Pannonian palaeoenvironments with abundant opercula are Richardhof and Götzendorf in the Vienna Basin (Harzhauser & Tempfer 2004).

Distribution: A widespread species during the Pannonian in the entire Pannonian basins complex and adjacent basins.

Subclass Pulmonata Cuvier in Blainville, 1814

Superorder Eupulmonata Haszprunar & Huber, 1990

Order Stylommatophora Schmidt, 1855

Suborder Orthurethra Pilsbry, 1900

Superfamily Pupilloidea Turton, 1831

Family Gastrocoptidae Pilsbry, 1918

Genus *Gastrocopta* Wollaston, 1878

Subgenus *Sinalbinula* Pilsbry, 1916

***Gastrocopta* (*Sinalbinula*) *nouletiana* (Dupuy, 1850)**
(Fig. 6.1)

1850 *Pupa nouletiana* Dupuy: 309, Pl. 15, Fig. 6.
1981 *Gastrocopta* (*Sinalbinula*) *nouletiana* Dupuy – Lueger: 25, Pl. 2, Figs 16–19, 22.
2004 *Gastrocopta* (*Sinalbinula*) *nouletiana* Dupuy – Harzhauser & Binder: 19, Pl. 8, Figs 9–11.

Material: One shell fragment in the NHMW collection (Inv. NHMW 2009z0162/0003); h.: 2.5 mm, d.: 1.3 mm.

Remarks: A very widespread and common species. It seems to have been an opportunistic element in the wetlands fringing Lake Pannon and its tributaries. Modern gastrocoptids are forest dwellers living in litter in the periphery of streams (Moser et al. 2009).

Distribution: Sarmatian and Pannonian of the North Alpine Foreland Basin and the entire Pannonian basins complex.

Superfamily Buliminoidea Clessin, 1879

Family Buliminidae Clessin, 1879

Genus *Mastus* Beck, 1837

***Mastus* nov. sp.**
(Figs 6.2a-6.2b)

Material: One shell fragment in the NHMW collection (Inv. NHMW 2009z0162/0005); h.: 13, d.: 9 mm.

Description: The fragment consists only of the last whorl and parts of the penultimate one which both are only slightly convex. The transition into the base is gradual; its suture is narrow and thread-like. The aperture is wide ovoid with a slight adapical angulation; columella straight; parietal area slightly convex. A thin everted outer lip grades into a well developed columellar lip, which is separated from the base. No continuous parietal lip is

developed; instead, two very short ledges are developed at the terminations of the outer and the columellar lip. Weak and strongly oblique growth lines are the only sculpture.

Remarks: The occurrence of the genus *Mastus* BECK, 1837 is new for the Pannonian. *Mastus sarmaticus* PAPP, 1974 from the Sarmatian of Austria and Hungary is the oldest record of the genus (PAPP 1974; KÓKAY 2006). It differs from the species from Gaweinstal in its broader last whorl and the regularly convex and less protruding basal part of the aperture. A second probably Middle Miocene species was described by PAPP (1974) from the Kolubara Basin in Serbia as *Mastus pupa maeoticus* WENZ, 1926. These specimens differ from the Pannonian shell distinctly in its cylindroid outline of the last two whorls, the median convexity of the penultimate whorl and the slender and elongate last whorl. Despite PAPP's identification, the shells from the Kolubara basin are also distinctly separated from *Mastus maeoticus* WENZ, 1926 by their stout broad-conical spire angle. Therefore, they represent an undescribed Middle Miocene species. *Mastus maeoticus* WENZ, 1926 from the Late Miocene Meotian stage of Rumania is reminiscent of the herein reported shell but differs in its continuous parietal callus (WENZ 1942). Its base is rapidly contracting and the point of maximum convexity of the last whorl is much lower than in the herein described shell. Therefore, there seem to be at least four Miocene species of *Mastus*, of which only two are valid taxa. No new species, however, can be based on the fragmentary Pannonian specimen.

The Recent south-eastern European *Mastus pupa* (LINNAEUS, 1758) differs in its more convex whorls and the incised sutures. Moreover, it develops a continuous parietal lip, which is well demarcated from the base. A spire fragment identified as *Ena* sp. by LUEGER (1981) from the late Pannonian of the Vienna Basin is the sole additional evidence of that group in the area. It is unclear if both specimens may belong to the same species.

Distribution: This species is known so far only from the early Pannonian of Gaweinstal.

Suborder Sigmurethra PILSBRY, 1900

Infraorder Achatinoinei SCHILEYKO, 1979

Superfamily Punctoidea MORSE, 1864

Family Patulidae TYRON, 1866

Genus *Discus* FITZINGER, 1833

***Discus* aff. *pleuradrus* (BOURGUIGNAT, 1881)**
(Figs 6.3a-6.3b)

aff. 1881 *Helix pleuradra* BOURGUIGNAT: 53, Pl. 3, Figs 67–72.
1981 *Discus* (*Discus*) *pleuradrus* BOURGUIGNAT – LUEGER: 40, Pl. 4, Figs 6–7.
2004 *Discus pleuradrus* BOURGUIGNAT – HARZHAUSER & BINDER: 22, Pl. 7, Figs 9–11.

Material: One shell in the Schebeczek collection (Figs 6.3a-3b; d.: 4.6 mm) and 4 subadult shells in the NHMW collection (Inv. NHMW 2009z0162/0002).

Remarks: The species is conspecific with the shells from the Pannonian of the Vienna Basin referred to as *Discus pleuradrus* (Bourguignat, 1881) by Lueger (1981) and Harzhauser and Binder (2004). Moser et al. (2009) and Schlickum (1976), however, consider the Late Miocene shells as a related but different species. We do not have any material from the c. 4 my older Middle Miocene type locality Sansan from where Bourguignat (1881) did describe *Discus pleuradrus*. Moser et al. (2009) classify representatives of *Discus* as woodland dwellers, living on dead wood.

