MIOCENE LAND SNAILS FROM BEŁCHATÓW (CENTRAL POLAND). IV: PUPILLOIDEA (GASTROPODA PULMONATA). SYSTEMATIC, BIOSTRATIGRAPHIC AND PALAEOECOLOGICAL STUDIES

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ABSTRACT: Twenty five species of Pupilloidea of 10 genera have been found in the Miocene brown coal deposits of the open-cast mine Bełchatów. Four genera: Gastrocopta, Strobilops, Nesopupa and Negulus became extinct in Europe before the first major glaciation. Another one – Planogyra – is now represented by one extant species in southern Europe only. Three malacofauna-bearing horizons: Be³-C, Be³-B and Be³-A are correlated with biozones MN 4, MN 5 and MN 9, respectively. Analysis of ecological requirements of extant pupilloid snails, particularly of the taxa extinct in Europe and found in the Bełchatów mine, combined with palaeobotanical data, provide some palaeoecological and palaeoclimatic cues. Stratigraphic significance of some pupilloid species is discussed. A new combination, Nesopupa minor (Boettger, 1870), is proposed.

KEY WORDS: Pupilloidea, Miocene, Bełchatów, Poland, systematics, biostratigraphy, palaeoecology

INTRODUCTION

Pupilloidea underwent the most spectacular changes during the Neogene, resulting in extinction in Europe of some genera, which today have representatives in remote regions of the world. Twenty five species of Pupilloidea of 10 genera have been identified in the Miocene deposits of the Bełchatów brown coal mine. Of these, four genera, namely Gastrocopta, Strobilops, Nesopupa and Negulus, became extinct in Europe before the first major glaciation. Another genus, Planogyra, is now represented in Europe by only one extant species; its occurrence is limited to the western parts of the Balkan Peninsula and Italy (GITTENBERGER 1972). Apart from Pupilloidea, land Prosobranchia (STWORZEWICZ 1995, STWORZEWICZ & SOŁTYS 1996), Carychiinae (STWORZEWICZ in press), one species of Helicodiscus (STWORZEWICZ & PRISYAZHNYUK 1997) and other representatives of Endodontidae, Clausiliidae, Subulinidae, Vitrinidae, Zonitidae and Helicidae have been found. Freshwater gastropods and bivalves have been dealt with by PIECHOCKI (1997).

The brown coal mine Belchatów (51°15’N, 19°20’E) is one of the largest open-cast mines in Central Europe. The thickness of the brown coal deposits reaches ca. 60 m (locally 250 m). According to the lithostratigraphic scheme of the Tertiary deposits in the Belchatów basin (cf. STWORZEWICZ & SZYNKIEWICZ 1989, STUCHLIK & SZYNKIEWICZ 1998) lacustrine limestones with molluscan and mammalian remains were found in the coal unit W – in the upper part of the main coal seam (Bel-C) and above xylitic brown coal seam B (Bel-B), as well as in the mid part of clayey-coal unit I-W consisting of clays and small xylitic-clayey coal layers with lacustrine limestone intercalations (Bel-A) (Fig. 1). Within the Neogene sequence, exposed in the Belchatów mine escarpments, there are several tuffitic intercalations that enable dating. Zircons extracted from two of them yielded...
fission-track ages of 18.1±1.7 My and 16.5±1.3 My (BURCHART et al. 1988). These dates suggest that the part of the sediment was deposited between the Upper Eggenburgian and the Mid Badenian. One more tephra layer has been lately sampled for subsequent radiometric dating.

Based on mammalian remains (KOWALSKI 1993a, b, KOWALSKI & KUBIAK 1993), the three fauna-bearing horizons: Bel-C, Bel-B and Bel-A have been correlated with MAIN’s biozones MN 4, MN 5/6 and MN 9, respectively. However, taking into account the above fission-track dates, it is more probable that horizons Bel-B and Bel-C are somewhat older: Bel-B should rather be correlated with MN 5 and Bel-C with MN 3/4 or even MN 5 (SZYNKIEWICZ pers. com.). The Lower and Mid Miocene age of the deposits was also confirmed by pollen and leaf flora analyses (STUCHLIK et al. 1990, WOROBIEC 1995, STUCHLIK & SZYNKIEWICZ 1998). Due to the continuous exploitation of the coal bed, two upper fauna-bearing horizons (Bel-A and Bel-B) have been covered with an overlay and their further palaeontological examination is impossible, whereas the lowermost horizon Bel-C is still regularly sampled.

The material collected hitherto in Belchatów provides an exceptional opportunity to study the changes of malacofauna during almost ten million years.

Specimens of land snails from Belchatów are stored at the Institute of Systematics and Evolution of Animals, Polish Academy of Sciences, Cracow, under catalogue numbers given in the text.

The following abbreviations of the museum collections have been used in the text:

- **BSP** – Bayerische Staatssammlung für Paläontologie und Historische Geologie (Munich)
- **IGS** – Institute of Geological Sciences (Kiev)
- **ISEA PAS** – Institute of Systematics and Evolution of Animals, Polish Academy of Sciences (Cracow)

The following abbreviations of the museum collections have been used in the text:

**Beł** – Belchatów

**MN** – Miocene Neogene Mammalian Zone

**Q** – Quaternary

**PG** – Polanka Górska

**TS** – Tephrasubdivision

**W** – Wieliczka

**PW** – Pieskowa Skała

**1-17** – consecutive levels

Fig. 1. Lithostratigraphic scheme of the Tertiary brown coal deposits of the open-cast mine Belchatów and correlation of the malacofauna-bearing horizons: 1 – erosion border of the Tertiary and Quaternary (Q) deposits, 2 – sands, 3 – coalized sands with plant detritus, 4 – clayey sands, 5 – peat, 6 – clays, 7 – coalized clays, 8 – sapropelic coals, 9 – xylite-sapropelic brown coals with clay, 10 – xylite brown coals, 11 – bituminous-pyropissite brown coals, 12 – lacustrine limestones, 13 – weathered Mesozoic rocks with silica or ferruginous cement, 14 – silicated sands or quartzitic sandstones, 15 – kaolinitized volcanic tuff (paratonstein), 16 – distinct erosion borders and discordance, 17 – range of palaeontological profiles with continental mammals and malacofauna (Beł-A, Beł-B, Beł-C – profile numbers, MN 4, MN 5, MN 9 – continental Neogene Mammalian zone number) (according to STWORZEWICZ & SZYNKIEWICZ 1989 and STUCHLIK & SZYNKIEWICZ 1998).
MAFI – Magyar Állami Földtani Intézet (Hungarian Geological Survey – Budapest)
MH – Muséum d’Histoire Naturelle (Toulouse)
MNHN – Muséum National d’Histoire Naturelle (Paris)
NHML – The Natural History Museum (London)
NMP – Narodni Muzeum (Prague)
NMNH – Muséum National d’Histoire Naturelle (Paris)
SMF – Senckenberg Museum (Frankfurt/Main).

SYSTEMATIC REVIEW

Family: Pupillidae Turton, 1831
Genus: Arguna Cossmann, 1889

Argna oppoliensis (Andreae, 1902)

Figs 2–5

1902 Coryna oppoliensis ANDREAE: 16, Fig. 8a.
1902 Coryna oppoliensis var. turrita ANDREAE: 16, Fig. 8b.
1976 Arguna oppoliensis – SCHLICKUM: 10, Pl. 2: Fig. 28.

Material examined: Belchatów: Bel-B – 8 specimens MI/990/98, 2 specimens MI/991/98 with damaged aperture, 33 damaged specimens without aperture MI/992/98; Opole (Astaracian, MN 7+8) – 1987/43/1 (NMW), 152511/2 (SMF), 1954 XV/1 and 1966 XXVI (BSP).

