



## The fossil land and freshwater mollusks of Sandelzhausen (Early/Middle Miocene, Germany): Caenogastropoda, Neritimorpha, lower Heterobranchia and Bivalvia

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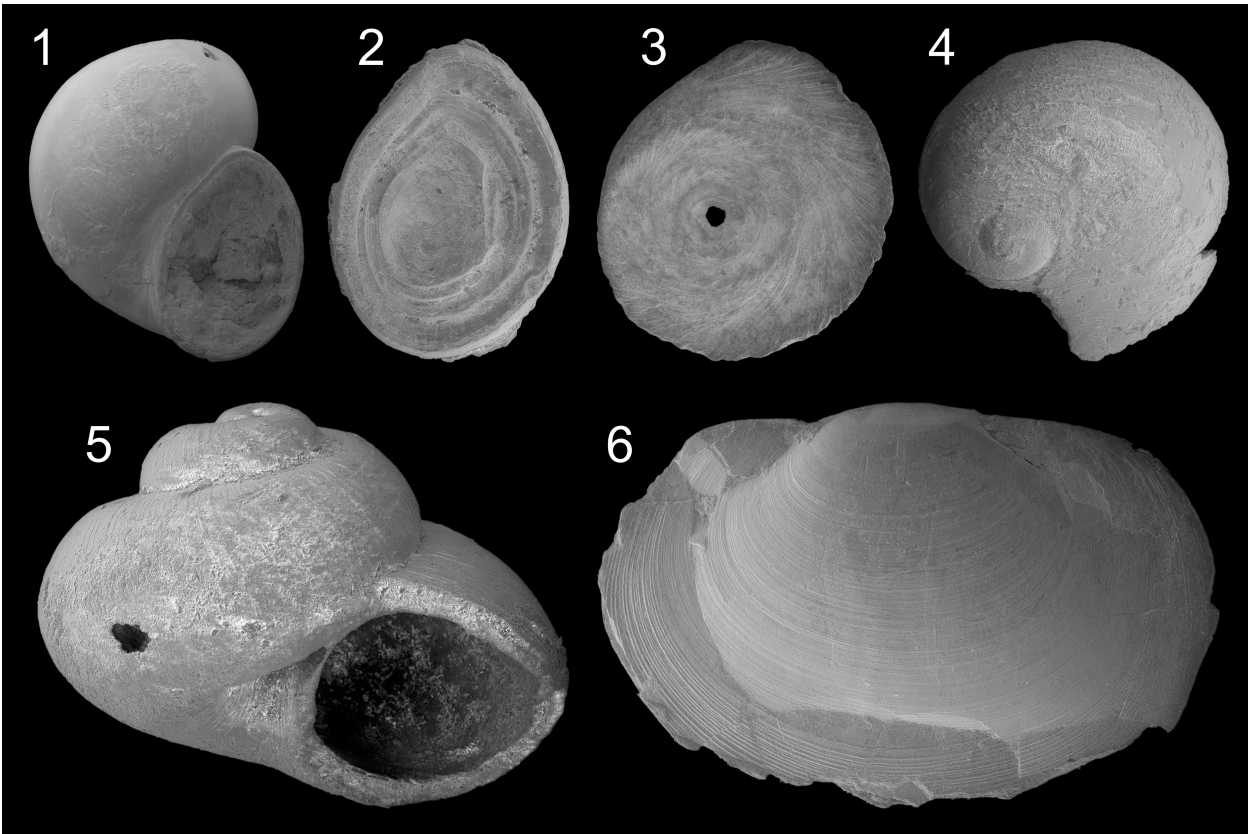
### ABSTRACT

Sandelzhausen is a rich Early/Middle Miocene (Mammal Neogene zone MN5) fossil site near Mainburg, Southern Germany. Hundreds of fossil continental mollusks, almost exclusively pulmonate snails, were recovered during the excavations, but never received due attention by researchers. Here, a taxonomical treatment of the non-pulmonate fossil mollusks from Sandelzhausen is presented, dealing with the Caenogastropoda, Neritimorpha, lower Heterobranchia and Bivalvia. The following species were found in the material: *Bithynia* sp. (Bithyniidae); *Pomati* sp. (Pomatiidae); *Theodoxus* sp. (Neritidae); *Valvata* sp. (Valvatidae); *Sphaerium* sp. (Sphaeriidae). Unfortunately, the poor preservation of the material precludes a more precise identification.

**Keywords:** Burdigalian-Langhian, MN5 European Mammal Neogene zone, Mollusca, non-pulmonate snails, Upper Freshwater Molasse.