Distribution: *Discus* aff. *pleuradrus* (Bourguignat, 1881) is a common species from the early to late Pannonian in the entire Pannonian basins complex and the North Alpine Foreland Basin.

Infraorder Arionoinei Hoffmann, 1924

Superfamily Vitrinoidea Fitzinger, 1833

Subfamily Zonitinae Mörch, 1864

Genus *Aegopinella* Lindholm, 1927

***Aegopinella reussi* (Schlosser, 1907)**
(Figs 6.4a-6.4b)

1907 *Hyalinia Reussi* n. sp. Schlosser: 767, Pl. 17, Fig. 10.
1981 *Aegopinella orbicularis* (Klein) – Lueger: 45, Pl. 6, Figs 4–6.

Material: One shell in the Schebeczek collection (Fig. 6.4a-4b; d.: 5.2 mm.) and one in the NHMW collection (Inv. NHMW 2009z0162/0009); d.: 8.5 mm.

Remarks: The Pannonian shells are usually identified with the Middle Miocene *Aegopinella orbicularis* (Klein, 1846) and *Aegopinella subnitens* (Klein, 1853) (e.g.: Schlickum 1976, 1978; Lueger 1981). Already Lueger (1981) discussed if these shells should be treated as separate species but finally preferred to unite all shells in *Aegopinella orbicularis*. Slight differences between the Middle Miocene and the Late Miocene shells seem to be the usually smaller size of the latter ones and the fact that they rarely show a faint spiral sculpture. Another weak difference might be the slightly stronger increase of whorl diameter in the Pannonian shells. Aside from these poorly defined morphologic differences, the different stratigraphic ages are an additional argument to assume the presence of two different species.

Distribution: This species is either known so far only from the Pannonian of the North Alpine Foreland Basin and the Pannonian basins complex. If it is a synonym of *Aegopinella orbicularis*, it would have a much larger range starting in the Middle Miocene of Southern Germany.

Superfamily Helicoidea RAFINESQUE, 1815

Family Helicidae RAFINESQUE, 1815

Genus *Pseudochlorites* BOETTGER, 1909

***Pseudochlorites gigas* (PFEFFER, 1929)**
(Figs 6.5a-6.5c)

1929 *Tropidomphalus* (*Pseudochlorites*) *gigas* PFEFFER: 76.
1981 *Tropidomphalus* (*Pseudochlorites*) *gigas* PFEFFER – LUEGER: 58, Pl. 12, Figs 4a-c, Pl. 13, Fig. 4.
2008 *Pseudochlorites gigas* (PFEFFER) – BINDER: 174, Pl. 2, Figs 4a-c [cum syn.].

Material: Numerous shells in the SCHEBECZEK collection and 3 shells in the NHMW collection (Inv. NHMW 2009z162/0001); h.: 21, d.: 30.

Remarks: The shells display a similar variability in spire height as coeval populations from Lanzendorf (LUEGER 1981). Low spired shells, as illustrated by BINDER (2008) are rare. This species is very abundant in the point-bar sands of the Hollabrunn-Mistelbach Formation and always co-occurs with *Cepaea etelkae*. Therefore, it is likely that these species lived very close to the rivers and rivulets of the palaeo-Danube. Similarly, LUEGER (1981) suggests shrubs and dry ground within the riverine environments as preferred habitat. An adaptation to less humid climates might also be indicated by the extinction of the species with the onset of the humid Vallesian optimum.

Distribution: Known from the Sarmatian and the early Pannonian in the North Alpine Foreland Basin and the Vienna Basin (LUEGER 1981).

Genus *Cepaea* HELD, 1838

***Cepaea etelkae* (HALAVÁTS, 1923)**
(Figs 6.6a-6.6c)

1923 *Helix* (*Tachaea*) *Etelkae* n. sp. HALAVÁTS: 403, Pl. 14, Figs 7a-b.
1981 *Cepaea etelkae* HALAVÁTS – LUEGER: 72, Pl. 13, Figs 1–2, Pl. 14, Figs 1–7.
1985 *Cepaea etelkae* HALAVÁTS – LUEGER: 361, Pl. 47, Figs 4–6 [cum syn.].
2004 *Cepaea etelkae* HALAVÁTS – HARZHAUSER & BINDER: 28, pl., 11, Figs 20–21.

Material: Numerous shells in the SCHEBECZEK collection and 10 specimens in the NHMW collection (Inv. NHMW 2009z0162/0010); h.: 17, d.: 24.

Remarks: One of the most abundant terrestrial Pannonian gastropods at the locality. LUEGER (1981) interprets the species to have lived along the shores of the rivulets of the palaeo-Danube. The high number of shells and the good preservation support this interpretation and suggest rather short transport. The morphology is quite variable; generally, moderately high spired shells as those illustrated by LUEGER (1981, Pl. 13, Fig. 1 and Pl. 14, Figs 4, 6, 7) predominate whilst flat-spired types are exceptions.

Distribution: *Cepaea etelkae* is a common species during the entire Pannonian in the wetlands fringing Lake Pannon (Lueger 1981; Harzhauser & Binder 2004).

Class Mammalia Linnaeus, 1758

Order Lagomorpha Brandt, 1855

Family Ochotonidae Thomas, 1897

Genus *Amphilagus* Pomel, 1853

***Amphilagus fontannesi* (Deperet, 1887)**
(Figs 7.1a-7.1c)

1887 *Lagodus Fontannesi* – Deperet: 171, Pl. 13, Fig. 19.
1974 *Amphilagus fontannesi* (Deperet) – Tobien: 149–162, Figs 34–46.
1990 ? *Amphilagus* sp. – Daxner-Höck et al.: 509.
2009 „*Amphilagus*“ sp. – Angelone: 516, Fig. 1.