Measurements of 8 adult shells from Belchatów and one from Opole:

<table>
<thead>
<tr>
<th></th>
<th>H</th>
<th>W</th>
<th>h</th>
<th>w</th>
<th>H</th>
<th>Number of whorls</th>
<th>H/W ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bel-B</td>
<td>2.59</td>
<td>1.15</td>
<td>0.94</td>
<td>0.76</td>
<td>1.45</td>
<td>6.0</td>
<td>2.25</td>
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<tr>
<td></td>
<td>2.80</td>
<td>1.19</td>
<td>1.02</td>
<td>0.78</td>
<td>1.55</td>
<td>6.0</td>
<td>2.35</td>
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<tr>
<td></td>
<td>2.80</td>
<td>1.12</td>
<td>1.03</td>
<td>0.79</td>
<td>1.55</td>
<td>6.0</td>
<td>2.50</td>
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<tr>
<td></td>
<td>2.82</td>
<td>1.15</td>
<td>1.02</td>
<td>0.71</td>
<td>1.53</td>
<td>6.0</td>
<td>2.45</td>
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<tr>
<td></td>
<td>2.83</td>
<td>1.14</td>
<td>0.99</td>
<td>0.72</td>
<td>1.59</td>
<td>6.0</td>
<td>2.48</td>
</tr>
<tr>
<td></td>
<td>2.86</td>
<td>1.16</td>
<td>1.01</td>
<td>0.80</td>
<td>1.51</td>
<td>6.0</td>
<td>2.46</td>
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<tr>
<td></td>
<td>3.08</td>
<td>1.23</td>
<td>1.09</td>
<td>0.73</td>
<td>1.60</td>
<td>6.5</td>
<td>2.50</td>
</tr>
<tr>
<td></td>
<td>3.29</td>
<td>1.15</td>
<td>0.92</td>
<td>0.75</td>
<td>1.54</td>
<td>7.0</td>
<td>2.86</td>
</tr>
<tr>
<td>Opole</td>
<td>2.70</td>
<td>1.04</td>
<td>0.90</td>
<td>0.67</td>
<td>1.54</td>
<td>6.0</td>
<td>2.59</td>
</tr>
</tbody>
</table>

Comparative remarks: Specimens from Belchatów vary in the height of whorls and in the general shape of their shells which is cylindrical or claviform, whereas their aperture shape and apertural barriers are only slightly variable. They were referred to A. oppoliensis, but the systematic position of the species and its description by ANDREAE (1902) require a comment. Neither ANDREAE nor subsequent authors took into consideration all of the apertural barriers that are actually present in this species. A close examination of over a dozen specimens of A. oppoliensis from Opole (ex coll. BSP, NMW and SMF) and those from Belchatów indicates that, besides one parietal, one columellar and two palatal lamellate teeth (noted by ANDREAE 1902) there are very often two small, short-lamellate or knob-shaped additional barriers: supraparietal (spiralis) and infracolumellar teeth, located deep inside the aperture, hardly visible in a direct front view, and a rudimentary basal tooth situated at a distance from the aperture margin, often missing (Fig. 4). Two of the specimens from Belchatów have also a rudimentary suprapalatal tooth. This type of apertural barriers makes A. oppoliensis similar to recent A. biplicata (Michaud, 1831), and particularly to A. biplicata excessiva (Gredler, 1856) and to A. bielzi (Rossmüssler, 1859). However, the shells of the fossil species are nearly by half smaller than those of the latter two and they have fewer whorls (by 3–4). Besides, in recent A. bielzi there is a distinct callus between the apertural margin and the palatal teeth, but there is no trace of small knob-shaped surface tooth (sensu SHILEYKO 1984) on the palatal margin, the tooth being rather well visible in most specimens of A. oppoliensis from Opole (Fig. 5) and less distinct (looking like a convexity rather than a tooth) in the shells of ANDREAE’S (1902) var. turrita and in specimens from Belchatów (Fig. 3). The shell surface of A. oppoliensis is very weakly and rather irregularly striated or nearly smooth, similar to that of A. biplicata, whereas A. bielzi differs from both in having its surface sculpture composed of regular, rib-like striae. Nevertheless, A. oppoliensis can be undoubtedly regarded as an ancestor of the mentioned living species.

Examination of almost two hundred shells of A. bielzi from a valley in the Tatra Mts (W Carpathian Mts, coll. ISEA PAS) revealed a great variability in the shell shape, number of whorls and their convexity, as
well as in the position and degree of development of palatal teeth. This induced me to regard some forms of *Argna* known from Miocene and Pliocene as con-specific.

Figs 2–5. *Argna oppolensis* (Andreae): 2 – specimen from Belchatów, front view, H = 2.72 mm; 3 – aperture with some teeth visible (lower palatal weakly developed), 100×; 4 – aperture with palatal wall broken, all teeth visible; 5 – aperture of specimen from Opole (lower palatal tooth strongly developed), 100×
According to ANDREAE (1902) the shells of *A. oppolensis* var. *turrita* are higher (3.5 mm) than those of *A. oppolensis* (2.5–3 mm) and have a higher number of whorls (7 instead of 5–6), while such a variability range is a normal phenomenon in *A. bielzi*, even within one population. Among the specimens from Belchatów there are also some with higher shells (above 3 mm) and a higher number of whorls (6.5–7). Hence, in my opinion ANDREAE’S (1902) var. *turrita* (treated as a subspecies by subsequent authors) should not be regarded as a separate form on subspecific level, but as a morphotype at most.

In the light of the above facts, the systematic distinction of *A. suemeghyi* (Bartha, 1956) and *A. reyi* Schlickum, 1978 also seems to be questionable. Disregarding the overlapping shell shape and the number of whorls of all the mentioned forms/species, the only clear difference between *A. oppolensis* from Belchatów on one hand and *A. oppolensis* from Opole and *A. suemeghyi* from Tab (ex coll. MAFI No. Pl. 116) on the other, is a weakly or strongly developed lower palatal tooth (Figs 3, 5). However, both such a variability of palatal teeth and the presence of a more or less distinct surface tooth are characteristic of *A. biplicata* (PILSBRY 1922–1926).

*A. reyi* was described on the basis of one specimen only, and its similarity to *A. oppolensis* is so close that its specific distinctness is rather questionable.

Finding *A. oppolensis* in the mid horizon (Bel-B) of the Belchatów mine shifts the stratigraphic range of this species to the Lower/Mid Miocene limit and thus it is the oldest known trace of *Argna* in the Neogene.

Family: Vertiginidae Fitzinger, 1833
Genus: Vertigo O. F. Müller, 1774
Subgenus: Vertigo s. str.

**Vertigo callosa** (Reuss, 1849)

Figs 6–7

1849 *Pupa callosa* REUSS: 30, Pl. 3: Fig. 7.
1858 *Pupa* (*Vertigo*) *allooeodus* SANDBERGER: 58, Pl. 35: Fig. 10.
1860 *Pupa callosa* – REUSS: 72, Pl. 2: Figs 6–7.
1914 *Vertigo* (*Alaea*) *callosa* – FISCHER & WENZ: 99, Pl. 6: Fig. 23.
1923 *Vertigo* (*Vertigo*) *callosa allooeodus* – WENZ: 984.
1998 *Vertigo* (*Vertigo*) *callosa* – FINGER: 18, Pl. 9: Figs A, B, C.

**Material examined:** Belchatów: Bel-B – 58 specimens MI/993/98; Wiesbaden (Agenian, MN 2) – 31A/40 (BMNH); Frankfurt a. M.: Corbiculatohen (Lower Miocene, MN 2b) – 31A/30 (NHML); Tuchóřice (Orleanian, MN 3) – 1196 (NMP), 1966 XXVI (BSP), 1909.7.77 (NMW), 31A/40 (BMNH), 1390 (MAFI); Ocs (Vallesian, MN 10) – Pl. 197, 374, 393 (MAFI); Varpalota (Turolian) – Pl. 627, 658, 808, 856 (MAFI); Ciscaucasia (Sarmatian) – 1872/265-268 (PIM).

**Measurements** of 30 specimens from Belchatów;
shell: *H* = 1.72–2.30, *W* = 1.11–1.48; aperture: *h* = 0.61–0.80, *w* = 0.64–0.83; *H* of body whorl = 1.06–1.35; number of whorls: 4.5–5.5.

**Comparative remarks:** Shells of *V. callosa* from Belchatów are very variable in their size and shape – from ovate to tapering ovate. Poorly convex whorls separated by a rather shallow suture are covered with very weak and irregular striae. The umbilicus is deep, open but very narrow. A distinctly heart-shaped aperture has a deep incision at the level of the upper palatal tooth. On the outer surface of the palatal wall there is usually a weakly developed crest and two or more less visible depressions corresponding in position to the two palatal teeth.

Out of 58 specimens having 6 teeth, 13 had an additional vestigial suprapalatal tooth and only one specimen had a small tubercular infraparietal tooth. Because of all the above mentioned characters, the specimens from Belchatów are the most similar to the typical form of the species known from Tuchóřice and to the form described as *V. allooeodus* (Sandberger, 1858) [= *V. callosa allooeodus sensu Wenz*].

*V. callosa* is one of the commonest vertiginid snails in the European Neogene, the most variable (cf. BOETTGER 1889, WENZ 1923, STEKLOV 1966) and widespread. Several forms were described, starting with the Upper Oligocene, with five, six and more teeth and some of them were later regarded as subspecies or even separate species; WENZ (1923) listed as many as six subspecies of *V. callosa* from one locality – Steinheim am Albuch! However, it is necessary to take into account that most of those forms were described on the basis of very scanty material, in some cases single specimens only, so intraspecific variability was not known. Examination of a large series of recent *V. antivertigo* (Draparnaud, 1801) from one locality has shown that even intrapopulation variability of the species is conspicuous. In the light of recent knowledge (POKRYSZKO 1990), some shell characters of the vertiginids, e.g. number of teeth, vary considerably not only between but also within populations.

