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Fossil land and freshwater gastropods from the Middle Miocene of Bechingen and Daugendorf, southwestern Germany

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Abstract

This study presents a taxonomic treatment of the fossil land and freshwater gastropods from Bechingen and Daugendorf (Riedlingen, Baden-Württemberg state, SW Germany). The fossils stem from the Tautschbuch carbonate unit, which belongs to the so-called Silvana Beds of the Upper Freshwater Molasse. Nineteen gastropod species (mainly pulmonates) are reported here from Bechingen and eleven from Daugendorf, belonging to the families: Pachychilidae, Bithynidae, Pomatiidae, Lymnaeidae, Planorbidae, Subulinidae, Cochlicopidae, Elonidae, Helicidae, Hygromiidae, Trissexodontidae, Discidae, Gastrocoptidae, Succineidae, Oleacinidae and possibly Chondrinidae and Zonitidae. Two species previously mentioned on the literature from Bechingen were not found in the present material: *Pseudoleacina eburnea* and *Janulus supracostatus*. The gastropod fauna agrees with the previously proposed paleoenvironment consisting of shallow temporary lakes or ponds surrounded by reeds.

Key words: Caenogastropoda, Langhian, Pulmonata, Silvana Beds, Tautschbuch, Upper Freshwater Molasse.

Introduction

The Upper Freshwater Molasse ("Obere Süßwassermolasse", in German; abbreviated OSM) is remarkable for its numerous fossiliferous outcrops (*e.g.*, Sandberger 1870–1875, Wenz 1923, Abdul-Aziz et al. 2008, 2010, Kälin & Kempf 2009). The Tautschbuch is a somewhat coherent carbonate unit belonging to the OSM and located on the southern border of the Swabian Alb (southern Germany). The Tautschbuch and its surroundings have several mollusk-bearing fossil outcrops, such as Zwiefaltendorf, Mörsingen, Gauingen, Bechingen and Emerberg. With the exception of Zwiefaltendorf (Schlickum 1976), the molluscan faunas of these localities were not studied in recent times. The present work provides a taxonomical account of the mollusks from Bechingen and the less-known neighbouring locality Daugendorf.

Geological setting and localities

Bechingen and Daugendorf (ca. 2 km south of the former; Fig. 1) are two neighbourhoods of the town of Riedlingen (Biberach district, Baden-Württemberg state, SW Germany); both are located to the east of the Tautschbuch hills. Only scarce information on the Tautschbuch's geology can be found in Schwarz (1913) and Haag (1960). It is part of a formerly huge and continuous freshwater carbonate platform situated at the southern margin of the Swabian Alb, along the Danube River (Fig. 1). The Miocene carbonates discordantly overlay Jurassic and older Miocene rocks (the interval between the latest Jurassic and the Miocene was a time of emersion and erosion in the course of Alpine orogeny). Werner (2014) provides

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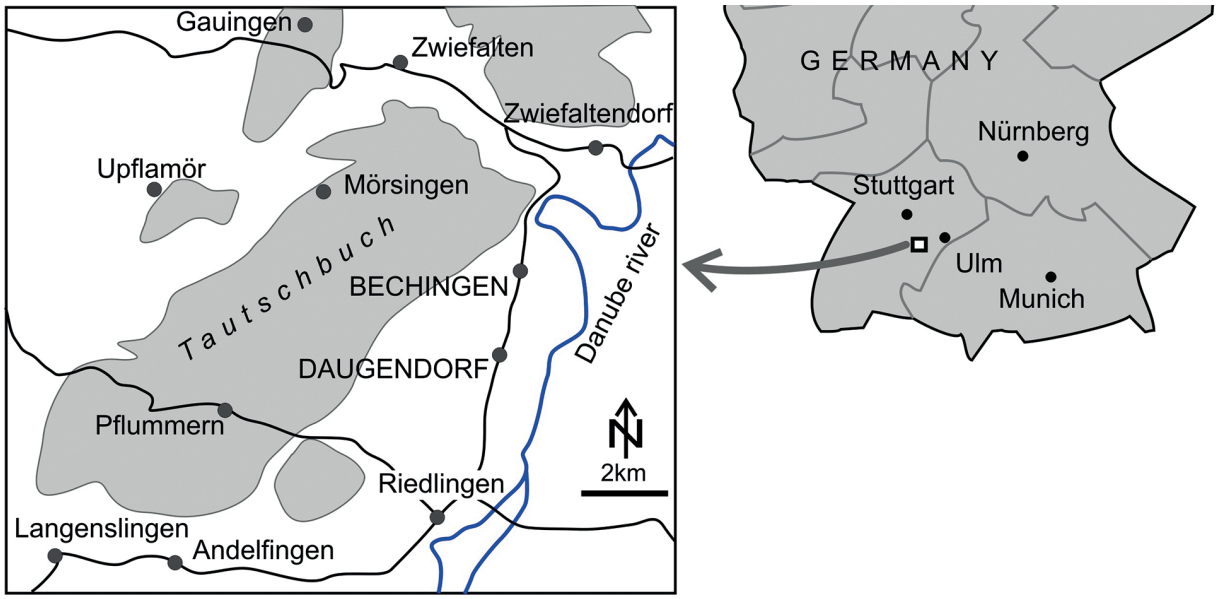

Figure 1. Map showing Bechingen and Daugendorf, located between the Tautschbuch area and the Danube River. Further localities indicated on the surrounding regions are those known from the literature to have mollusk-bearing OSM sediments. The grey areas on the inset map are the remains of an extensive Miocene freshwater carbonate platform formed by the Sylvana Beds.

some new data on the limestones from this area, proposing a paleoenvironment consisting of shallow temporary lakes or ponds surrounded by reeds. Unfortunately, actual biostratigraphic data of the Tautschbuch are not available. Based on the snail fauna and literature data, the Tautschbuch is deemed part of the Silvana Beds ("Silvanaschichten" or "Silvanakalk") and thus is tentatively dated as Langhian (early "Badenian", Middle Miocene; Höltke, pers. comm.). The Silvana Beds are part of the Obere Süßwassermolasse ("Upper Freshwater Molasse") in the North Alpine Foreland Basin, which is a freshwater sequence that was situated between the northward-migrating Alps in the South, and the Swabian Alb in the North (*e.g.*, Kuhlemann & Kempf 2002).