### INTRODUCTION

The Sandelzhausen fossil site is an important continental site in Europe that has yielded thousands of specimens (MOSER *et al.* 2009a), among which there are numerous land and freshwater mollusks. Still, only two works dealt specifically with the mollusks: Gall (1972), who identified 49 gastropods and two bivalves in the material recovered, but based his work heavily on younger faunas and did not figure the specimens; and Moser *et al.* (2009b), who dealt with paleoecological questions, also presenting a very preliminary list of the species. Here is presented the taxonomic treatment of the non-pulmonate mollusks from Sandelzhausen, dealing with land and freshwater snails and bivalves. The pulmonate snails are treated elsewhere (SALVADOR 2013a, 2013b; SALVADOR & RASSER in preparation)



**Figure 1.** *Bithynia* sp., fragmentary specimen (BSPG 1959 II 17714; D = 3.7 mm). **Figure 2.** *Bithynia* sp., operculum (BSPG 1959 II 17715; h = 2.1 mm). **Figure 3.** *Pomatias* sp., operculum (BSPG 1959 II 17713; h = 8.7 mm). **Figure 4.** *Theodoxus* sp., fragmentary specimen (BSPG 1959 II 17716; D = 3.6 mm). **Figure 5.** *Valvata* sp., juvenile (BSPG 1959 II 17717; H = 1.6 mm). **Figure 6.** *Sphaerium* sp. (BSPG 1959 II 17720; L = 4.5 mm).

### GEOLOGICAL SETTING

Sandelzhausen fossil site was located in the vicinities of the city of Mainburg, 60 km north of Munich, in the Molasse Basin (Molassebecken) of southern Germany, which harbors the “formation” known as Upper Freshwater Molasse (Ober Süßwassermolasse, OSM; MOSER *et al.* 2009a). The fossils from Sandelzhausen fossils belong to a member of the OSM called Nördlicher Vollschocter, composed primarily of marl and gravel (Moser *et al.* 2009a). The age of these deposits was established by stratigraphic, biostratigraphic and magnetostratigraphic correlations: the Early/Middle Miocene Burdigalian/Langhian boundary (~16.47–16.27 Ma; MOSER *et al.* 2009a), within the early middle MN5 European Mammal Neogene zone (corresponding to the Karpatian/Badenian boundary in terms of regional Paratethys stratigraphy; HARZHAUSER & PILLER 2007).

The division into facies was established by Fahlbusch & Gall (1970) and Moser *et al.* (2009a): **Layer A:** marly gravels, sometimes cemented by carbonates; fossil content rare and limited to robust skeletal parts; **Layer B:** gravel-rich marl, in which size and number of pebbles diminish upwards, with intercalated sand horizons; origin of most macrovertebrate fossils; **Layer C:** fossil rich marl; divided in three smaller layers (C1, C2 and C3) by a black, organic rich layer (C2); **Layer D:** marl (mainly silt) with few pebbles and diffuse carbonates and carbonatic nodules; rich in fossils, many in excellent preservation state due to a less intense compaction; **Layer E:** silty clays with microvertebrate fossils; **Layer F:** laminite with alternating light and dark bands, carbonate concretions and desiccation cracks; no fossils. Fossil mollusks can be found from layer A to D.

For a more throughout description of the lithology of the site, see Moser *et al.* (2009a).

## MATERIAL AND METHODS

All the material from Sandelzhausen is housed in the collection of the Bayerische Staatssammlung für Paläontologie und Geologie (BSPG; Munich, Germany) under the record number BSPG 1959 II. All available material was examined in the present work; a list of the analyzed material can be found on the species descriptions below. A portion of the material has data on the layer of origin, but the remaining either cannot be safely attributed to the layers or completely lack stratigraphical data (including the sample labeled as “Grube Bergmaier”, or “pit Bergmaier” in English); for more information on this, refer to Salvador (2013a). As such, only the samples that can correctly be attributed to layers are used here to determine the stratigraphical range of the species. Moreover, here is also presented the previous identification of the material given by Gall (1972) and Moser *et al.* (2009b) in order to facilitate the correlation of the material for future workers.

Specimens in a good state of preservation were measured either with a digital caliper or with the aid of computer software. Selected specimens were examined by scanning electron microscopy (SEM) in the Staatliches Museum für Naturkunde Stuttgart (SMNS; Stuttgart, Germany). Shell measurements abbreviations: H = shell height; D = shell greatest width; h = aperture/operculum height; d = aperture/operculum width; L = shell length.