From among extant vertiginids, *V. antivertigo* and North American *V. ovata* Say, 1822 were considered to be the closest related to *V. callosa*. STEKLOV (1966: 145) regarded the latter species even as a subspecies of *V. antivertigo*. On the other hand, BOETTGER (1889: 311) proposed a phyletic lineage starting with forms of *V. callosa* and leading to the recent *V. antivertigo*.

In my opinion *V. antivertigo* differs significantly from *V. callosa* in the position of angular tooth which...
in the latter species is located high (closer to the pari-
etal callus margin) and short – its inner end only very slightly overlaps with the outer end of the parietal tooth (Fig. 7). Besides, the short lamellate columnellar tooth in *V. callosa* is moderately developed and subhorizontal whereas in *V. antivertigo* it is larger and more or less ascending inward. Moreover, the umbilicus in *V. callosa*, being somewhat narrow, is always open.

It seems probable that *V. callosa* became extinct not leaving any direct descendant, and a more likely ancestor for *V. antivertigo* is *V. diversidens*.

**Vertigo diversidens** (Sandberger, 1874)

Fig. 8

1874 *Pupa* (Vertigo) *diversidens* SANDBERGER: 549, Pl. 29: Fig. 23.
1919 *Vertigo (Alaea) callosa diversidens* – GOTTSCHE & WENZ: 15, Pl. 1: Fig. 31.
1919 *Vertigo (Alaea) callosa steinheimensis* GOTTSCHE & WENZ: 15, Pl. 1: Figs 32–33.
1919 *Vertigo (Alaea) callosa perarmata* GOTTSCHE & WENZ: 15, Pl. 1: Figs 34–35.
1998 *Vertigo callosa steinheimensis* – FINGER: 44, Pl. 9: Fig. D.
1998 *Vertigo callosa diversidens* – FINGER: 44, Pl. 9: Fig. E.
1998 *Vertigo callosa perarmata* – FINGER: 44, Pl. 9: Fig. F.

**Material examined:** Belchatów: Bel-B – 12 specimens MI/994/98; Sansan (Astaracian, MN 6) – 3 specimens B 30057 and 30 B 30053 (MNHN).

**Measurements** of 12 specimens from Belchatów; shell: $H = 1.57–2.04$, $W = 1.06–1.23$; aperture: $h = 0.58–0.80$, $w = 0.58–0.75$; $H$ of body whorl = 1–1.23; number of whorls: 4.25–5.25.

**Comparative remarks:** A comparison of specimens from Belchatów with *V. diversidens* from the type locality (Sansan) has revealed no significant differences. The shells from both localities are very similar in their outline, size, surface sculpture of whorls, shape of aperture and in having rather strongly developed crest and two depressions corresponding to the palatal teeth on the outer surface of the palatal wall. Their apertural barriers: columnellar, basal, parietal, angular, lower and upper palatal and suprapalatal (more often present) are essentially also similar, but the other secondary teeth (infraparietal and infrapalatal) in the specimens from Belchatów are more frequent. The number of
teeth seems to be the only difference between the forms described by GOTTSCHEICK & WENZ (1919).

A conspicuous character of *V. diversidens* is the position and degree of development of parietal and angu-
lar teeth. The lamellate parietal tooth is more or less arcuate in top view. Its outer end only slightly overlaps with the inner end of angular tooth which is much shorter and thinner. Both these teeth are often distinctly divergent. Besides, the angular is situated very high (closer to parietal margin of aperture, like in V. callosa) and, in combination with the very solid upper palatal tooth and the incision of palatal margin of aperture, results in an almost circular sutureus (called "kleblattförmig Mündung" by BOETTGER 1889, GOTTSCICK & WENZ 1919 and others). This character is unknown among recent vertiginid snails in Europe.

Because of the shell shape and size, very convex whorls and the suture deeper than in V. callosa, surface sculpture of very weak and irregular, poorly visible striae and as a rule more than 6 teeth (7–9, only exceptionally 6), V. diversidens seems to be closer to V. antivertigo than V. callosa, as was thought before.

The oldest fossil record of V. diversidens is that from Belchatów (Bel-B), but a very similar species – V. kochi – was described by BOETTGER (1889) from Upper Oligocene deposits in Hochheim; however, BOETTGER’s specimens which I have examined (SMF N° 152150/5) did not conform to his description (1889: 304). Two successive findings of V. diversidens come from Sansan (MN 6) and Steinheim (MN 7). PRISYAZHNYUK (in: GOZHIK & PRISYAZHNYUK 1978) listed some findings of V. (Vertigo) antivertigo callosa from the Upper Miocene of Ukraine and Ciscaucasia, but emphasized that there were two forms of the sub-species. Judging from PRISYAZHNYUK’S (1978) descriptions and figures it seems likely that the author had among his materials both V. callosa and V. diversidens.

Vertigo protracta (Sandberger, 1874)

**Fig. 9**

1874 *Pupa protracta* SANDBERGER: 400.

1889 *Vertigo (Alaea) protracta* – BOETTGER: 300, Pl. 7: Fig. 5.

1919 *Vertigo (Alaea) protracta suevica* GOTTSCICK & WENZ: 21, Pl. 1: Figs 40–41.

1973 *Vertigo (Vertigo) protracta* – PRISYAZHNYUK: 67, Pl. 2: Fig. 9.

1998 *Vertigo protracta* – FINGER: 44, Pl. 9: Fig. I.

**Material examined:** Belchatów: Bel-B – 6 specimens MI/997/98; Hochheim (Upper Oligocene) – 152192/2 (SMF); 1966 XXVI (BSP); Steinheim (Astartacian, MN 7) – specimens 1953 XXXVII (BSP, as V. suevica Gott. et Wenz); Bogdanowski Karier (Ukraine) and Goyani (Moldavia) (both Mid Sarmatian) – ex. coll. IGS; Eichkogel (Turolian, MN 11) – 2 specimens (NMW).

**Measurements** of specimens from Belchatów; shell: H = 1.50–1.68, W = 1.03–1.08; aperture: h = 0.55–0.60, w = 0.52–0.56; H of body whorl = 0.95–1.08; number of whorls: 4.5–5.

**Comparative remarks:** There are no distinct differences in shell characters between the specimens from Belchatów and those from other localities. BOETTGER (1889) considered the smaller size and the lack of basal tooth as main characters to distinguish *V. protracta* from *V. callosa*. However, some of the examined specimens have a small convexity or even a clearly visible knob in place of basal tooth. In my opinion *V. protracta* differs from *V. callosa* in several other important characters, apart from the smaller size: 1 – position of angular tooth; contrary to the latter species, in *V. protracta* the outer end of angular tooth is situate in line with the outer end of parietal tooth (i.e. angular is not displaced towards aperture margin) and they are parallel, 2 – aperture is rounded-triangular rather than heart-shaped, with no distinct palatal incision, 3 – upper palatal tooth is situated deeper inside the body whorl, 4 – shape is ovate but more or less elongated.

The differences between *V. protracta* and *V. protracta suevica* – the form described by GOTTSCICK & WENZ (1919) from Steinheim – do not justify their separation. Although BOETTGER (1889), in his complement to SANDBERGER’S (1874) very cursory description, noted that *V. protracta* from Hochheim (focus typicus) had always 5 teeth (basal tooth absent), the specimens from his collection, stored at the Senckenberg Museum, have a distinctly visible basal tooth. On the other hand, LUEGER (1981) noted “5–6 Zähne, angedeutetes Basalzähnchen kann fehlen” in *V. protracta suevica*.

*V. protracta* is known from several localities since the Upper Oligocene to the Upper Miocene, but everywhere is rather rare.

Vertigo sp.

**Fig. 10**

**Material examined:** Belchatów: Bel-B – 6 specimens MI/997/98.

**Comparative remarks:** Six shells from horizon Bel-B are similar in outline to *V. protracta* but somewhat bigger (H = 1.85–2.05 mm), with somewhat heart-shaped apertures and, most of all, with very distinctly striated whorls. They are tentatively called *Vertigo* sp. since they are not comparable with any known member of the genus. Such specimens are also kept in the collection from Opole stored in the Bayerische Staatsammlung in Munich, labelled as V. cf. *callosa*.

Vertigo ovatula (Sandberger, 1874)

**Figs 11–13**

1874 *Pupa ovatula* SANDBERGER: 400.
1884 *Vertigo (Alaea) ovatula* Sandb. var. *miliiformis*  
BOETTGER: 270, Pl. 4: Figs 9a–c.

1889 *Vertigo (Alaea) ovatula* – BOETTGER: 301, Pl. 7:  
Figs 6–8.

1914 *Vertigo (Alaea) ovatula* – FISCHER & WENZ: 101,  
Pl. 6: Fig. 25.