Type locality: La Grive (France; Middle Miocene, MN7+8)

Material: One right P4/M1 (l.: 2.52 mm, w.: 4.56 mm; Figs 7.1a-c) and a fragmentary incisor in the Schebeczek collection.

Remarks: The large sized and rooted Lagomorpha cheek-tooth indicates *Amphilagus*. The dental dimensions and morphology are within the range of *A. fontannesi* from the type locality.

Distribution: In Europe, *A. fontannesi* is a common species of the Middle Miocene (MN7+8) with last occurrences in the Late Miocene (MN9), ranging up to the late MN9 in Spain (López Martinez 1989).

Genus *Prolagus* Pomel, 1853

***Prolagus oeningensis* (König, 1825)**
(Figs 7.2a-7.3b)

Type locality: Oeningen (Germany; Middle Miocene, MN7+8).

Material: One left P2 (l.: 0.9 mm, w.:1.8 mm; Fig. 7.2 a-b), one right P4 (l.: 1.6 mm, w.: 2.5 mm; Fig. 7.3 a-b) and three fragments of lower molars in the Schebeczek collection.

Remarks: Small sized, hypsodont and rootless Lagomorpha cheek-teeth from Gaweinstal belong to *P. oeningensis*.

Distribution: The stratigraphic range is Early- to Late Miocene (MN5 to MN9).

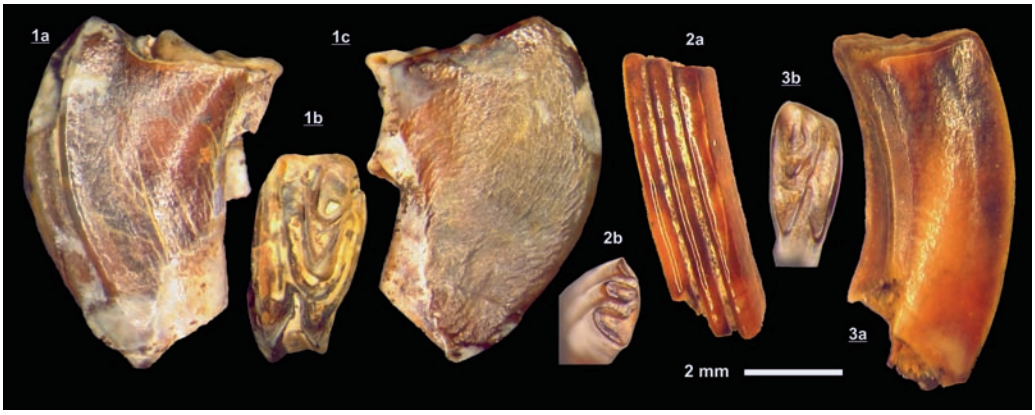


Fig. 7. Lagomorpha (Ochotonidae) from Gaweinstal, Hollabrunn-Mistelbach Formation, Early Pannonian.
1. *Amphilagus fontannesi* (DEPERET, 1887), SCHEBECZEK collection. 1a. right P4/M1 distal (invers), 1b. right P4/M1 occlusal (invers), 1c. right P4/M1 mesial (invers).
2. *Prolagus oeningensis* (KÖNIG, 1825), SCHEBECZEK collection. 2a. left P2 mesial, 2b. left P2 occlusal. 3a. right P4 mesial (invers), 3b. right P4 occlusal (invers).

Order Rodentia BOWDICH, 1821

Family Sciuridae FISCHER VON WALDHEIM, 1817

Subfamily Sciurinae FISCHER VON WALDHEIM, 1817

Genus *Spermophilinus* DE BRUIJN & MEIN, 1968

***Spermophilinus bredai* (VON MEYER, 1848)**
(Fig. 8.1)

1996 *Spermophilinus bredai* (VON MEYER) – DAXNER-HÖCK: 3.
2005 *Csakvaromys bredai* (VON MEYER) – KRETZOI & FEJFAR: 114, Text-Figs 4–5, Pl. 1, Figs 1–7.

Type locality: Oeningen (Germany; Middle Miocene, MN7+8)

Material: One left m1/2 in the SCHEBECZEK collection; l.: 2.04 mm, w.: 2.10 mm.

Remarks: *Spermophilinus* species do not differ significantly in dental morphology but show size increase through time (DE BRUIJN 1995). *S. bredai* is known from the Middle Miocene to the basal Late Miocene. Later, in the Turolian, *S. bredai* was replaced by the larger *S. turolensis*. The ground-squirrel *S. bredai* most probably inhabited areas with dry sandy ground and low vegetation of the deltaic area.

Distribution: S. *bredai* is a common species of the Middle Miocene and early Late Miocene in Turkey, Central Europe, France and the Iberian Peninsula (ENGESSER 1972; DE BRUIJN 1995; MEIN & GINSBURG 2002; KRETZOI & FEJFAR 2005; CASANOVAS-VILAR

2007). In Austria *S. bredai* is known from the Sarmatian assemblages of St. Stefan (Astaracian, MN7+8), and from the Pannonian (Vallesian, MN9–10) assemblages Gaweinstal, Richardhof-Golfplatz, Götzendorf, Richardhof-Wald in the Vienna Basin, and Schernham in the North Alpine Foreland Basin (Daxner-Höck 2010).