The collection of the Staatliches Museum für Naturkunde Stuttgart (Stuttgart, Germany) houses fossil snails labeled as Bechingen and Daugendorf, but without further information. There is no single work in the literature dealing specifically with Bechingen, but the locality was reasonably known, since several authors reported molluscan fossils from it (Jooss 1910, 1918, Gottschick 1911, Fischer & Wenz 1914, Wenz 1923, Schlickum 1976). According to Zöbelein (1973), there used to be an abandoned sand pit to the south of Bechingen, in the Maueresch area, that contained Pleistocene moraine sediments with blocks of "Silvana limestone" (containing continental gastropods) coming from the Tautschbuch hills. This gravel pit was also briefly mentioned by Engel (1908) and Schwarz (1913) to contain blocks of "Silvana limestone". The material studied in this paper certainly comes from this pit. The village Daugendorf has never been mentioned as a fossil site. It is either the same abandoned sand pit as above, or another pit that has been abandoned a long time ago and contained the same moraine sediments.

Material and methods

All main museum collections in Germany, Switzerland and Austria were contacted in search for mollusks from these localities. Unfortunately, only the Staatliches Museum für Naturkunde Stuttgart (SMNS; Stuttgart, Germany) and the Paläontologisches Institut und Museum der Universität Zürich (PIMUZ; Zurich, Switzerland) have specimens in their collections. This material consists almost entirely of specimens gathered in the early 20th century by several collectors and included in the collections of Carlo G.H. Jooss and Konrad Miller housed in the SMNS (see also Salvador et al. in press). The few later specimens date from the 1960's and 70's, collected by Helmut Hölder and M. Katzür.

All species are figured and discussed, including data on their diagnostic features and distribution. The majority of the specimens analyzed do not have precise locality or stratigraphic data, although some lots from Bechingen indicate collection in a gravel pit ("Kiesgrube"; see above). The list of analyzed material can be found under each species entry; an asterisk (*) after the lot's number means that it is a rock sample with several inscrusted specimens.

There is no single work in the literature dealing specifically with the molluscs from Bechingen. Previous authors often refer to single species recorded from there (Jooss 1910, 1918, Gottschick 1911, Fischer & Wenz 1914, Wenz 1923, Schlickum 1976). As such, literature data can be used to slightly complement the presently available material. The vast majority of species presented here have never been reported from Bechingen before. The locality of Daugendorf, as mentioned above, has never been reported in the literature.

The classification used here follows Bouchet et al. (2005) and Nordsieck (2014). The superfamilies, however, are arranged in alphabetical order. Specimens were measured either with a digital caliper or with the aid of the computer software Leica Application Suite (LAS, v.3.8.0) and ImageJ (Rasband 2012). The following abbreviations are used throughout the article for shell measurements: H = shell height (parallel to coiling axis); D = greatest shell width (perpendicular to H).

Systematic Paleontology

Caenogastropoda

Superfamily Cerithioidea

Family Pachychilidae

Genus ***Tinnyea*** Hantken 1887

Tinnyea cf. ***lauraea*** (Mathéron 1843)

Fig. 2

Material examined: Bechingen: SMNS 67854 (1 spc.), 106783 (1 spc.).

Remarks: Despite the poor preservation of the present material, the specimens' turriform shell and relatively large size allow a tentative identification as *T. lauraea*. This species is known from the Oligocene to the Pliocene of Central Europe (Harzhauser et al. 2002); such a large time span is considered an indication that this is a still unresolved species complex (Kadolsky 1995).

Superfamily Littorinoidea

Family Pomatiidae

Genus ***Pomatias*** Studer 1789

Pomatias cf. ***conicus*** (Klein 1853)

Fig. 3

Material examined: Bechingen: SMNS 106784 (4 spc.), 106817 (2 spc.), 106818 (1 spcm.), 106807*.

Remarks: This species can be identified by its trochiform shell and strongly convex whorl profile. Although most specimens are internal molds, a few well preserved external molds retain the characteristic teleoconch sculpture pattern of the shell (reticulated, with stronger spiral ribs and weaker axial ribs), allowing the tentative identification at species level. *Pomatias conicus* is a common species, known from the Middle to Late Miocene of Hungary, Austria and the Silvana Beds of southwestern Germany and Switzerland (Klein 1853, Harzhauser & Binder 2004, Kókay 2006). Despite being common in the fossil record, no opercula of this species were found in the present material.

Superfamily Rissooidea

Family Bithyniidae

Genus ***Bithynia*** Leach 1818

Bithynia glabra (Zieten 1832)

Fig. 4

1830 *Cyclostoma glabrum* Zieten, p. 42, pl. 31, fig. 9.
1852 *Paludina tentaculata*, – Krauss, p. 140 [non *Helix tentaculata* Linnaeus 1758, p. 774].
1872 *Bythinia* [sic] *gracilis* Sandberger, pl. 28, figs. 16–16a.
1875 *Bythinia* [sic] *gracilis*, – Sandberger, p. 561.
1964 *Bithynia glabra*, – Schlickum, p. 9.
1966 *Bithynia dunkeri*, – Schlickum, p. 324, pl. 12, figs. 19–21.
1966 *Bithynia glabra*, – Schlickum, p. 324, pl. 12, fig. 22.
1989 *Bithynia* cf. *glabra,* – Reichenbacher, p. 144, pl. 1, fig. 4.
1989 *Bithynia dunkeri,* – Reichenbacher, p. 144, pl. 1, figs. 6–7.
2005 *Bithynia* cf. *glabra,* – Kowalke & Reichenbacher, p. 629, figs. 8.1–8.2.
2014 *Bithynia glabra*, – Neubauer et al., supplementary material 1.

Material examined: Bechingen: SMNS 68142 (3 spc.), 106810 (1 spc.).

Remarks: The conical and imperforate small shell, with a wide circular aperture and complete peristome allows the identification as *B. glabra*, a common species in the Early and Middle Miocene of Germany. Although fossil opercula of *Bithynia* are commonly recovered, none was found in the present material.