1914 *Vertigo (Alaea) trolli* WENZ: 102, Pl. 7: Fig. 27.


Figs 11–13. *Vertigo ovatula* (Sandberger): 11 – shell, front view, $H = 1.45$ mm; 12 – a more inflated specimen, front view, $H = 1.4$ mm; 13 – aperture with spoon-like lower palatal tooth, $110\times$.
1966 *Vertigo (Vertigo) ovatula* – STEKLOV: 144, Fig. 50 and Pl. 3: Fig. 54.

**Material examined:** Belchatów: Bel-C – 9 specimens MI/998/98 + 8 fragments with aperture MI/999/98; Hochheim (Upper Oligocene) – 152162/~/ (SMF); Budenheim (MN 2) – 152166/1 (SMF); Frankfurt a. M.: Corbiculascichten (Lower Miocene, MN 2b) as *V. ovatula miliformis* Boettger – 152167/1 labelled as “Typus”) and 152170/3 (SMF); Opole (Astaracian, MN 7+8) as *V. ovatula trolli* Wenz – 152175/2 and 152176/7 (SMF), as *V. trolli* Wenz – 274198/9 (SMF); Dniepropietrovsk Oblast (Lower Sarmatian) – 1872/261–264 (PIM).

**Measurements** of specimens from Belchatów: shell: H = 1.27–1.43, W = 0.85–0.90; aperture: h = 0.47–0.53, w = 0.48–0.54; H of body whorl = 0.81–0.89; number of whorls: 4.5–4.8.

**Comparative remarks:** Specimens from Belchatów correspond very well to those from Ukraine, Opole and Frankfurt a. M., but particularly well to those from Ciscaucasia. STEKLOV (1966) gave a comprehensive description of the species based on 20 specimens from Dniepropietrovskaya Oblast and he was the first to note the presence of the longitudinal groove along the upper surface of a thick and wide lower palatal tooth. Only two specimens from Belchatów have that tooth very wide, with the groove strongly marked (Fig. 13); in some other shells the tooth is narrow and flattened – LUEGER (1981) termed it “kantig” – being “normal” in the remaining ones. Furthermore, LUEGER mentioned an arcuate columellar tooth with its inner end turned downward. A similar columellar tooth, more or less deflected downward, was observed in the specimens from Belchatów. The angular tooth in *V. ovatula* is situated much higher than the parietal (like in *V. callosa* and *V. diversisides*); it is somewhat arcuate and seems to be connected with the aperture margin, resulting in an almost circular sinus.

The specimens from Belchatów and Ciscaucasia have 7 teeth (infrapalatal always present) whereas those from other localities are as a rule 6-toothed (infrapalatal lacking), and rarely 7-toothed. Unfortunately, the specimens from older collections very often have their apertures filled with sediment, frequently obliterating the teeth; this pertains particularly to the knob-shaped infrapalatal.

*V. ovatula* was considered to be closely related to recent American *V. ovata* Say, 1822 (SANDBERGER 1874) and *V. milium* (Gould, 1840) (BOETTGER 1884) as well as to European *V. substriata* (Jeffreys, 1833) (LUEGER 1981). PILSBRY (in: PILSBRY & COOKE 1918–1920: 146), having not examined BOETTGER’S materials, rejected this view, based on the imprecise illustration of the columellar lamella presented by BOETTGER (1884). However, a recent examination of the specimens provides evidence that BOETTGER’S view is the most justified. Among the European Miocene vertiginids also some other species, besides *V. ovatula*, have columellar lamella more or less deflected downward.

*V. ovatula* is known from over a dozen localities (mainly in Germany) since the Upper Oligocene to the Upper Miocene, including two sites in Poland: Opole and Belchatów (only Bel-C). Furthermore, it seems possible (based on figures, since the description is only in Chinese) that *V. (Vertigo) mostra* described by Li YUNTONG (date unknown) from the Pliocene of Ertemte (northern China) is conspecific with *V. ovatula*.

**Subgenus:** *Vertilla* Moquin-Tandon, 1855

**Vertigo oecsensis** (Halaváts, 1911)

Figs 14–16

1911 *Pupa oecsensis* HALAVÁTS: 60, Pl. 3: Fig. 10.

1923 *Vertigo (Vertilla) angustior oecsensis* – WENZ: 1007.

1956 *Vertigo angustior oecsensis* – BARTHA: 518, Pl. 3: Fig. 20–21.

1966 *Vertigo (Vertilla) angustior* Jeffreys – STEKLOV: 148 [partim], Pl. 3: Fig. 58 (non 59).

1978 *Vertigo (Vertilla) angustior* – GOZHIK & PRISYAZHNIIK: 99, Pl. 15: Fig. 2.


1996 *Vertigo (Vertilla) oecsensis* – FORDINAL: 7, Pl. 1: Fig. 6.

**Material examined:** Belchatów: Bel-A – 12 specimens MI/1000/98 + 5 damaged MI/1001/98; Ócs (Vallesian, MN 10) – holotype Pl. 100 + 13 specimens Pl 515, 237 and 241 (MAFI), 152146/3 (SMF); Orešany (Upper Pannonian) – 1 damaged specimen MI/1002/98 (ISEA, ex coll. K. FORDINAL, Slovak Republic); Eichkogel (Turolian, MN 11) – 1966 XXV (BSP), 274215/~/ (SMF).

**Measurements** of 10 specimens from Belchatów and (in brackets) *V. angustior* (after PORKRYZKO 1990): shell: H = 1.33–1.49 (1.50–1.90), W = 0.81–0.88 (0.90–1.00); aperture: h = 0.45–0.52 (0.40–0.53), w = 0.43–0.48 (0.45–0.63); H of body whorl = 0.79–0.86 (0.85–1.00); number of whorls: 4.75–5 (4.5–5.1); H/W ratio = 1.58–1.82 (1.61–1.90).

**Comparative remarks:** Until quite recently *V. oecsensis* was regarded as a subspecies of *V. angustior* Jeffreys, 1830 (e.g. WENZ 1923 and LUEGER 1981) or as its older, Lower Sarmatian form (STEKLOV 1966). STEKLOV drew attention to the differences in the shape of columellar tooth between both these forms but he considered the older populations to have the columellar tooth less solid, lower palatal tooth lacking and shell of a smaller size. On the other hand, STOJASPAL (1989) elevated the form *oecsensis* to the species rank but without any explanation.
Figs 14–16. *Vertigo oesensis* (Halaváts): 14 – shell, front view, H = 1.45 mm; 15 – side view of palatal wall with gutter-like depression in the outer surface; 16 – H = 1.37 mm, knob-shaped columellar tooth exposed.

Fig. 17. *Vertigo angustior* Jeffreys – H = 1.56 mm, lamellate columellar tooth exposed.
Based on the fossil material examined and on recent specimens of *V. angustior*, I regard the differences in the shape of columellar tooth – lamellate and subvertical in *V. angustior* (Fig. 17) and knob-shaped in *V. oecsensis* (Fig. 16) – together with some other characters (callus on the palatal wall absent, shell of a smaller size, with very slightly striated whorls), as sufficient to justify their specific status. A very long upper palatal tooth and a long, gutter-like depression in the outer surface of palatal wall (Fig. 15) are characteristic of all the members of the subgenus *Vertilla*.

*V. oecsensis* was described from the Upper Pannonian of Hungary. In Belchatów it was found in the horizon Bel-A and it is the oldest known finding of the species.

**Vertigo angulifera** O. Boettger, 1884

*Fig. 18*

1884 *Vertigo (Alaea) angulifera* O. BOETTGER: 271, Pl. 4: Figs 10a–c.
1985 *Vertigo (Vertilla) angulifera angulifera* – ĖJECHAN: 176, Figs 1–2, Tab. 1 Figs 1–5, Pl. 2: Figs 1–3.

**Material examined**: Belchatów: Bel-B – 14 specimens MI/1003/98; Frankfurt a. M.: Corbiculaschichten (Lower Miocene, MN 2b) – holotype 152127/1 (SMF), 1966 XXVI1 i 1953 XXXVII (BSP); Dniepropetrovskaya Oblast (Lower Sarmatian) – 1872/272-279 (PIM); Steinheim (Astaracian, MN 7) – 274247/48, 274248/5; Hollabrun (Astaracian, MN 8) – 190014 (SMF); Voronovka (Upper Sarmatian) – II/152-160 (IGS).

**Measurements** of specimens from Belchatów; shell: H = 1.25–1.65, W = 0.80–0.93; aperture: h = 0.45–0.53, w = 0.45–0.55; H of body whorl = 0.75–0.85; number of whorls: 4.5–5.2.