Family Muridae Illiger, 1811

Subfamily Cricetodontinae Schaub, 1925

Genus *Megacricetodon* Fahlbusch, 1964

Megacricetodon minutus Daxner, 1967
(Figs 8.2–8.3)

1967 *Megacricetodon* (*Mesocricetodon* nov. subgen.) *minutus* nov. spec. – Daxner: 27–36; Abb. 2–3.
1968 *Megacricetodon debruijni* nov. sp. – Freudenthal: 61–68; Pl. 1, Figs 17–28; Text-Figs 1–3.
2004 *Megacricetodon minutus* Daxner – Daxner-Höck: 27–29, Fig. 2.
2005 *Megacricetodon minutus* Daxner – Joniak: 68–78, Fig. 4.23–25; tab. 4.11, Pl. 1, Figs 1–17.

Type locality: Inzersdorf (Austria; Late Miocene, MN9).

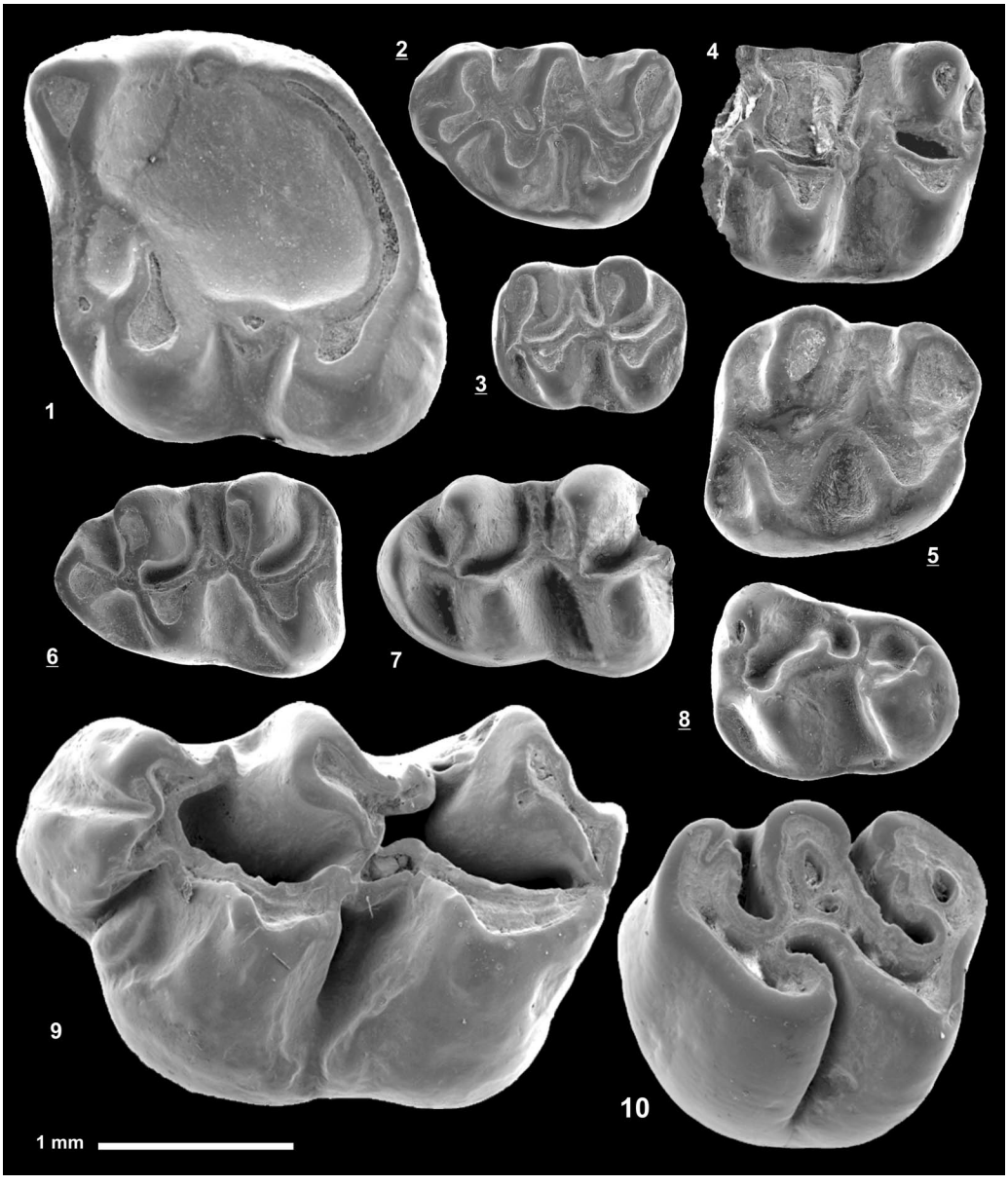
Material: One right M1 (Fig. 8.2) in the Schebeczek collection; l.: 1.44 mm, w.: 0.93 mm and 1 right m2 (Fig. 8.3) in the NHMW collection (Inv. NHMW 2010/0055/0001); l.: 1.08 mm, w.: 0.78 mm.

Remarks: *M. minutus* is one of the small sized species of the *M. minor*-lineage, which differs from *M. minor* by trends towards simplification of the anterocone of M1, subdivision of the anteroconid of m1, forwardly directed sinus of M1–2, reduction of mesolophs(ids) of M1–2 and m1–2. The Spanish *M. debruijni* Freudenthal, 1968 is a junior synonym of *M. minutus* Daxner, 1967 (Joniak 2005).