Pulmonata

Hygrophila

Superfamily Lymnaeoidea

Family Lymnaeidae

Genus ***Lymnaea*** Lamarck 1799

Lymnaea dilatata Noulet 1854

Fig. 5

1854 *Limnea dilatata* Noulet, p. 107.
1923 *Radix* (*Radix*) *socialis dilatata*, – Wenz, p. 1277.
2000 *Lymnaea dilatata*, – Fischer, p. 136, figs. 1–2.
2006 *Radix dilatata*, – Kókay, p. 52, pl. 17, fig. 14.
2014 *Radix dilatata*, – Neubauer et al., supplementary material 1.
2014 *Lymnaea dilatata*, – Salvador & Rasser, p. 189, figs. 8–9.

2015b *Lymnaea dilatata*, – Salvador et al., p. 204, figs. 2F–G.
2016 *Lymnaea dilatata*, – Salvador et al., p. 133, fig. 2G.

Material examined: Bechingen: SMNS 23314*, 67606 (1 spc.), 67655 (1 spc.), 106806 (3 spc.), 106809*, 106810*, 106796*, 106803 (1 spc.), 106807*. Daugendorf: SMNS 107212 (1 spc.).

Remarks: *Lymnaea dilatata* is diagnosed by its large lymnaeid shell, a proportionately small and acuminate spire, rapidly-expanding and slightly convex whorls, a roughly oval body whorl and a large ellipsoid aperture. This species is widely known from the entire Miocene of Western and Central Europe (Binder 2004, Kókay 2006).

Genus ***Radix*** Montfort 1810

Radix socialis (Zieten 1830)

Fig. 6

1830 *Limnaea socialis* Zieten, 40, pl. 30, fig. 4.
1846 *Limnaeus socialis* var. *elongata* Klein, p. 85, pl. 2, figs. 8a–b [non *Limneus elongatus* Draparnaud 1805, nec de Serres 1844].
1846 *Limnaeus socialis* var. *intermedia* Klein, p. 85, pl. 2, figs. 9a–b [non *Lymnaea intermedia* (Férussac) Lamarck 1822].
1846 *Limnaeus socialis* var. *striata* Klein, p. 85, pl. 2, figs. 10a–b [?non *Limnaeus striatus* Zieten, 1832].
1913 *Limnaea turrita* var. *milleri* Jooss, p. 61, figs. 5–6.
1923 *Radix* (*Radix*) *socialis socialis*, – Wenz, p. 1272.
2014 *Radix socialis*, – Neubauer et al., supplementary material 1.
2014 *Radix socialis*, – Salvador & Rasser, p. 189, fig. 10.

Material examined: Bechingen: SMNS 106794 (1 spc.), 106803 (1 spc.).

Remarks: The present material display the diagnostic features of the genus, such as the proportionately minute spire, round overall shell profile and proportionately large body whorl. It compares extraordinarily well to the specimens (housed in the SMNS) of *Radix socialis socialis* from the type locality (Steinheim Basin, southwestern Germany; MN 7–8) and the type material of its synonymized subspecies (*elongata* Klein 1846, SMNS 23911, 5 spc.; *intermedia* Klein 1846, SMNS 23905, 3 spc.; *striata* Klein 1846, SMNS 23904, 2 spc.).

Superfamily Planorboidea

Family Planorbidae

Genus ***Ferrissia*** Walker 1903

Ferrissia deperdita (Desmarest 1814)

Fig. 7

1814 *Ancylus deperditus* Desmarest, p. 19, pl. 1, fig. 14.
1923 *Pseudancylus deperditus deperditus*, – Wenz, p. 1692.
1976 *Ferrissia deperdita*, – Schlickum, p. 7, pl. 1, fig. 20.
2006 *Ferrissia deperdita*, – Kókay, p. 60, pl. 20, fig. 15, pl. 21, fig. 1.
2014b *Ferrissia deperdita,* – Harzhauser et al., p. 17, pl. 5, figs. 1, 2, 5, 12,
2014 *Ferrissia deperdita*, – Neubauer et al., supplementary material 1.
2014 *Ferrissia deperdita*, – Salvador & Rasser, p. 191, fig. 11.
2015a *Ferrissia deperdita*, – Salvador et al., p. 256, fig. 3C.
2016 *Ferrissia deperdita*, – Salvador et al., p. 134, fig. 2H.

Material examined: Bechingen: SMNS 67926 (1 spc.).

Remarks: The specimen compares well to *F. deperdita*, with a cap-like smooth protoconch, gradually transitioning to a teleoconch bearing well-marked growth lines. This species is recorded from the Middle Miocene of Hungary, Austria, southern Germany, France and Switzerland (Schlickum 1976, Kókay 2006, Harzhauser et al. 2014b).

Genus ***Gyraulus*** Charpentier 1837

Gyraulus applanatus (Thomä 1845)

Fig. 8

1845 *Planorbis applanatus* Thomä, p. 150.
1851 *Planorbis dealbatus* Braun, p. 1134.
1911 *Gyraulus laevis*, – Gottschick, p. 515.
1923 *Gyraulus* (*Gyraulus*) *trochiformis applanatus*, – Wenz, p. 1579.
1923 *Gyraulus* (*Gyraulus*) *trochiformis dealbatus*, – Wenz, p. 1591.
1964 *Gyraulus trochiformis dealbatus*, – Schlickum, p. 15, pl. 2, fig. 35.
1970a *Gyraulus trochiformis applanatus*, – Schlickum, p. 148, pl. 10, fig. 6.
1970b *Gyraulus trochiformis applanatus*, – Schlickum, p. 180.
1973 *Gyraulus trochiformis dealbatus*, – Steininger et al., p. 451, pl. 9, fig. 11a–b.
1989 *Gyraulus trochiformis dealbatus*, – Reichenbacher, p. 172, pl. 1, fig. 11.
1995 *Gyraulus dealbatus*, – Kadolsky, p. 40, fig. 47.
2004 *Gyraulus dealbatus*, – Binder, p. 193, pl. 2, figs. 1a–c.
2005 *Gyraulus applanatus,* – Kowalke & Reichenbacher, p. 631, figs. 9.1–9.3.
2006 *Gyraulus applanatus*, – Kókay, p. 56, pl. 19, figs. 13–14.
2006 *Gyraulus trochiformis dealbatus*, – Kókay, p. 57, pl. 19, fig. 15.
2014 *Gyraulus applanatus*, – Neubauer et al., supplementary material 1.
2014 *Gyraulus dealbatus*, – Neubauer et al., supplementary material 1.
2014 *Gyraulus dealbatus*, – Salvador & Rasser, p. 192, figs. 16–23.
2015b *Gyraulus applanatus*, – Salvador et al., p. 205, figs. 2H–I.
2016 *Gyraulus applanatus*, – Salvador et al., p. 134, fig. 2K–M.