**Comparative remarks**: *V. angulifera* is another species of *Vertilla* with a knob-shaped columellar tooth, similar to that in *V. oecsensis*. STEKLOV (1966) and ĖJECHAN (1985) gave comprehensive descriptions of the species based on new materials from Ukraine (the youngest localities) and former Czechoslovakia, respectively. Both STEKLOV’S and ĖJECHAN’S specimens are ovate, more or less elongate and correspond to the type series from Frankfurt a. M. GOTTSCICK & WENZ (1919) described subspecies *V. a. milleri* from Steinheim, characterized by cylindrical shape and somewhat more convex and weakly striated whorls. Among specimens from Belchatów there is one shell quite cylindrical in outline, but having the remaining characters of "angulifera" type. All the specimens from Belchatów have a very long lamellate palatal tooth, lowered moderately in the middle of its length but not divided in two parts (cf. ĖJECHAN 1985).

*V. angulifera* is common in the whole Miocene deposits (from MN 2 to MN 7 zones) but in Belchatów it was found only in the middle horizon – Bel-B.

**Genus**: *Nesopupa* Pilsbry, 1900

*Nesopupa minor* (Boettger, 1870) comb. nov.

*Figs 19–22*

1870 *Vertigo callosa var. minor* BOETTGER: 296, Pl. 13: Fig. 7a–b.
1889 *Vertigo (Alaea) minor* – BOETTGER: 305.
1923 *Vertigo (Vertigo) minor* – WENZ: 906.

**Material examined**: Belchatów: Bel-B – 2 specimens MI/1004/98 + 8 fragments with aperture MI/1005/98; Tuchoöice (Orleanian, MN 3) – XII 1714a (labelled as “Typus”), XII 1714b (SMF) and ca. 60 specimens 1199 (NMP).

**Measurements** of specimens from Belchatów; shell: H = 1.50–1.60, W = 0.97–1.04; aperture: h = 0.54–0.60, w = 0.53–0.60; H of body whorl = 0.90–1.02; number of whorls: 4.3–4.5.

**Comparative remarks**: Specimens from Belchatów correspond very well to those from Tuchoöice, al-
though the description of *N. minor* and its systematic status require some comments. Two shells from Belchatów are ovate but those from Tuchoice range from ovate to globose-ovate. Examination of the specimens from Tuchoice and Belchatów in SEM revealed a very minute punctuation on the embryonic whorls (1.75) and a combination of a distinct pitted-granulose sculpture with closely spaced, more or less regular striae on the surface of the definitive whorls (Figs 19–20). Such a surface sculpture is characteristic of most members of *Nesopupa* (Pilsbrý & Cooke 1918–1920), while it has never been noted in *Vertigo*. The aperture of *N. minor* is irregularly triangular with broadly rounded angles and with slightly marked lip. The body whorl ascends somewhat near the aperture. The columellar margin of aperture is slightly reflexed, whereas the palatal and basal parts are slightly contracted. The contraction passes into a low swelling parallel to the aperture margin, looking like a slight crest of *Vertigo*. Beyond the swelling there is a depression with two grooves corresponding in position to the palatal teeth. The aperture is armed with 7–8 teeth. Out of three teeth on the parietal wall, the middle one – arcuate and deeply entering parietal tooth – is the largest. The infraparietal is moderately developed and deepest set. The angular is most variable – from a very short plica, not extending to the aperture margin (specimens from Belchatów) to a well developed lamella, almost joining the aperture margin (specimens from Tuchoice) (Figs 21–22). The columellar tooth is rather strong, somewhat ascending in front, but its inner end is slightly deflected downward. There are two (specimens from Belchatów) or three (a knob-shaped suprapalatal present in specimens from Tuchoice), deeply seated palatal teeth, slightly converging backwards. A high lamellate upper palatal has the highest rise in its middle part. The lower palatal is much more solid but low. The basal tooth is either fairly big (specimens from Tuchoice) or only slightly marked, sometimes absent. The umbilicus is hardly open, slit-like.

Boettger (1870) placed the species in *Vertigo*, ignoring the pitted-granulose surface sculpture and the peculiar features of aperture (though the angular tooth not fully joins the aperture margin), and both Pilsbrý & Cooke (1918–1920) and Wenz (1923) shared his view. However, I am inclined to place the form *minor* in *Nesopupa*, though a different combination of other characters makes it difficult to specify which nesopupine group could be the closest related (cf. Pilsbrý & Cooke 1918–1920: 275). In terms of the pitted-granulose surface sculpture of typical *Nesopupa*, *N. minor* seems to be the closest to the Oriental and, particularly, Ethiopian group of species, some of which have both pitted surface sculpture and weakly developed angular tooth (Adam 1954, 1957). On the other hand, a very short angular tooth, not reaching the margin of the aperture (like in specimens from Belchatów) is frequent in Hawaiian species having, however, the shell surface mostly ribbed-striate and covered with very minute wrinkles, visible under high magnification.

Fossil species of *Nesopupa* – *N. blumi* (Boettger, 1884), *N. trigonostoma* (Sandberger, 1863) and *N. minor* – are known in Europe from the Upper Oligocene to the Lower and Mid Miocene limit and, according to Pilsbrý (in Pilsbrý & Cooke 1918–1920) they appear to be the closest related to *Indopupa* group (Oriental Region). Their weakly developed angular tooth is only slightly (if at all) connected with the peristome by a callus. Solem (1988), studying nesopupines from Australia, remarked that “the reduced angular tooth recurs in peripheral parts of the genus range”. It seems probable that during the Neogene the present area of Europe could be just a peripheral part of the then range of *Nesopupa*.

**Genus: Negulus O. Boettger, 1889**

*Negulus suturalis* (Sandberger, 1858)

Figs 23–25

1843 *Bulimus lineolatus* A. Braun: 149 (nomen nudum).

1858 *Pupa suturalis* Sandberger: 54, Pl. 5: Fig. 13, Pl. 6: Fig. 1–1a.

1889 *Negulus lineolatus* (Al. Br.) – Boettger: 269, Pl. 6: Fig. 8.

1914 *Negulus suturalis* – Fischer & Wenz: 92, Pl. 5: Fig. 13.

1919 *Negulus suturalis gracilis* Gottschick & Wenz: 9, Pl. 1: Fig. 12–13.

1919 *Negulus suturalis francofurtanus* Gottschick & Wenz: 10.


1996 *Negulus gracilis* – Fordinal: 6, Pl. 1: Fig. 3–4.

**Material examined:** Belchatów: Bel-C – 10 specimens + 5 damaged Mi/1006/98; Bel-B – 27 specimens Mi/1007/98 and 10 damaged specimens with aperture Mi/1008/98; Hochheim (Chattian, Upper Oligocene) – 151990 (SMF), 1966 XXVI (BSP), specimens labelled as *N. lineolatus and N. suturalis* (NHML); Ulm (Agenian, MN 2) – 273757/20 (SMF); Tuchoice (Orleanian, MN 3) – 1909.1.71 (NMW); Zwiefaltendorf (MN 5–6) – 273738/1 and 241670/1 (SMF); Frankfurt a. M.: Landschneckenmergel (MN 5–6) – 152008/3 (SMF) as *N. suturalis francofurtanus*; Opole (Astaracian, MN 7+8) – 1987/43/2 and 2b (NMW), 152005/1 (SMF), two specimens from BSP; Steinheim (Astaracian, MN 7+8) – 152006/1 (SMF) as *N. suturalis gracilis*.

**Measurements.** 10 specimens from Bel-C; shell: H = 1.54–1.91, W = 0.78–0.86; aperture: h = 0.57–0.68, w = 0.47–0.57; H of body whorl = 0.95–1.17; number of
whorls: 4–4.5. 27 specimens from Bel-B; shell: $H = 1.45–1.77$, $W = 0.69–0.85$; aperture: $h = 0.55–0.66$, $w = 0.45–0.54$; $H$ of body whorl = 0.92–1.09; number of whorls: 4–4.5. The number of ribs on the penultimate whorl (16–20) in specimens from Bel-C and in those from Bel-B is similar.

Comparative remarks: The systematic position of *N. suturalis* is rather intricate since several varieties of

Figs 23–25. *Negulus suturalis* (Sandberger): 23 – shell, front view, $H = 1.75$ mm; 24 – microsculpture of embryonic whorls, 440×; 25 – some examples of shell variability
the species were described from the Neogene of Europe. However, these descriptions were based on a very scanty material including only few specimens from the type locality, hence the range of shell variation was not considered. The type specimen could not be located, and the description by SANDBERGER (1858) does not quite correspond to the figures of the species by this author. He wrote (1858: 54): “Anfractus sex convexi...” while in his figure at most 5 whorls can be seen. Another few specimens from the type locality (Hochheim), stored in SMF (No. 151 990) and BSP (1966 XXVI), are similar to those from Belchatów with respect to their number of whorls.