Distribution: The species occurs rather abundantly in the late Middle Miocene (MN7+8) and the early Late Miocene (MN9) of the Iberian Peninsula and the Pannonian basins complex (Hungary, Slowakia and Austria) and is also known from Switzerland. In Austria, *M. minutus* is known from the Sarmatian assemblages St. Stefan and

Fig. 8. Rodentia from Gaweinstal, Hollabrunn-Mistelbach Formation, Early Pannonian. ►
1. *Spermophilinus bredai* (Meyer von, 1848). Left m1/2, Schebeczek collection.
2. *Megacricetodon minutus* Daxner, 1967. Right M1(invers), Schebeczek collection.
3. *Megacricetodon minutus* Daxner, 1967. Right M2 (invers), NHMW 2010/0055/0001.
4. *Democricetodon* sp. Left M1-fragment, NHMW 2010/0056/0001.
5. *Democricetodon* sp. Right M2 (invers), NHMW 2010/0056/0002).
6. *Democricetodon* sp. Right m1 (invers), Schebeczek collection.
7. *Democricetodon* sp. Left m1, NHMW 2010/0056/0003.
8. *Democricetodon* sp. Right m3 (invers), NHMW 2010/0056/0004.
9. *Hispanomys* cf. *bijugatus* Mein & Freudenthal, 1971. Left M1, Schebeczek collection.
10. *Anomalomys* cf. *rudabanyensis* Kordos, 1989.Left M1, Schebeczek collection.

St. Margareten (MN7+8) and from the Early to Middle Pannonian of Gaweinstal, Bullendorf, Mataschen, Inzersdorf, Vösendorf and Richardhof-Golfplatz (MN9) (DAXNER 1967; DAAMS & FREUDENTHAL 1988; HIR 2003, 2004; JONIAK 2005; CASANOVAS-VILAR 2007; KÄLIN & KEMPF 2009).



Genus *Democricetodon* Fahlbusch, 1964

***Democricetodon* sp.**
(Figs 8.4, 8.5–6, 8.7, 8.8)

Material: One right m1 (Fig. 8.6) in the Schebeczek collection (l.: 1.62 mm, w.: 1.08 mm); a left m1 (Fig. 8.7; Inv. NHMW 2010/0056/0003; l.: 1.68 mm, w.: 1.14 mm), a right m3 (Fig. 8.8; Inv. NHMW 2010/0056/0004; l.: 1.38 mm, w.: 1.02 mm), a left M1–fragment (Fig. 8.4; Inv. NHMW 2010/0056/0001; w.: 1.23 mm), and a right M2 (Fig. 8.5; Inv. NHMW 2010/0056/0002; l.: 1.38 mm, w.: 1.32 mm) in the NHMW collection.

Remarks: *Democricetodon* from Gaweinstal combines dental characters of *D. brevis* (Schaub, 1925) – known from the Middle Miocene of Central Europe – and a larger species from the Late Miocene of Austria (so far undescribed).

Distribution: In Europe, *Democricetodon* is a very common genus of the Early and Middle Miocene (MN4 to MN7+8). Last occurrences are known from the Late Miocene. In Austria, the last evidences of the genus are: Gaweinstal, Götzendorf, Richardhof-Golfplatz (MN9) and Richardhof-Wald (MN10) (Fahlbusch 1964; Maridet 2003).

Genus *Hispanomys* Mein & Freudenthal, 1971

***Hispanomys* cf. *bijugatus* Mein & Freudenthal, 1971**
(Fig. 8.9)

1971 *Cricetodon* (*Hispanomys*) *bijugatus* nov.sp. – Mein & Freudenthal: 20.
2009 *Hispanomys bijugatus* (Mein & Freudenthal) – López-Antonanzas & Mein: 3–13, Figs 2–4, Table 1–2.

Type locality: La Grive L3 (France; Middle Miocene, MN7+8)

Material: One left M1 (Fig. 8.9) in the Schebeczek collection (l.: 3.42 mm, w.: 2.10 mm).

Remarks: To some respect the M1 resembles *Hispanomys* and *Cricetodon*. It is attributed to *Hispanomys* because of its moderate hypsodonty, the absent cingula and the development of ectolophs. The tooth belongs to a medium sized species of *Hispanomys*, has no mesoloph, no labial cingula. It has posteriorly directed spurs of the labial anterocone and the paracone, which form partial anterior and posterior ectolophs and close the anterosinus and mesosinus. It has a prominent protostyle, and the sinus is constricted by a ridge that emerges from the anterior side of the hypocone. These characters and the tooth size are in good agreement with *H. bijugatus* from the type locality. *Cricetodon klariankae* Hir, 2007 from the Middle Miocene of Felsötárkány-Felnément (FF 2/3, 2/7) in Hungary is also similar but not identical in morphology and size.

Distribution: *Hispanomys* developed from *Cricetodon* and dispersed mainly in Western Europe from the Middle- to the Late Miocene (BRUIJN DE, H. & ÜNAY, E. 1996). So far the species *H. bijugatus* is known from the Middle and Late Miocene of France, i.e. from the fissures of La Grive L3, L5 (MN7+8) and from Lo Fournas 5 and Jujurieux (MN9) (LÓPEZ-ANTONANZAS & MEIN 2009; AGUILAR et al. 1999; MEIN 1999). Gaweinstal is the easternmost occurrence of the species.

Subfamily Anomalomyinae SCHAUB, 1925

Genus *Anomalomys* GAILLARD, 1900

***Anomalomys* cf. *rudabanyensis* KORDOS, 1989**
(Fig. 8.10)

1989 *Anomalomys rudabanyensis* n. sp. – KORDOS: 298–301, Fig. 3.
1996 *Anomalomys* cf. *gaillardi* – DAXNER-HÖCK: 3.

Type locality: Rudabanya (Hungary; Late Miocene, MN9)

Material: One left M1 (Fig. 8.10) in the SCHEBECZEK collection (l.: 1.74 mm, w.: 1.40 mm).