Unfortunately, part of the material described by Gall (1972) and Moser *et al.* (2009b) could not be found at the BSPG collection: *Pisidium* sp. (GALL 1972: Nr. 2; MOSER *et al.* 2009b: Nr. 69) and Unionidae gen. indet. sp. nov. (MOSER *et al.* 2009b: Nr. 67). Moser *et al.* (2009b) argued correctly that the specimen they analyzed and described (their fig. 9a) would be a new species, although the genus assignment remained doubtful. However, the only material present at the BSPG collection was the fragments of the left valve (BSPG 1959 II 12303; MOSER *et al.* 2009b: fig. 9b).

## SYSTEMATICS

### Gastropoda

### Caenogastropoda

### Family Bithyniidae

### Genus *Bithynia* Leach, 1818

### *Bithynia* sp.

(Figures 1–2)

**Material examined:** BSPG 1959 II 17714 (1 shell), 17715 (13 opercula).

**Stratigraphic occurrence:** The shell fragment comes from the Grube Bergmaier site, while the opercula lack stratigraphical data; nevertheless, Moser *et al.* (2009b) indicate Layers C2, C3 or D.

**Description:** Shell small. Teleoconch smooth. Whorl profile convex. Aperture oval, elongated, pointed at the upper portion. Peristome simple. Umbilicus imperforate. Operculum with concentric growth pattern.

**Measures (in mm):** BSPG 1959 II 17714 (incomplete specimen): D = 3.7; h = 2.9; d = 1.9.

**Previous identification of the material:** Gall (1972: Nr. 48 and 49): respectively, *Bithynia glabra glabra* (von Zieten) and *Bithynia* sp. Moser *et al.* (2009b: Nr. 5): *Bithynia* sp.

**Discussion:** Only a single shell fragment (and many opercula) is present in the material from Sandelzhausen. The whorl and aperture profile indicates the genus *Bithynia*. However, it is not possible to proceed further than genus level in the identification, since: (1) there seems to be some degree of morphological variation in each species; and (2) diagnostic features include not only aperture and body whorl but also suture, apex and shell profile, features not preserved in the present specimen. Recent *Bithynia* species live in richly vegetated slow moving or standing waters, some are also found in temporary water bodies (WELTER-SCHULTES 2012).

### Family Pomatiidae

Genus *Pomatias* Studer, 1789

*Pomatias* sp.

(Figure 3)

**Material examined:** BSPG 1959 II 17713 (1operculum).

**Stratigraphic occurrence:** The material lacks stratigraphical data, but Moser *et al.* (2009b) indicate either Layer B or C1.

**Measures (in mm):** operculum, h = 8.7, d = 7.7.

**Previous identification of the material:** Gall (1972: Nr. 47): *Pomatias* sp. Moser *et al.* (2009b: Nr. 4): *Pomatias* sp.

**Discussion:** Only a single operculum was found in the material from Sandelzhausen. It belongs to the genus *Pomatias*, but further identification is not possible. Nevertheless, by its large size and number of whorls, this operculum likely belongs to *P. consorbina* (Sandberger, 1874), the largest species known from the German Middle Miocene, as already remarked by Gall (1972). Recent species live in forests or shrublands, with humid soil where they can burrow (WELTER-SCHULTES 2012).

### Neritimorpha

Family Neritidae

Genus *Theodoxus* Montfort, 1810

*Theodoxus* sp.

(Figure 4)

**Material examined:** BSPG 1959 II 17716 (1 shell).

**Stratigraphic occurrence:** The material lacks stratigraphical data, but Moser *et al.* (2009b) indicate Layer D.

**Description:** Shell small, with quickly growing whorls. Protoconch (~1 whorl) smooth, dome-shaped; transition to teleoconch clear. Teleoconch sculptured by well-marked axial ripples. Suture shallow, but well-marked. Whorls profile convex.

**Measures (in mm):** incomplete specimen, H = 3.7, D = 3.6.

**Previous identification of the material:** Gall (1972: Nr. 51): *Theodoxus* sp. Moser *et al.* (2009b: Nr. 2): *Theodoxus* sp.

**Discussion:** The fragmentary nature of the single specimen found in Sandelzhausen precludes identification beyond genus level. The habitat range of recent *Theodoxus* species is very variable, so its use for paleoecological inferences is very limited; nevertheless, all species seem to prefer rocky substrates on water depths of circa 5 m and are intolerable to drought (WELTER-SCHULTES 2012).

## Heterobranchia

Family Valvatidae

Genus *Valvata* O.F. Müller, 1773

*Valvata* sp.

(Figure 5)

**Material examined:** BSPG 1959 II 17717 (1 shell).

**Stratigraphic occurrence:** The material lacks stratigraphical data, but Moser *et al.* (2009b) indicate either Layer C2 or C3.