A detailed comparison of the material from Belchatów and from some collections (SFM, BSP, NMW) reveals that the shells of *N. suturalis* vary considerably in their size and shape (Fig. 25) as well as in the degree of development and the number of sparse ribs on the shell surface. Finely wrinkled-granulose embryonic whorls (Fig. 24) and very fine striation of definitive whorls are similar in all the specimens. Shells of the Belchatów specimens are mostly nearly cylindrical (like those from Ulm and Zwiefaltendorf), whereas those from Tuchofice, Hochheim and Opole have both cylindrical and somewhat tapering shells; specimens with tapering shells were described by BOETTGER (1889: 270) as var. *sublineolata*, the name later placed among synonyms by WENZ (1923: 1025). The number of whorls in the specimens from Belchatów is rather constant, most often 4.25; the whorls are extremely convex and often shouldered, the suture is deep or very deep, and the umbilicus is slit-like. The aperture margin is more or less reflexed but not thickened.

The measurements have revealed that the subspecies *N. suturalis gracilis* and *N. suturalis francofurtanus* are well within the variability range of *N. suturalis* from Belchatów, and thus are not justified.

*N. suturalis* was a widespread species in the area of the present Europe from the Upper Oligocene throughout the whole Miocene. Earlier authors referred it to the extant African species *N. reinhardti* (Jickeli, 1874), but none of the four living *Negulus* species have surface sculpture similar to that of *N. suturalis* (cf. PILSBRY 1920–1921). The resemblance to the American *Pupoides (Ischnopupoides) hordaceus* (Gabb, 1866) discussed by BOETTGER (1889; 269) seems not to be so close since the latter species – in contrast to *N. suturalis* – has a smooth shell surface between widely spaced ribs. On the other hand, PILSBRY (1922–1926: 253) indicated another species with sculpture similar to that of *N. suturalis*, living in Australia – *Glyptopupoides egregia* (Hedley et Musson, 1891) [= *Pupoides hedleyi* PILSBRY, 1926]; however, the latter species has a prominent spiral striation between rather widely separated radial ribs (SOLEM 1988).

**Family: Valloniidae Morse, 1864**

**Genus: Vallonia Risso, 1826**

*Vallonia subcyclophorella* (Gottschick, 1911)

**Fig. 26**

1911 *Helix (Vallonia) subcylophorella* GOTTSCHECK: 503, Pl. 7: fig. 2.

1996 *Vallonia subcyclophorella* – GERBER: 147, Figs 3w, x; 56b-e; 59; 60; 61a-c.

**Material examined:** Belchatów: Bel-B – 1 specimen MI/1009/98 + 1 specimen in GERBER’S coll.; Reisperbach bei Stein (Upper Miocene) – 275345/2 (SMF); Ukraine (Lower Sarmatian) – 275348/12 (SMF).

**Measurements** of one specimen from Belchatów and (in brackets) extremes of variability range of *V. subcyclophorella* after GERBER (1996); shell: H = 0.85 (0.87–1.13), W = 2.02 (1.70–2.36); aperture: h = 0.77 (0.74–0.94), w = 0.80 (0.77–1.04); number of whorls: 3 (2.63–3.25).

**Comparative remarks:** Two specimens from Belchatów conform very well to GERBER’S description of the species in his comprehensive account of

Fig. 26. *Vallonia subcyclophorella* (Gottschick): shell, front view, W = 2.02 mm
Vallonia (GERBER 1996). On the other hand, GERBER’s data on the age of sediments with *V. subcyclophorella* from Belchatów are not quite correct, since the species was found only in the middle horizon (Bel-B) correlated to biozone MN 5.

*V. subcyclophorella* is very frequent in the Miocene deposits beginning from the Lower/Mid Miocene limit (MN 5) to the Upper Miocene (MN 10) (for details, see GERBER 1996).

**Genus: Acanthinula Beck, 1847**

*Acanthinula trochulus* (Sandberger, 1874)

Figs 27–29

1874 *Pupa* (Modicella) *trochulus* SANDBERGER: 601, Pl. 29: Fig. 25a-b.


**Material examined:** Belchatów: Bel-C – 3 specimens MI/1010/98; Bel-B – 2 specimens + 3 fragments with aperture MI/1011/98; Undorf (Orleanian, MN 5) – 241676/1 (SMF), 1967 XI (BSP); Möringen (Orleanian, MN 5) – 1966 XXVI (BSP); Opole (Astaracian, MN 7+8) – as *Acanthinula tuchoricensis* (Klika, 1891) (NMW).

**Measurements** of all specimens from Belchatów (*– juv.):

<table>
<thead>
<tr>
<th>Shell</th>
<th>Aperture</th>
<th>Body whorl</th>
<th>Number of whors</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>H</td>
<td>W</td>
<td>h</td>
</tr>
<tr>
<td>Bel-C</td>
<td>2.16</td>
<td>1.78</td>
<td>0.98</td>
</tr>
<tr>
<td></td>
<td>2.20</td>
<td>1.86</td>
<td>1.17</td>
</tr>
<tr>
<td></td>
<td>2.43</td>
<td>2.07</td>
<td>1.10</td>
</tr>
<tr>
<td>Bel-B</td>
<td>2.01*</td>
<td>1.62</td>
<td>0.80</td>
</tr>
<tr>
<td></td>
<td>2.66</td>
<td>1.98</td>
<td>1.09</td>
</tr>
</tbody>
</table>

**Comparative remarks:** *A. trochulus* is very distinct in its regularly conical shape, whereas other Neogene *Acanthinula* have a more or less dome-like conical form. The only adult specimen from Bel-B distinctly differs from three specimens from the older horizon (Bel-C) in having a more elongate shell (like that figured by SANDBERGER 1874). Several highly conical specimens, similar to those from Bel-B, were found in one of the samples from Opole stored at the Vienna Museum of Natural History and labelled as *A. tuchoricensis* (Klika, 1891). All the specimens from Belchatów have their embryonic whors (1.5) spirally sculptured (Fig. 28). The remaining whors are covered with combined fine, irregular, radial striae and rather distinct spiral lines. Apart from the microsculpture, there are widely spaced, finely marked ribs. The aperture ranges from broadly elliptical to almost circular, except for the parietal incision. A more or less reflexed aperture margin has a very slightly thickened lip, in contrast to *A. tuchoricensis* having it unexpanded and simple. The umbilicus of *A. trochulus* (Fig. 29) is distinctly wider than that of *A. tuchoricensis*.

*A. trochulus* is a rare species in Miocene deposits; the present study extends its stratigraphic range to the Lower Miocene. The upper limit of its occurrence is determined by the finding in Opole (MN 7+8), although LUEGER (1981) reports *A. trochulus* from deposits of two Upper Miocene localities in Austria. However, his specimens are not in a condition sufficient to make detailed comparisons with other species, hence the data are uncertain.

**Genus: Spermodea Westerlund, 1902**

*Spermodea cf. candida* Falkner, 1974

Figs 30–31

1974 *Spermodea candida* FALKNER: 231, Pl. 10: Figs 1–2, Pl. 11: Figs 5–6.

**Material examined:** Belchatów: Bel-B – 2 damaged specimens MI/1012/98; Undorf (Orleanian, MN 5) – holotype 1967 XI 25, paratype 1967 XI 26 (BSP).

**Comparative remarks:** Both specimens from Belchatów are damaged, thus precluding complete measurements. One specimen, of 4.75 whors, is not quite adult, hence its deep and narrow umbilicus is still quite open. The second specimen, of almost 5 whors (the first three whors are somewhat pressed into the lower two), has its umbilicus partly covered with a reflexed columellar margin of semilunar aperture. In the second specimen, there is a very weak but visible knob on the columella (Fig. 31), somewhat similar to that described by FALKNER and considered to be a vestigial columellar lamellate tooth. A comprehensive discussion of the Neogene *Spermodea* and Acanthinulinae as well as their relationships with recent species has been presented by FALKNER (1974) and SCHLICKUM & TRUC (1972).

**Genus: Planogryra Morse, 1864**

*Planogryra nana* (A. Braun, 1851)

Figs 32–33

1851 *Helix nana* A. BRAUN in: WALCHNER: 1140.

1874 *Patula (Acanthinula) nana* – SANDBERGER: 374, Pl. 22: Figs 4a-c.

1923 *Acanthinula nana* – WENZ: 972.

1974 *Planogryra nana* – FALKNER: 240, Pl. 10; Fig. 4, Pl. 11: Figs 9–10.

**Material examined:** Belchatów: Bel-B – 6 specimens + 4 juv. MI/1013/98; Tuchoøice (Orleanian, MN 3) –
275433/10 (SMF); Opole (Astaracian, MN 7+8) – 275435/5 and 238829/4 (SMF), 1966 XXVI 3 (BSP).