Remarks: Size and morphology of the specimens from Gaweinstal and Bullendorf (lowermost MN9) are transitional between the Middle Miocene *Anomalomys gaudryi* GAILLARD, 1900 and the Late Miocene *Anomalomys rudabanyensis* KORDOS, 1989. Some advanced dental characters of the Gaweinstal specimen show affinities to *A. rudabanyensis* rather than to *A. gaudryi*, i. e. an almost complete fusion of protolophule + mesoloph and the more oblique direction of syncline and anticlines. The specimen is smaller and less hypsodont than *Anomalomys gaillardi* VIRET & SCHAUB, 1946 known from the Late Miocene of Western and Southwestern Europe.

Distribution: *A.* cf. *rudabanyensis* / *A. rudabanyensis* are evidenced from the Late Miocene (MN9–MN10) of the Vienna Basin (Gaweinstal, Bullendorf, Richardhof-Golfplatz, Götzendorf and Richardhof-Wald) and from the type locality Rudabanya in Hungary (KORDOS 1989).

Family Castoridae HEMPRICH, 1820

Subfamily Castoroidinae ALLEN, 1877

Genus *Trogontherium* FISCHER VON WALDHEIM, 1809

Subgenus *Euroxenomys* SAMSON & RADULESCO, 1973

***Trogontherium* (*Euroxenomys*) *minutum* (VON MEYER, 1838)**

1999 *Trogontherium* (*Euroxenomys*) *minutum*. – HUGUENEY: 290–291, Figs 28.7–28.

Type locality: Elgg (Switzerland; Middle Miocene, MN5)

Material: One left p4, two left m1/2, one left m3, one right P4, two fragments of an incisor and a cheek tooth in the Schebeczek collection.

Remarks: *T.* (*E.*) *minutum* is a small sized Castoridae with tetra-lophodont, high crowned but rooted teeth. P4 is strongly enlarged, p4 is also larger than m1–3. The mesial surface of incisors is slightly convex but smooth. *Trogontherium* had a rounded tail of 25 to 30 cm length; it lived semi-aquatic and was an excellent swimmer (Daxner-Höck 2004).

Distribution: In Europe *T.* (*E.*) *minutum* is very common and ranges stratigraphically from the Early- to the Late Miocene (MN4 to MN13) (Hugueney 1999).

Order Lipotyphla Haeckel, 1866

Family Erinaceidae Fischer, 1814

Subfamily Galericinae Pomel, 1848

Genus *Schizogalerix* Engesser, 1980

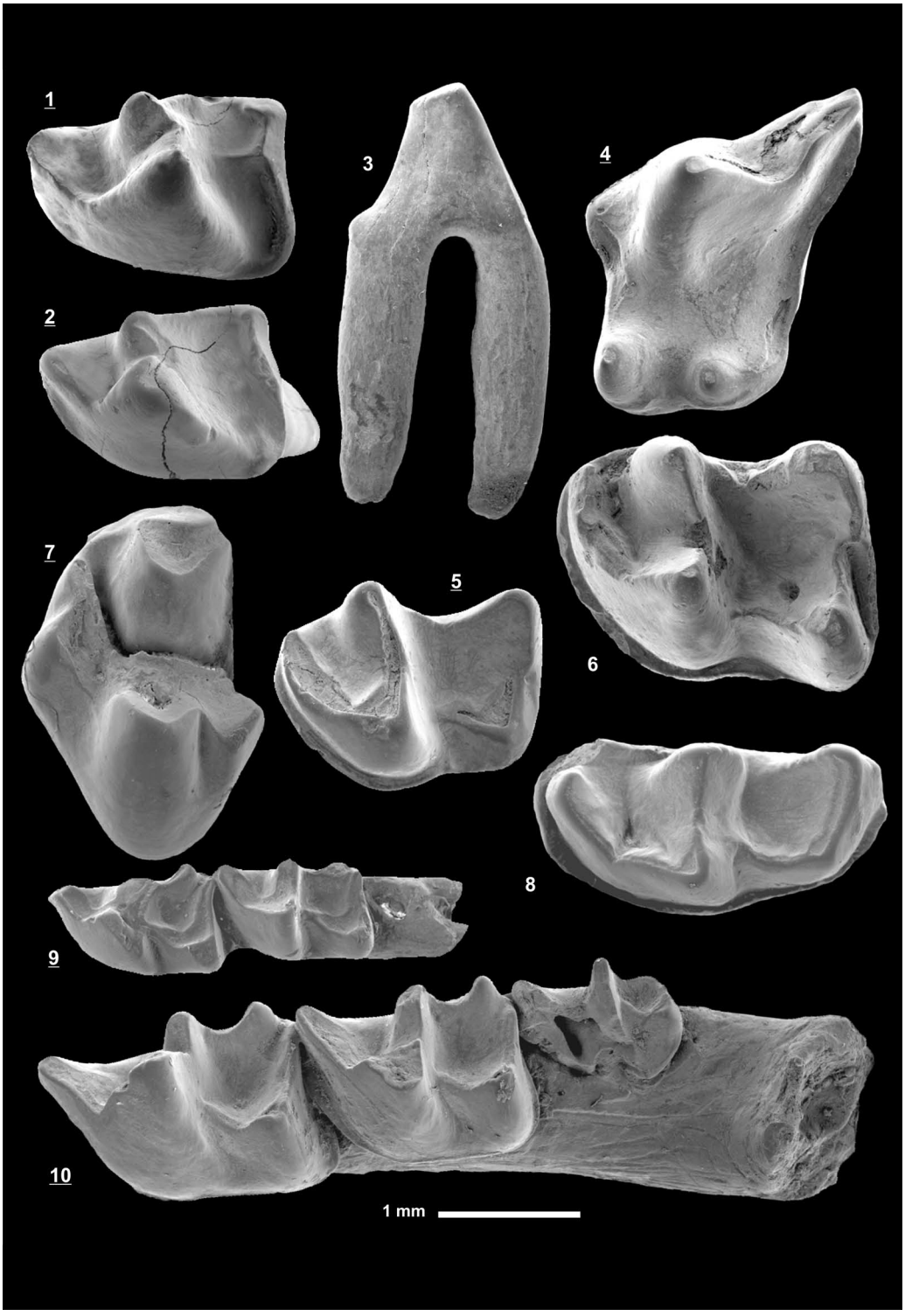
***Schizogalerix voesendorfensis* (Rabeder, 1973)**
(Figs 9.1–2, 9.3, 9.4–5, 9.6)

1973 *Galerix voesendorfensis* n.sp. – Rabeder: 430–433, Figs 1–2.
2001 *Schizogalerix voesendorfensis* (Rabeder) – Kälin & Engesser: 13–15, Figs 8–9.