Material examined: Bechingen: SMNS 23314*, 67784 (1 spc.), 106794 (1 spc.), 106809*, 106810*, 106796*, 106803*, 106807*. Daugendorf: SMNS 106813 (2 spc.), SMNS 107207 (14 spc.).

Remarks: The present specimens, although poorly preserved, compare well to *G. applanatus*, by their flattened shell profile and closely packed whorls. This species is known for a great deal of conchological variation, occurring in several localities from the Early/Middle Miocene of southern Germany (Gottschick & Wenz 1916, Kowalke & Reichenbacher 2005, Salvador & Rasser 2014). *Gyraulus dealbatus* was considered an extreme of morphological variation and the species was synonymized with *G. applanatus* by Kowalke & Reichenbacher (2005).

Genus ***Planorbarius*** Duméril 1806

Planorbarius mantelli (Dunker 1848)

Figs 9–11

1848 *Planorbis Mantelli* Dunker: p. 159, pl. 21, figs. 27–29.
1923 *Coretus cornu mantelli*, – Wenz, p. 1452.
1966 *Planorbarius cornu*, – Schlickum, p. 326, pl. 13, fig. 27.
1970a *Planorbarius cornu*, – Schlickum, p. 149, pl. 10, fig. 7.
1989 *Planorbarius cornu*, – Reichenbacher, p. 172, pl. 1, fig. 10.
2004 *Planorbarius cornu*, – Binder, p. 193, pl. 2, figs. 2–3.
2006 *Planorbarius cornu cornu*, – Kókay, p. 58, pl. 20, fig. 6.
2009 *Planorbarius cornu cornu*, – Böttcher et al., p. 239, figs. 2.4–2.6.
2014b *Planorbarius mantelli*, – Harzhauser et al.: p. 15, pl. 3, figs. 5, 7–13, 15–16.
2014 *Planorbarius mantelli,* – Neubauer et al: supplementary material 1.
2014 *Planorbarius cornu*, – Salvador & Rasser: p. 193, figs. 26–28.
2015a *Planorbarius cornu*, – Salvador et al., p. 256, figs. 3G–H.
2015 *Planorbarius cornu*, – Salvador et al., p. 205, fig. 2J.
2016 *Planorbarius cornu*, – Salvador et al., p. 135, fig. 2P–Q.

Material examined: Bechingen: SMNS 23314*, 67841 (10 spc.), 67856 (7 spc.), 106790 (16 spc.), 106791 (14 spc.), 106797 (7 spc.), 106798 (36 spc.), 106799 (8 spc.), 106801 (3 spc.), 106809*, 106810*, 106817 (1 spc.), 106826 (7 spc.), 106827 (1 spc.), 106828 (1 spc.), 106795*, 106796*, 106803 (1 spc.), 106807*, 106808*. Daugendorf: SMNS 106793 (3 spc.), 106821 (10 spc.); PIMUZ 011610*.

Remarks: The shell's characteristic flattened shape, whorl growth pattern and unique sculpture (protoconch with spiral lines of regularly organized circular pits and teleoconch with spiral striae on the first ca. 1½ whorl; the remainder of the teleoconch is marked only by coarse growth lines) enables the identification as *P. mantelli*. This species is very abundant in OSM sediments, being known from the late Early to the Late Miocene of Central Europe (Harzhauser et al. 2014b). Specimens of *P. mantelli* from these localities and ages have been usually identified as *P. cornu* (Brongniart 1810), which occurs from the Late Oligocene to Early Miocene. These two species are actually hard to differentiate, being presently separated by their age alone and, thus, in dire need of revisionary work.

Eupulmonata

Stylommatophora

Superfamily Achatinoidea

Family Subulinidae

Genus ***Opeas*** Albers 1850

Opeas minutum (Klein 1853)

Fig. 12

1853 *Bulimus minutus* Klein, p. 212, pl. 5, fig. 9.
1923 *Opeas minutum*, – Wenz, p. 872.
1926 *Opeas minutum*, – Seemann, p. 92.
1976 *Opeas* (*Opeas*) *minutum*, – Schlickum, p. 14, pl. 3, fi g. 46.
2006 *Opeas minutum*, – Kókay, p. 80, pl. 30, fig. 16.
2014b *Opeas minutum*, – Harzhauser et al., 2014b, p. 28, pl. 9, figs. 3–5, 7.
2015 *Opeas minutum*, – Salvador et al., p. 206, fig. 2K.

Material examined: Bechingen: SMNS 67039 (1 spc.). Daugendorf: SMNS 107206 (1 spc.), SMNS 107209 (1 spc.).

Remarks: This species is easily diagnosed in European Miocene depositis by its small and typical subulinid shell. *Opeas minutum* is known from the Early to Middle Miocene of Hungary, Austria, Germany and Switzerland (Harzhauser et al. 2014b, Salvador et al. 2015b).

Superfamily Cochlicopoidea

Family Cochlicopidae

Genus ***Hypnophila*** Bourguignat 1858

Hypnophila loxostoma (Klein 1853) comb. nov.