**Description:** Shell small. Protoconch (~1 whorl) rounded, sculptured by numerous fine spiral striae for ca.  $\frac{3}{4}$  whorl and then interdigitating with the teleoconch sculpture for another  $\frac{1}{4}$  whorl; transition to teleoconch clear. Teleoconch sculptured by numerous prosocline parallel fine axial striae. Suture deep, well-marked. Whorls profile convex. Aperture rounded.

**Measures (in mm):** BSPG 1959 II 17717 (juvenile specimen): H = 1.6, D = 1.9.

**Previous identification of the material:** Gall (1972: Nr. 50): *Valvata* (*Cincinna*) cf. *radiatula radiatula* Sandberger. Moser *et al.* (2009b: Nr. 7): *Valvata* (*Cincinna*) sp.

**Discussion:** Since only the early whorls are preserved, a more precise identification of this material is not possible. The overall shell shape and protoconch size and sculpture pattern are consistent with the genus *Valvata* (BINDER 1967; RIEDEL 1993). Regarding the previous identification, however,

it should be noted that the name *Cincinna* Hübner, 1810 was considered invalid by Welter-Schultes (2012), since it was never published and does not comply with the ICZN. The habitats of recent *Valvata* species are highly variable and thus its use for paleoecological inferences is limited; nevertheless, they usually inhabit lakes, from shallow to very deep waters, and some can live in temporary water bodies, enduring periods of drought (WELTER-SCHULTES 2012).

## **Bivalvia**

### **Heterodonta**

#### Family Sphaeriidae

Genus *Sphaerium* Scopoli, 1777

*Sphaerium* sp.

(Figure 6)

**Material examined:** BSPG 1959 II 17720 (2 complete shells), 17721 (4 complete shells and 1 valve fragment).

**Stratigraphic occurrence:** BSPG 1959 II 17721 specimens come from the Grube Bergmaier site, while the others lack stratigraphical data; nevertheless, Moser *et al.* (2009b) indicate Layers B or C.

**Description:** Shell small, elliptical, with fine well-marked concentric ribs; moderately bulbous; shell height  $\sim 2/3$  shell length. Umbo central; anterior and posterior regions of shell roughly the same size. Prodissoconch apparently smooth.

**Measures (in mm):** BSPG 1959 II 17720 (deformed specimen): H = 2.9, L = 4.5.

**Previous identification of the material:** Gall (1972: Nr. 1): *Sphaerium* sp. Moser *et al.* (2009b: Nr. 68): *Sphaerium* sp.

**Discussion:** Most specimens are juveniles and the preservation of the single adult specimen is very poor, with the valves flattened together and the umbonal region much deformed. The hinge also cannot be examined and thus identification beyond genus level is not possible. The overall shell shape and size conforms well to European recent and fossil *Sphaerium* species. *Sphaerium* is well known from the Miocene of Central Europe and material similar to the specimens from Sandelzhausen have often been identified as recent species such as *S. rivicola* (Lamarck, 1818) (*e.g.*, LUEGER 1979; SCHNEIDER & PRIETO 2011; from the Late and Middle/Late Miocene, respectively). Recent *Sphaerium* inhabits a broad range of habitats and thus offer very limited paleoecological information (WELTER-SCHULTES 2012).

## **DISCUSSION**

Among freshwater snails, the non-pulmonates tend to be less diverse than the pulmonates in geologically short-lived water bodies, tending to be more diverse and abundant in deeper and/or



faster moving perennial waters (DILLON 2000; WELTER-SCHULTES 2012). This last case is especially true in many Neogene fossil lakes of Central Europe (*e.g.*, HARZHAUSER & MANDIC 2008; NEUBAUER *et al.* 2013). In Sandelzhausen, the non-pulmonates snails (and bivalves) are represented by a very fragmentary material, being strikingly few in number, especially when compared to the richness of freshwater pulmonate taxa (MOSER *et al.* 2009b; SALVADOR & RASSER in preparation). Sandelzhausen, for most of the duration where mollusks occur, was a temporary water body, turning into a perennial but shallow lake only towards the end of Layer D1 (BÖHME 2009; TÜTKEN & VENNEMANN 2009). However, most (if not all) of the species here seem to occur in layers other than D1. As such, they could represent unsuccessful colonization of the lake or incidental transport into the lake sediment from neighboring regions. The exception would perhaps be *Bythinia*, since recent species live in slow moving or standing waters, sometimes temporary (WELTER-SCHULTES 2012). A more elaborated paleoecological and paleoenvironmental treatment of the entire molluscan fauna from Sandelzhausen is currently being conducted and will be presented in a future work.

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