### Measurements of specimens from Bełchatów:

<table>
<thead>
<tr>
<th>Shell H</th>
<th>W</th>
<th>Aperture h</th>
<th>w</th>
<th>Number of whorls</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.83</td>
<td>1.17</td>
<td>0.42</td>
<td>0.48</td>
<td>3.3</td>
</tr>
<tr>
<td>0.90</td>
<td>1.22</td>
<td>0.39</td>
<td>0.50</td>
<td>3.4</td>
</tr>
<tr>
<td>0.79</td>
<td>1.23</td>
<td>0.37</td>
<td>0.46</td>
<td>3.4</td>
</tr>
<tr>
<td>0.80</td>
<td>1.24</td>
<td>0.40</td>
<td>0.47</td>
<td>3.5</td>
</tr>
<tr>
<td>0.86</td>
<td>1.27</td>
<td>0.37</td>
<td>0.49</td>
<td>3.5</td>
</tr>
</tbody>
</table>

### Comparative remarks:

Specimens from Bełchatów do not differ from those from Tuchońce and Opole. Examination of materials from the mentioned localities indicates that variation among and within fossil populations of *P. nana* is insignificant. All of them have a rather low spire (although higher than in three recent species of *Planogyra*) and distinct, rounded keel on the body whorl, above the periphery. The surface sculpture is similar to that of *A. trochulus*, except for embryonic whorls which are distinctly pitted-granulose. The aperture is broadly semilunar, simple, oblique in side view. In the moderately broad, circular umbilicus all the whorls are visible.

The generic membership of the species has remained unclear until quite lately. On the basis of the granulose microsculpture of embryonic whorls FALKNER (1974) placed it in *Planogyra*. He also listed all localities of *P. nana* known from the Upper Oligocene (Hochheim) to the Mid Miocene (Opole).
Figs 30–31. *Spermodea* cf. *candida* Falkner: 30 – shell, front view, \( H = 2.3 \) mm; 31 – shell with body whorl partly broken to show a small knob on the columella

Figs 32–33. *Planogyra nana* (A. Braun): 32 – shell, front view, \( W = 1.22 \) mm; 33 – microsculpture of first two whorls, \( 320\times \)
Family: Strobilopsidae Pilsbry, 1918
Genus: Strobilops Pilsbry, 1892
Subgenus: Strobilops s. str.

Strobilops costata (Clessin, 1877)

Figs 34–37

1877 Strobilus costatus CLESSIN: 37.

1915 Strobilops costata – WENZ: 79, Textfig. 7, Pl. 4:
Figs 15–16.

Material examined: Belchatów: Bel-C – 20 + 16 damaged specimens MI/1014/98, Bel-B – ca. 1500 + 45 damaged specimens MI/1015/98; Undorf (Orleanian, MN 5) – 275453/5 (SMF); Opole (Astaracian, MN 7+8) – 151122 (SMF), 1967 XI and 1966 XXVI (BSP); Ciscaucasia (Upper Miocene) – 1872/31-33, 1872/43 (PIM); Zamiechow (Lower Sarmatian) – S. costata govorkaensis Prisyazhnyuk, 1978: holotype II/8 + 20 specimens (IGS).

Measurements. All specimens from Bel-C; shell: H = 1.23–1.52, W = 1.97–2.15; W/H ratio = 1.41–1.64; number of whors: 4.5–5. 30 specimens from Bel-B; shell: H = 1.32–1.58, W = 1.98–2.26; W/H ratio = 1.37–58; number of whors: 4.7–5.2.

Comparative remarks: Examination of a large series of S. costata, the most abundant species of the Belchatów deposits, provides comprehensive data on its variability. Specimens from the older horizon (Bel-C) differ somewhat from those of Bel-B horizon in having smaller and less elevated shells, whereas the variability of other characters is similar. The embryonic whors (ca. 1.5) of S. costata are finely granulose and the definitive whors are distinctly ribbed. The number of ribs on the body whorl varies considerably (40–60), and the sculpture of its base is also variable, from hardly striated to distinctly ribbed. The periphery of the shell is more or less obtusely subangular. All the specimens have a generally similar umbilicus: very narrow and deep, but the last half whorl deflects rapidly and considerably from the shell axis (Fig. 36). The aperture is semilunar with expanded and thick peristome and distinct parietal callus.

The apertural barriers of S. costata and other strobilopids are generally lamellate in shape (only exceptionally very short lamellate, almost knob-like) and their evolution differs from that in other Pupilloidea (PILSBRY 1948). Hence, in my opinion, it seems more appropriate to call them all lamellae: colunellar, parietal, infraparietal, interparietal, palatal and basal (instead of lamellae and plicae or folds).

There are two or three lamellae on the parietal wall, but only two are visible in the aperture. The parietal lamella is somewhat elevated before reaching the margin of the distinct parietal callus, its inner edge being provided with regular, thin but well marked nodules (Fig. 37). The infraparietal lamella is lower and poorly nodulose, its anterior part ends just before the callus margin. Between their inner parts there is occasionally a very short interparietal lamella, not visible in the aperture. The columellar lamella of S. costata is very variable; from well developed in specimens from Belchatów (Fig. 35) and Podolia (S. costata govorkaensis Prisyazhnyuk, 1978) to weakly marked (“eben angedeutet” – WENZ 1915) in specimens from Undorf and absent in those from Podolia and Ciscaucasia (STEKLOV 1966). There are as a rule two basal lamellae, rarely three or one, and only exceptionally four, positioned as follows: the shorter one near the columella, the middle one – the most massive and always present, and the peripheral – thin and the most variable, varying from very long to very short or absent.

S. costata has been hitherto found in the Mühl and Upper Miocene deposits, therefore the finding of the species in Belchatów considerably shifts its stratigraphic range in the Miocene.

Strobilops tiarula (Sandberger, 1886)

Figs 38–40

1886 Strobilus tiarula SANDBERGER: 331.

1915 Strobilops tiarula – WENZ: 81, Pl. 4: Fig. 13.

Material examined: Belchatów: Bel-B – 117 + 20 damaged specimens MI/1016/98, Bel-A – 1 + 4 damaged specimens MI/1017/98; Leobersdorf (Vallesian, MN 10) – 151134/1 (SMF), 1958 XI (BSP); Öcs (Vallesian, MN 10) – 248372 (SMF), Pl. 193, 305, 337, 369, 380 (MAFI).

Measurements of 30 specimens from Bel-B; shell: H = 1.50–1.71, W = 2.02–2.25; W/H ratio = 1.29–1.42; number of whors: 5–5.5.

Comparative remarks: The shells of S. tiarula from Belchatów are similar to those from the type locality (Leobersdorf) and differ from specimens from Öcs in having a less thickened peristome. LUEGER (1981) examined about two hundred specimens from Leobersdorf (his search for the holotype failed) and his description is compatible with my observations. STEKLOV (1966) described S. ukrainica as a new species from Ciscaucasia; it is strikingly similar to S. tiarula but somewhat bigger (“nieskolko krupnej” – STEKLOV 1966: 171): H = 1.45–1.65, W = 1.95–2.1. Only one specimen is 1.45 high and one is 1.95 wide, whereas the remaining ones are 1.50–1.65 x 2–2.1, and thus fit well within the size range of S. tiarula. Moreover, W/H ratio is also similar – 1.25–1.37 for S. ukrainica. A closer examination of STEKLOV’S material is needed to synonymise both species.

The shells of S. tiarula differ at first glance from those of S. costata in having a more elevated spire (W/H ratio is lower), a very narrow and deep umbili-
cus, partly covered with reflexed peristome (Fig. 40) and a more flattened base. The ribbing seems to be more distinct than that of *S. costata*.

The parietal and infraparietal lamellae are similar to those of *S. costata*, except the nodules on their inner edges which in *S. tiarula* are much weaker and closer spaced. The interparietal lamella is almost always present. The columellar lamella is weakly marked. There are as a rule three basal lamellae, arranged in a sequence, from the shortest one being

Figs 34–37. *Strobilops costata* (Clessin): 34 – shell, front view, W = 1.45 mm; 35 – top view of lamellae inside the body whorl; 36 – umbilical view; 37 – side view of broken shell with two parietal and one of the basal lamellae visible
located near the columella, to the longest. The middle one is the most massive and the highest. It seems that *S. tiarula* is much more constant, both in its proportions and in apertural barriers, than *S. costata*.

*S. tiarula* was hitherto regarded as an Upper Miocene element, then the occurrence of the species in Bel-B horizon shifted its stratigraphic range to the Lower/Mid Miocene limit.

**Strobilops cf. joossi** (Gottschick, 1911)

Figs 41–43

1911 *Strobilus joossi* GOTTSCHICK: 502, Pl. 7: Fig. 16.
1915 *Strobilops joossi* – WENZ: 80, Textfig. 9, Pl. 4: Fig. 14.