Fig. 13

1853 *Achatina loxostoma* Klein, p. 214, pl. 5, fig. 12.
1923 *Cochlicopa subrimata loxostoma*, – Wenz, p. 1107.
1926 *Cochlicopa subrimata loxostoma*, – Seemann, p. 90.
1954 *Cochlicopa subrimata loxostoma*, – Papp & Thenius, p. 21, pl. 4, fig. 7a–c.
1981 *Cochlicopa subrimata loxostoma*, – Lueger, p. 16, pl. 1, fig. 4.
2013 *Cochlicopa subrimata loxostoma*, – Rasser et al., p. 440, pl. 4, fig. 6.
2013 *Cochlicopa subrimata*, – Rasser et al., p. 434, pl. 4, fig. 6.
2015a *Cochlicopa loxostoma*, – Salvador et al., 258, fig. 3O.

Material examined: Bechingen: SMNS 106786 (5 spc.).

Remarks: This species has traditionally been classified in the genus *Cochlicopa* Férussac 1821. Harzhauser et al. (2014a), however, transferred the coeval and morphologically similar *H. subrimata* (Reuss *in* Reuss & Meyer 1849) to the genus *Hypnophila*. This deci-

sion is followed here, resulting in the new combination *Hypnophila loxostoma*.

In fact, *H. loxostoma* has been usually considered a subspecies of *H. subrimata* in the literature, but Harzhauser et al. (2014b) has since shown that the topotypes of the latter differ from specimens stemming from other localities. Salvador et al. (2015a) thus considered *H. loxostoma*, known from the OSM layers in Germany, a distinct species, diagnosed by a much wider aperture, with a taller columellar region.

Superfamily Helicoidea

Family Elonidae

Genus ***Apula*** C. Boettger 1909

Apula coarctata (Klein 1853)

Figs 14–16

1853 *Helix coarctata* Klein, p. 206, pl. 5, fig. 6.
1923 *Klikia* (*Apula*) *coarctata coarctata*, – Wenz, p. 534.
1926 *Klikia* (*Apula*) *coarctata coarctata*, – Seemann, p. 92.
1976 *Klikia* (*Apula*) *coarctata,* – Schlickum, p. 17, pl. 4, fig. 60.
2006 *Klikia* (*Apula*) *coarctata*, – Kókay, p. 92.
2013 *Klikia coarctata,* – Rasser et al., p. 440, pl. 4, fig. 9.
2013 *Klikia coarctata*, – Salvador, p. 161, figs. 6–9.
2014b *Apula coarctata*, – Harzhauser et al., p. 34, pl. 11, figs. 5–8, 21.
2015a *Apula coarctata*, – Salvador et al., p. 259, figs. 3S–U.

Material examined: Bechingen: SMNS 66290 (1 spc.), 66315 (4 spc.), 106789 (7 spc.). Daugendorf: SMNS 106812 (2 spc.).

Remarks: The specimens compare fittingly with the original description of *A. coarctata* and topotypes housed in the SMNS collection by their raised spire profile and a high and round body whorl. *Apula coarctata* is a common species in the Miocene of Central Europe, with records from Hungary, Austria, Germany and Switzerland (Harzhauser et al. 2014b).

Genus ***Klikia*** Pilsbry 1895

Klikia giengensis (Klein 1846)

Figs 17–19

1846 *Helix Giengensis* Klein, p. 69, pl. 1, fig. 9.
1914 *Klikia osculum*, – Fischer & Wenz, p. 70.
1923 *Klikia* (*Klikia*) *giengensis giengensis*, – Wenz, p. 539.
1976 *Klikia* (*Klikia*) *giengensis*, – Schlickum, p. 16, pl. 4, fig. 58.
2004 *Klikia giengensis*, – Binder, p. 203, pl. 6, figs. 3a–b.
2006 *Klikia* (*Klikia*) *giengensis*, – Kókay, p. 91, pl. 35, fig. 9.
2014b *Klikia giengensis*, – Harzhauser et al., p. 33, pl. 11, figs. 9–11, 9–22

Material examined: Bechingen: SMNS 66275 (3 spc.).

Remarks: This species can be distinguished in the material from the similar *A. coarctata* by its smaller size, greatly reflected peristome, a slight indentation on the upper palatal region of the aperture, a deep and wide umbilicus, and the stronger teleoconch sculpture consisting of numeros papillae. *Klikia giengensis* is known from several Miocene localities of Ukraine, Poland, Hungary, Austria, Germany and France (Harzhauser et al. 2014b).

Family Helicidae

Genus ***Palaeotachea*** Jooss 1912

Palaeotachea silvana (Klein 1853)

Figs 20–22

1853 *Helix silvana* Klein, p. 205, pl. 5, fig. 2.
1923 *Cepaea silvana silvana*, – Wenz, p. 667.
1976 *Cepaea silvana silvana*, – Schlickum, p. 17, pl. 4, figs. 62–63.
1989 *Cepaea silvana silvana*, – Reichenbacher, p. 165, pl. 2, figs. 17–19.
2006 *Cepaea silvana*, – Kókay, p. 93, pl. 36, figs. 2–3.
2013 *Cepaea silvana*, – Rasser et al., p. 440.
2015a *Megalotachea silvana*, – Salvador et al., p. 261, figs. 4C–D.
2015 *Megalotachea silvana*, – Salvador et al., p. 208, figs. 2U–W.
2016 *Megalotachea silvana*, – Salvador et al., p. 137, fig. 3A–C.

Material examined: Bechingen: SMNS 23314*, 66635 (2 spc.), 66652 (2 spc.), 66665 (1 spc.), 66842 (2 spc.), 106781 (1 spc.), 106782 (2 spc.), 106792 (7 spc.), 106802 (3 spc.), 106816 (1 spc.), 106829 (1 spc.), 106795*, 106803 (3