Type locality: Brunn-Vösendorf (Austria; Late Miocene, MN9)

Material: One left mandible with p4, and one C? (Fig. 9.3) in the Schebeczek collection (l.:1.44 mm) and five teeth in the NHMW collection: i.e. right p4 (Fig. 9.1; Inv. NHMW 2010/0057/0001; l.: 2.04 mm, w.: 1.32 mm), right p4 (Fig. 9.2; Inv. NHMW 2010/0057/0002; l.: 1.86 mm, w.: 1.26 mm), right P4 (Fig. 9.4; Inv. NHMW 2010/0057/0003; l.: 2.10 mm, w.: 2.16 mm), right m3 (Fig. 9.5; Inv. NHMW 2010/0057/0004; l.: 2.04 mm, w.: 1.44 mm), left m2 (Fig. 9.6; Inv. NHMW 2010/0057/0005; l.: 2.46 mm, w.: 1.86 mm).

Fig. 9. Lipotyphla from Gaweinstal, Hollabrunn-Mistelbach Formation, Early Pannonian. ►
1. *Schizogalerix voesendorfensis* (Rabeder, 1973). Right p4 (invers), NHMW 2010/0057/0001.
2. *Schizogalerix voesendorfensis* (Rabeder, 1973). Right p4 (invers), NHMW 2010/0057/0002.
3. *Schizogalerix voesendorfensis* (Rabeder, 1973). C?, Schebeczek collection.
4. *Schizogalerix voesendorfensis* (Rabeder, 1973). Right P4 (invers), NHMW 2010/0057/0003.
5. *Schizogalerix voesendorfensis* (Rabeder, 1973). Right m3 (invers), NHMW 2010/0057/0004.
6. *Schizogalerix voesendorfensis* (Rabeder, 1973). Left m2, NHMW 2010/0057/0005.
7. cf. *Archaeodesmana* sp. Right M1-fragment (invers), Schebeczek collection.
8. *Plesiodimylus* cf. *chantrai* Gaillard, 1897. Left m2, Schebeczek collection.
9. *Paenelimnoecus repenningi* (Bachmayer & Wilson, 1970). Right lower jaw with m1-2 (invers), NHMW 2010/0058/0001.
10. *Crusafontina exculta* (Mayr & Fahlbusch, 1975). Right lower jaw with m1-3 (invers). Schebeczek collection.



Remarks: Dental morphology of the Gaweinstal specimens is in agreement with *S. voesendorfensis* from the type locality Brunn-Vösendorf (Austria; Rabeder 1973) and Nebelbergweg (Switzerland; Kälin & Engesser 2001), however, dimensions partly exceed the upper range limit of the species. *Schizogalerix* nov. sp. (Kälin & Engesser 2001), a second species from Nebelbergweg is much larger. Most likely *S. voesendorfensis* inhabited forested environments of the palaeo-Danube delta. It is in agreement with its extant relatives, which live in humid forests with dense undergrowth in Southeast Asia (Nowak 1991; Ziegler 2006a).

Distribution: The genus *Schizogalerix* ranges from the Early Miocene to the end of the Late Miocene with occurrences from Europe to Kazakhstan and China. The species *S. voesendorfensis* is known from the Late Miocene (MN9) of the Vienna Basin (Gaweinstal, Brunn-Vösendorf, Inzersdorf; Lower Austria) and from the Alpine Foreland Basin (Nebelbergweg; Switzerland) (Rabeder 1973; Ziegler 1999; Kälin & Kempf 2009).

Family Talpidae Fischer, 1814

Subfamily Desmaninae Mivart, 1871

Genus *Archaeodesmana* Topachevski & Pashkov, 1983

cf. *Archaeodesmana* sp.
(Fig. 9.7)

Material: One right M1–fragment (Fig. 9.7) in the Schebeczek collection (w.: > 2.58 mm).

Remarks: The molar fragment was identified as cf. *Archaeodesmana*, however, species identification is impossible. The presence of *Archaeodesmana* indicates water bodies close by, as all extant Desmaninae are known for semiaquatic life.

Distribution: *Archaeodesmana* ranges all over Europe in the Late Miocene and Pliocene (Ziegler 1999). Other Vallesian and Turolian occurrences from Austria are: Richardhof-Golplatz and Götzendorf (MN9), Richardhof-Wald and Schernham (MN9), Kohfidisch and Eichkogel (MN11) (Ziegler & Daxner-Höck 2005; Ziegler 2006a).

Family Dimylidae Schlosser, 1887

Genus *Plesiodimylus* Gaillard, 1897

***Plesiodimylus* cf. *chantrei* Gaillard, 1897**
(Fig. 9.8)

Type locality: La Grive F (France (Middle Miocene, MN7+8)

Material: One left m2 (Fig. 9.8) in the SCHEBECZEK collection (l.: 2.28 mm, w.: 1.02 mm).

Remarks: The tooth is within the morphological and size-range of *P. chantrei* but does not allow definite species determination.

Distribution: *P. chantrei* ranges all over Europe from the Early to the Late Miocene (MN4–11) (ZIEGLER 1999).