Figure 2. *Tinnyea* cf. *lauraea*, internal mold (SMNS 106783; H = 21.7 mm, D = 9.1 mm). Figure 3. *Pomatias* cf. *conicus*, internal mold (SMNS 106784; H = 12.0 mm, D = 10.1 mm). Figure 4. *Bithynia glabra* (SMNS 68142; H = 4.7 mm, D = 3.2 mm). Figure 5. *Lymnaea dilatata* (SMNS 67606; H = 18.9 mm, D = 8.9 mm). Figure 6. *Radix socialis*, embedded in the matrix (SMNS 106794; H = 27.6 mm, D = 16.8 mm). A small specimen of *Gyraulus applanatus* can be seen on the top left, also embedded in the matrix. Figure 7. *Ferrissia deperdita*, embedded in the matrix (SMNS 67926; H = 2.4 mm, D = 1.9 mm). Figure 8. *Gyraulus applanatus* (SMNS 67425; D = 4.0 mm). Figures 9–11. *Planorbarius mantelli*, juvenile specimen (SMNS 67856; H = 8.3 mm, D = 20.7 mm). Figure 12. *Opeas minutum* (SMNS 67039; H = 7.2 mm, D = 2.4 mm). Figure 13. *Hypnophila loxostoma* comb. nov. (SMNS 106786; H = 5.5 mm, D = 2.3 mm). Figures 14–16. *Apula coarctata* (SMNS 66290; H = 6.8 mm, D = 11.3 mm). Figures 17–19. *Klikia giengensis* (SMNS 66275; H = 6.2 mm, D = 9.5 mm). Figures 20–22. *Palaeotachea silvana* (SMNS 66635; H = 13.6 mm, D = 20.7 mm). Figures 23–25. *Pseudochloritis incrassata* (SMNS 66208; H = 13.7 mm, D = 21.5 mm). Figure 26. *Leucochroopsis kleinii* (SMNS 106787; H = 4.3 mm, D = 6.3 mm). Figures 27–29. *Praeoestophorella phacodes* (SMNS 107208; H = 2.2 mm, D = 3.9 mm). Figure 30. *Discus pleuradrus* (SMNS 65789; H = 4.2 mm, D = 6.6 mm).


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spc.). Daugendorf: SMNS 66647 (2 spc.), 106822 (3 spc.); PIMUZ 011663 (29 spc.).

Remarks: The present material compares well to *P. silvana* (syntype: SMNS 22738) in size, spire profile, and overall shell shape and proportions. This is a very common species in the Silvana Beds, which are named after this species. On some specimens (SMNS 66635, 106795) it is possible to observe under UV light (and even with the naked eye) two kinds of patterns of colored spiral bands: bi- and trifasciate. A wide variety of banding patterns is commonly found in Recent Helicidae and is known to occur in fossil specimens of *Pseudochloritis* and *Palaeotachea* (*e.g.*, Górka 2008, Salvador 2013, Salvador et al. 2015b).

Genus ***Pseudochloritis*** Boettger 1909

Pseudochloritis incrassata (Klein 1853)

Figs 23–25

1846 *Helix inflexa* Klein, p. 71, pl. 1, fig. 12 [*non* Zieten 1832].
1853 *Helix incrassata* Klein, p. 208, pl. 5, fig. 6.
1923 *Tropidomphalus* (*Pseudochloritis*) *incrasstus incrassatus,* – Wenz, p. 510.
1926 *Tropidomphalus* (*Pseudochloritis*) *incrasstus incrassatus*, – Seemann, p. 91.
1976 *Tropidomphalus* (*Pseudochloritis*) *incrasstus incrassatus*, – Schlickum, p. 16, pl. 4, fig. 56.
2006 *Tropidomphalus* (*Pseudochloritis*) *incrassatus*, – Kókay, p. 90, pl. 34, figs. 12–14.
2008 *Pseudochloritis incrassata*, – Binder, p. 172, pl. 3, figs. 2–4, pl. 6, fig. 2.
2013 *Pseudochloritis incrassata,* – Rasser et al., p. 434, pl. 4, fig. 12.
2013 *Tropidomphalus* (*Pseudochloritis*) *incrassata* [sic], – Rasser et al., p. 440.
2014b *Pseudochloritis incrassata*, – Harzhauser et al., p. 35, pl. 12, figs. 9–16, 19–24.
2015 *Pseudochloritis incrassata,* – Höltke & Rasser, p. 1, figs. 4.3, 5.1–5.2, 6.11–6.12.
2015a *Pseudochloritis incrassata*, – Salvador et al., p. 261, figs. 4E–G.
2015 *Pseudochloritis incrassata,* – Salvador et al., p. 207, figs. 3A–C.

Material examined: Bechingen: SMNS 23314*, 66208 (1 spc.), 106804 (2 spc.), 106815 (4 spc.), 106827 (1 spc.), 106808 (2 spc.). Daugendorf: 106820 (1 spc.); PIMUZ 011663 (1 spc.).

Remarks: This species can be identified by its helicoid shell, with a strongly depressed spire and characteristic sculpture (preserved only in fragmentary specimens and consisting of: protoconch with fine striae dotted with weak papillae, teleoconch with well-marked growth lines and irregular weak furrows, with regularly arranged papillae). On one specimen (SMNS 66208) it is possible to observe under UV light a single colored spiral band immediate below the shoulder. *Pseudochloritis incrassata* is known from the Middle Miocene of Poland, Austria, several localities in Germany, and possibly also Hungary (Kókay 2006, Binder 2008, Górka 2008).

Family Hygromiidae

Genus ***Leucochroopsis*** O. Boettger 1908

Leucochroopsis kleinii (Klein 1846)

Fig. 26

1846 *Helix kleinii* Klein, p. 69, pl. 1, fig. 8.
1923 *Trichia* (*Leucochroopsis*) *kleini kleini* [sic], – Wenz, p. 429.
1926 *Trichia* (*Leucochroopsis*) *kleini kleini* [sic], – Seemann, p. 91.
1972 *Leucochroopsis kleini kleini* [sic], – Gall, p. 9.
1976 *Leucochroopsis kleini* [sic], – Schlickum, p. 15, pl. 3, fig. 52.
2004 *Leucochroopsis kleini* [sic], – Harzhauser & Binder, p. 25, pl. 11, figs. 8–10.
2013 *Leucochroopsis kleini* [sic], – Rasser et al., p. 440, pl. 4, fig. 10.
2013 *Leucochroopsis kleinii*, – Salvador, p. 166, figs. 26–27.
2014b *Leucochroopsis kleinii*, – Harzhauser et al., p. 35, pl. 11, figs. 12–14.
2015a *Leucochroopsis kleinii*, – Salvador et al., p. 262, figs. 4K–M.

Material examined: Bechingen: SMNS 65952 (6 spc.), 106787 (8 spc.), 106800 (1 spc.). Daugendorf: SMNS 106814 (1 spc.), SMNS 107210 (5 spc.).

Remarks: *Leucochroopsis kleinii* is easily identified by its small shell, with a depressed conical spire and a rounded base, and by its sculpture (protoconch with fine parallel striae and teleoconch with fine regularly distributed well-marked scales, giving the impression of prosocline axial striae). The species is widely known from the Middle Miocene of the Silvana Beds to the Late Miocene of the Vienna Basin (Schlickum 1976, Harzhauser & Binder 2004).

Family Trissexodontidae

Genus ***Praeoestophorella*** Pfeffer 1930

Praeoestophorella phacodes (Thomä 1845)

Figs 27–29

1845 *Helix phacodes* Thomä, p. 142, pl. 2, fig. 8.
1921 *Oestophora phacodes subphacodes,* – Ehrat & Jooss, p. 3.
1923 *Caracollina phacodes phacodes,* – Wenz, p. 461.
1926 *Caracollina phacodes barreri*, – Seemann, p. 91.
1976 *Caracollina phacodes barreri*, – Schlickum, p. 16, pl. 4, fig. 55.
2013 *Caracollina phacodes*, – Rasser et al., p. 439, pl. 4, fig. 5.
2014a *Praeoestophorella phacodes*, – Harzhauser et al., p. 887.
2015a *Praeoestophorella phacodes*, – Salvador et al., p. 263, figs. 4N–P.

Material examined: Daugendorf: SMNS 107208 (3 spc.).

Remarks: This species is easily identified by its small lenticular shell with a marked keel. Despite the

present specimens being all juvenile, they compare well to the conchological features of *Praeoestophorella phacodes*, a species known since the Late Oligocene and very common in OSM sediments (Salvador et al. 2015a). The present specimens display much weaker and more numerous axial ribs than seen in other OSM localities. This variation in teleoconch sculpture had already been noticed by Sandberger (1870–1875) for other German Miocene material and resulted in the description of several subspecies (*e.g.*, Wenz 1923), the validity of which should be the focus of future revisionary work.

Superfamily Punctoidea

Family Discidae

Genus ***Discus*** Fitzinger 1833

Discus pleuradrus (Bourguignat 1881)

Fig. 30

1881 *Helix pleuradra* Bourguignat, p. 53, pl. 3, figs. 67–72.
1923 *Gonyodiscus* (*Gonyodiscus*) *pleuradra pleuradra*, – Wenz, p. 341.
1942 *Gonyodiscus* (*Gonyodiscus*) *pleuradra pleuradra*, – Wenz & Edlauer, p. 93.
1967 *Discus* (*Discus*) *pleuradrus*, – Schütt, p. 213, fig. 16.
1976 *Discus* (*Discus*) *pleuradrus*, – Schlickum, p. 12, pl. 2, fig. 37.
1981 *Discus* (*Discus*) *pleuradrus,* – Lueger, p. 40, pl. 4, figs. 6–7.
2000 *Discus* (*Discus*) *pleuradra* [sic], – Fischer, p. 145, fig. 21.
2004 *Discus pleuradrus,* – Harzhauser & Binder, p. 22, pl. 7, figs. 9–11.
2006 *Discus pleuradrus,* – Kókay, p. 75, pl. 28, figs. 3–4.
2009 *Discus pleuradrus,* – Böttcher et al., p. 239, figs. 2/10–11.
2013 *Discus pleuradrus,* – Rasser et al., p. 439.
2014b *Discus pleuradrus,* – Harzhauser et al., p. 29, pl. 9, figs. 8–13.
2014 *Discus pleuradrus,* – Salvador & Rasser, p. 195, figs. 32–33.
2015a *Discus pleuradrus*, – Salvador et al., p. 264, figs. 4U–W.
2016 *Discus pleuradrus*, – Salvador et al., p. 140, fig. 3M–N.

Material examined: Bechingen: SMNS 65789 (1 spc.). Daugendorf: SMNS 107211 (1 spc.).

Remarks: This specimens compare well with *D. pleuradrus*, given their discoid shell, with a faint shoulder, low spire, whorls regularly increasing in size, a wide umbilicus and the teleoconch sculptured by strong prosocline ribs. This is a common species in the Miocene of Central and Western Europe (Kókay 2006, Böttcher et al. 2009). Early and Late Miocene records could represent another species, which would restrict *D. pleuradrus* to the Middle Miocene of Austria, Germany and France (Moser et al. 2009, Harzhauser et al. 2014b).

Superfamily Pupilloidea

Family Gastrocoptidae

Genus ***Gastrocopta*** Wollaston 1878

Gastrocopta cf. ***acuminata*** (Klein 1846)

Fig. 31

Material examined: Bechingen: SMNS 67425 (2 spc.), 106785 (6 spc.). Daugendorf: SMNS 106811 (7 spc.

Remarks: Despite the poor preservation, the present material compares well to *G. acuminata* (syntypes: SMNS 106361, 2 spc.) due to the overall rounded shell shape and the proportionately larger size when compared to coeval congeners. The species is recorded from the Middle Miocene to the Late Pliocene, and maybe Early Pleistocene, of Europe (Stworzewicz 1999, Manganelli & Giusti 2000).

Superfamily Succineoidea

Family Succineidae

Genus ***Oxyloma*** Westerlund 1885

Oxyloma minima (Klein 1853)

Figs 32–33

1853 *Succinea minima* Klein, p. 205.
1923 *Succinea* (*Amphibina*) *minima minima*, – Wenz, p. 893.
1976 *Succinea* (*Hydrotropa?*) *minima*, – Schlickum, p. 11, pl. 2, fig. 34.
2006 *Succinea minima*, – Kókay, p. 74, pl. 27, fig. 13.
2013 *Succinea minima*, – Salvador, p. 158, figs. 1–2.
2014b *Oxyloma minima*, – Harzhauser et al., p. 27, pl. 9, figs. 1–2, 6.
2016 *Oxyloma minima*, – Salvador et al., p. 143, fig. 4C–D.