Family Soricidae FISCHER, 1814

Subfamily Soricinae FISCHER, 1814

Genus *Paenelimnoecus* BAUDELOT, 1972

***Paenelimnoecus repenningi* (BACHMAYER & WILSON, 1970)**
(Fig. 9.9)

1970 *Petenyiella* ? *repenningi* nov. spec. – BACHMAYER & WILSON: 549–500, Figs 7, 32, 32a, 33, 50, 50a.
2006 *Paenelimnoecus repenningi* (BACHMAYER & WILSON) – ZIEGLER: 171–174, Fig. 24.

Type locality: Kohfidisch (Austria; Late Miocene, MN11)

Material: One right lower jaw with m1–2 in the NHMW collection. m1 (Fig. 9.9; Inv. NHMW 2010/0058/0001; m1 l.: 1.18 mm, w.: 0.69 mm, m2 l.: 1.09 mm, w.: 0.60 mm).

Remarks: Molar morphology, size and the position of foramen mentale below protoconid of m1 agree with *Paenelimnoecus repenningi* (BACHMAYER & WILSON, 1970), which is well known from the Late Miocene (MN9 to MN11) of Austria. The Middle Miocene *Paenelimnoecus crouzeli* BAUDELOT, 1972 is smaller (ZIEGLER 2003).

Distribution: *P. repenningi* ranges from MN9 to MN11 (Late Miocene) in Austria (ZIEGLER 2006a and is also evidenced from Rudabanya (MN9) in Hungary (ZIEGLER 2005).

Genus *Crusafontina* GIBERT, 1975

***Crusafontina exculta* (MAYR & FAHLBUSCH, 1975)**
(Fig. 9.10)

1975 *Angustidens excultus* n.sp. – MAYR & FAHLBUSCH: 96–99, Pl. 7, Figs 1–9.
2006a *C.* aff. *endemica* – ZIEGLER: 168.

Type locality: Hammerschmiede (Germany; Late Miocene, MN9)

Material: One right lower jaw fragment 333 with m1–3 (Fig. 9.10) in the SCHEBECZEK collection: m1–3 (l.: 4.68 mm); m1 (l.: 1.92 mm, w.: 0.84 mm), m2 (l.: 1.56 mm, w.: 0.78 mm), m3 (l.: 1.20 mm).

Remarks: The Gaweinstal specimen has close affinities with *C. exculta* concerning dental morphology, dimensions and the position of foramen mentale below protoconid of m1 (Mayr & Fahlbusch 1975: 97–99). *C. exculta* is the smallest and oldest species of the lineague: *C. exculta* – *C.*aff. *endemica* Gibert, 1975 – *C. endemica* – *C. kormosi* (Bachmayer & Wilson, 1970). In the lineage a continuous size increase of m1 goes along with a size decrease of m2–3 (Ziegler 2005, 2006a). However, the synonymy of *C. exculta* with *C. endemica* or *C.* aff. *endemica* is under discussion (Ziegler 2006a: 168).

Distribution: The first record of *Crusafontina* in Europe coincides with the immigration of *Hippotherium*. So far the oldest species, *C. exculta* is known from the NAFB (Hammerschmiede, Germany; MN9, see Mayr & Fahlbusch, 1975) and from the Vienna Basin (Gaweinstal, Austria; MN9).

The youngest species, *C. kormosi*, is well known from the Turolian (MN11) faunas Kohfidisch, Eichkogel (Austria) and Dorn-Dürkheim (Rhine Valley). Some *C.* aff. *endemica* occurrences of the Vienna Basin (Richardhof-Golfplatz, Götzendorf, Richardhof-Wald), NAFB (Schernham) and Pannonian Basin (Rudabanya) ranging from MN9 to MN10 are intermediate in size and age (Ziegler 2006a; Tab. 21).

Conclusions

The biostratigraphically condensed assemblage of Gaweinstal is an extraordinary example for the pitfalls for biostratigraphers in highly mobile settings along basin margins where reworking was a common process. Mollusc taxa from at least four different habitats from different time slices occur within a single sample. The vertebrate remains, however, comprise no unambiguous proof of faunal mixing with vertebrate remains from older deposits. The mammalian fauna is typical for the early Pannonian (early Late Miocene). The Gaweinstal mammals comprise taxa with last occurrences in the European Land Mammal Zone MN9 (early Late Miocene) and taxa with first occurrences in MN9. Thus, the ranges of all mammal taxa overlap within MN9; none of the taxa became extinct before the Middle/Late Miocene transition.

Preservation is not a foolproof feature to recognise reworking as transport distance may have been very short within the palaeo-Danube delta. Thus, a paleoecologic interpretation of the assemblage is impossible without deep understanding of regional geology, taxonomy and (bio)stratigraphy. Moreover, the analysis of the taphonomic processes allows reconstructing the latest Sarmatian extension of the Paratethys Sea in this region although the corresponding sediments are completely eroded.

Acknowledgements

This paper is part of a special volume dedicated to Prof. Werner E. Piller. Especially the first author is deeply grateful for his support, encouragement and friendship.

Many thanks to Peter Schebeczek (Pellendorf) who provided material from the locality studied. We also thank our colleagues R. Ziegler (Stuttgart) who helped identify the Lipotyphla, O. Schulz (Natural History Museum Vienna) who determined the Osteichthyes, I. Giaourtsakis (Munich/Athens) who confirmed the determination of *A. incisivum*, and P. Mein (Lyon), I. Casanovas (Barcelona) and J. Hir (Pasto) for comments and discussions on *Hispanomys* and *Cricetodon*. Thanks to O. Mandic (NHMW), R. Ziegler (Stuttgart) and R. Roetzel (GBA, Vienna) for critical comments.

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