Material examined: Bechingen: SMNS 67065 (1 spc.), 106788 (5 spc.).

Remarks: *Oxyloma minima* is easily identified in fossil samples by its small succineiform shell, the growth pattern of its whorls and the incised suture. The present material compares well to the syntypes (SMNS 106410, 2 spc.). Despite the fossils of *O. minima* being usually scarce, the species is known from several outcrops from the Early/Middle Miocene of Germany, Hungary, Austria and possibly Ukraine (Kókay 2006; Harzhauser et al. 2014b).

Superfamily Testacelloidea

Family Oleacinidae

Genus ***Palaeoglandina*** Wenz 1914

Palaeoglandina gracilis (Zieten 1830)

Fig. 34

1830 *Limnaea gracilis* Zieten, p. 39, pl. 30, fig. 3.
1923 *Poiretia* (*Palaeoglandina*) *gracilis gracilis*, – Wenz, p. 839.
1960 *Palaeoglandina gracilis*, – Zilch, p. 457, fig. 1627.
2015a *Palaeoglandina gracilis*, – Salvador et al., p. 267, fig. 5E.

Figure 31. *Gastrocopta* cf. *acuminata* (SMNS 106785; H = 2.4 mm, D = 1.6 mm). Figures 32–33. *Oxyloma minima* (SMNS 106788; H = 8.7 mm, D = 4.4 mm). Figure 34. *Palaeoglandina gracilis*, partially embedded in the matrix (SMNS 106805; H = 38.4 mm).

Material examined: Bechingen: SMNS 106805 (3 spc.).

Remarks: The present material compares well with *P. gracilis* by the large size, broad fusiform shell, elongated aperture, and strong sculpture, consisting of regularly distributed well-marked opistocline ribs. This species is known from the Late Oligocene to the Middle Miocene of Central Europe (Salvador 2013).

Discussion

In total, twenty gastropod species were found in the Bechingen/Daugendorf material (Table 1). All species, with the exception of *Praeoestophorella phacodes*, occur in Bechingen, but only eleven occur in Daugendorf (Table 1). Moreover, in the material from Daugendorf, there are some external molds whose size, shape and sculpture pattern suggest the presence of the genera *Archaeozonites* Sandberger 1873 (Zonitidae; SMNS 106793) and *Granaria* Held 1838 (Chondrinidae; SMNS 106819); this would raise the count to thirteen species for this locality. Additionaly, some species listed by previous authors from Bechingen were not found in the present material: *Pseudoleacina eburnea* (Klein 1853) (Jooss 1910: 20, Wenz 1923: 858) and *Janulus supracostatus* (Sandberger 1872) (Jooss 1918: 290, Wenz 1923: 305, Schlickum 1976: 13). All of the presently listed species have been reported from the geographically close and likely coeval locality of Zwiefaltendorf, which is likewise composed of reworked material (Schlickum 1976). This is not surprising, if we are dealing with the same rocks reworked by Pleistocene morain sediments (Zöbelein 1973).

Werner (2014) proposed for the neighboring Tautschbuch localities a paleoenvironment consisting of shallow temporary lakes or ponds surrounded by reeds. Despite the snail fauna being scarce, it agrees with this scenario. The extant congeners of the freshwater snails can be found in several different environments, but they share a preference for richly vegetated, stagnant or slow moving water (Welter-Schultes 2012). *Ferrissia*, in particular, is a typical inhabitant of reed-belts on the upper littoral zone of water bodies (Glöer 2002). *Oxyloma* species are hygrophilous, living in very humid forests and meadows, and often found in reed belts surrounding water bodies (Welter-Schultes 2012).

In terrestrial environment, *Opeas*, *Leucochroopsis, Discus* and *Archaeozonites* (and *Janulus* and *Pseudoleacina*, recorded from the literature) are thought to inhabit humid (and generally) warm woods (Zilch 1959–1960, Lueger 1981, Kerney et al. 1983, Harzhauser & Tempfer 2004, Willig et al. 2013). Recent *Pomatias* would also prefer humid environments, living in both forests and shrublands (Kerney & Cameron 1979, Welter-Schultes 2012). The genera *Pseudochloritis*, *Praeoestophorella* (allied to the Recent *Caracollina* Beck, 1837) and *Granaria* would represent drier and more open habitats (Binder 2008, Moser et al. 2009, Welter-Schultes 2012, Höltke & Rasser 2013).

This high variablity of snail habitats is not surprising, since the snails may come from a variety of layers reworked during the Pleistocene. The Tautschbuch area contains more then 100 meters of OSM sediments and thus provide a variety of different habitats changing through time and space.

Table 1. List of molluscan species recorded from the OSM localities Bechingen and Daugendorf. An "?" indicates a doubtful identification based on external molds. — Be = Bechingen, Dau = Daugendorf

Species	Be	Dau
Caenogastropoda		
Bithynia glabra (Zieten 1832)	x	
Pomatias cf. *conicus* (Klein 1853)	x	
Tinnyea cf. *lauraea* (Mathéron 1843)	x	
Hygrophila		
Ferrissia deperdita (Desmarest 1814)	x	
Gyraulus applanatus (Thomä 1845)	x	x
Lymnaea dilatata (Noulet 1854)	x	x
Planorbarius mantelli (Dunker 1848)	x	x
Radix socialis (Zieten 1830)	x	
Stylommatophora		
Apula coarctata (Klein 1853)	x	x
Archaeozonites sp.		?
Discus pleuradrus (Bourguignat 1881)	x	x
Gastrocopta cf. *acuminata* (Klein 1846)	x	x
Granaria sp.		?
Hypnophila loxostoma (Klein 1853)	x	
Klikia giengensis (Klein 1846)	x	
Leucochroopsis kleinii (Klein 1846)	x	x
Opeas minutum (Klein 1853)	x	x
Oxyloma minima (Klein 1853)	x	
Palaeoglandina gracilis (Zieten 1830)	x	
Palaeotachea silvana (Klein 1853)	x	x
Praeoestophorella phacodes (Thomä 1845)		x
Pseudochloritis incrassata (Klein 1853)	x	x

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