**Material examined**: Belchatów: Bel-B – 23 + 10 damaged specimens M1/1018/98; Steinheim (Astartacian, MN 7+8) – 151132/1 and 246439/1, syntypes (SMF).
Measurements of specimens from Bel-B; shell: H = 1.35–1.67, W = 1.95–2.20; W/H ratio = 1.27–1.43; number of whorls: 4.8–5.25.

Comparative remarks: Although S. joossi is at first glance very similar to S. tiarula in general proportions of the shell, it differs in having umbilicus of S. costata type – the last half whorl deflects rapidly from the shell axis, but not so distinctly as in costata. STEKLOV (1966) noted that with respect to the umbilicus, S. joossi was intermediate between S. costata and S. tiarula. Another specific character of S. joossi from Belchatów is its very distinct ribbing (36–42 ribs on the body whorl), which is also strongly marked on the base. The lamellae inside the body whorl are actually similar to those of S. tiarula, but the inner end edges of parietal and infraparietal lamellae are only weakly folded, rather than nodulose.

The specimens from Belchatów have been compared with only two specimens from Steinheim, hence the identification, despite the general similarity, is uncertain.
S. joosi was hitherto known only from Steinheim (Mid Miocene), and the locality is stratigraphically placed between Bel-A and Bel-B.

Subgenus: Discostrobilops Pilsbry, 1927

Strobilops uniplicata (A. Braun, 1851)

Figs 44–45

1851 Helix uniplicata A. Braun in: Walchner: 1138.
1858 Helix uniplicata – Sandberger: 35, pl. 3: fig. 7.
1874 Strobilus uniplicatus – Sandberger: 406, pl. 23: fig. 24.
1923 Strobilops (Strobilops) uniplicata uniplicata – Wenz: 1057.
1923 Strobilops (Strobilops) uniplicata plana (Clessin) – Wenz: 1059.
1923 Strobilops (Strobilops) uniplicata sesquiplicata (Boettger) – Wenz: 1060.
1948 Strobilops (Discostrobilops) uniplicata (Sandberger) – Pilsbry: 865, fig. 468 (10–13).

Material examined: Belchatów: Bel-B – 2 + 3 damaged specimens MI/1019/98; Hochheim (Upper Oligocene) – 151136/5 (SMF), 1950 XXXIV (BSP); Budenheim (Agenian, MN 2a) – 151143/17 (SMF); Niederrad/Frankfurt (Lower Miocene, MN 2b) – XII 3014a/1, labelled as S. uniplicata sesquiplicata, Typus (SMF); Tuchôfice (Orleanian, MN 3) – 151147/3 (SMF), 3 specimens in KLKA’S coll. (NMP), 31A/40 (NHML); Undorf (Orleanian, MN 5) – 238825/1, labelled as S. uniplicata plana, Topotyp (SMF); Zwiefaltendorf (Orleanian/Astaracian, MN 5–6) – 275490/1 (SMF).

Measurements of two adult specimens from Belchatów; shell: H = 1.07–1.10, W = 2.25–2.44; umbilicus: max. W = 0.68–0.70, min. W = 0.50–0.58; number of whorls: 4.4.

Comparative remarks: S. uniplicata is the only fossil species of Discostrobilops, the subgenus distinguished by having a depressed shell with a large umbilicus, exhibiting all the whorls. The shell surface of S. uniplicata is covered with rather regular, closely spaced, fine ribs, with the exception of 1.5 embryonic whorls which are finely granulose. The ribs on the base of the shell are weak and irregular. The shape of the umbilicus changes with the increasing number of whorls; initially it is circular but the last half whorl deflects rapidly from the shell axis, so that the umbilicus gets oval. The aperture is rounded semilunate, with moderately expanded peristome, well thickened within.

Of two adult specimens from Belchatów only one has its apertural barriers well preserved. The parietal lamella, ca. 1/4 whorl long, is somewhat elevated before reaching the edge of the distinct parietal callus. The infraparietal lamella is very low, inconspicuous in its anterior part and shorter than the parietal (not reaching the edge of the callus). Between their inner ends there is a very short, thread-like interparietal lamella. Three basal lamellae of various length are situated inside the aperture, within the last ca. 1/3 body whorl. The columellar lamella is absent; although Wenz (1915: 76) reports that in S. uniplicata columellar lamella is “schwache, tief sitzende Falte”, neither Pilsbry’s (1948) nor my observations confirm it. Particular lamellae are also well visible in the other, damaged shells from Belchatów.

The subspecific distinction of S. uniplicata sesquiplicata (Boettger, 1884) and S. uniplicata plana (Clessin, 1885) presented by Wenz (1915, 1923) seems not to be well justified. Both forms occur together with typical S. uniplicata in most localities, and the differences between them – infraparietal lamella reaching the parietal callus edge in the former subspecies and more depressed shell in the latter – seem to be, in my opinion, only infraspecific variations. A similar variation of infraparietal lamella was observed by Pilsbry (1948) in extant American S. hubbardi (Brown, 1861). Moreover, Pilsbry stated that S. uniplicata “in all of its characters ... agrees so com-

Figs 44–45. Strobilops uniplicata (A. Braun): 44 – shell, front view, W = 2.44 mm; 45 – umbilical view
pletely with the living *S. hubbardii* that the relationship appears to be well established”.

*S. uniplicata* has been recorded from over ten localities in Europe, dated from the Upper Oligocene to the Mid Miocene (WENZ 1915, 1923), but the first record of the species from Poland is Be³chatów.

**Subgenus: Eostrobilops Pilsbry, 1927**

**Strobilops boettgeri** (Andreae, 1902)

Figs 46–47

1902 *Strobilus böttgeri* ANDREAE: 10, Textfig. 5.
1915 *Strobilops boettgeri* – WENZ: 80, Textfig. 8, Pl. 4: Fig. 4.

**Material examined**: Be³chatów: Bel-C – 30 + 20 damaged specimens MI/1020/98, Bel-B – 2 specimens ML/1021/98, Bel-A – 6 specimens MI/1022/98; Opole (Astaracian, MN 7+8) – 151115/1, 151117/7, 151118/14 (SMF), 1954 XV and 1966 XXVI (BSP), 1987/43/5 (NMW).

**Measurements** of 30 specimens from Bel-C; shell: 

\[
H = 1.10–1.27, W = 1.82–2.05; \text{number of whorls: 4.1–4.5.}
\]

**Comparative remarks**: Specimens of *S. boettgeri* from the three horizons of Be³chatów do not differ from each other; they are also similar to those from Opole. Specimens from both Be³chatów and Opole have a rather low conical spire, covered with more or less visible closely spaced striae, whereas the base is only very weakly striated, almost smooth. The body whorl is rounded at the periphery. The umbilicus is very deep and narrow, however the last ca. 1/3 whorl deflects somewhat from the shell axis (Fig. 47) and a more or less reflexed peristome partly covers it.

The description of apertural barriers by ANDREAE (1902) is rather cursory and it concerns only lamellae on the parietal wall. Both parietal and infraparietal lamellae reach the callus margin. They have their inner ends with nodulose edges, but in contrast to *Strobilops* s. str. the nodules are very weak and closer spaced. On the other hand, the incisions between them are deeper (like in the other species of *Eostrobilops* from Be³chatów, Fig. 50). There is no interparietal lamella. The columellar lamella is weakly marked, and of three basal lamellae the middle one is the most massive and always present. The peripheral basal lamella is much variable, from long and thin to very short, or is absent. Among the specimens examined there was even one with only one basal lamella – a similar phenomenon was described by MANGANELLI et al. (1989) as a specific character of their newly described *Eostrobilops aloisii*.

*S. boettgeri* was hitherto known only from Opole, hence its occurrence in all horizons of Be³chatów significantly extends its stratigraphic range in the Miocene.

**Strobilops fischeri** Wenz, 1914

Figs 48–50

1915 *Strobilops fischeri* – WENZ: 78, Textfig. 6, Pl. 4: Fig. 5.

**Material examined**: Be³chatów: Bel-C – 58 + 25 damaged specimens MI/1023/98, Bel-B – 3 specimens ML/1024/98, Bel-A – 2 specimens MI/1025/98; Tuchórfice (Orleanian, MN 3) – 151131/1 “Cotypus”, 275462/1 (SMF), 1971 XXVII (BSP).

**Measurements** of 30 specimens from Bel-C; shell: 

\[
H = 1.30–1.47, W = 2.30–2.56; \text{number of whorls: 4.5–5.}
\]

**Comparative remarks**: Specimens of *S. fischeri* from Be³chatów correspond very well to WENZ’S
(1915) description, with exception of the number of basal lamellae. In several of the examined specimens there are two or three basal lamellae instead of only two recorded by WENZ (1915: 79, Textfig. 6). The apertural barriers of *S. fischeri* are essentially similar to those of *S. boettgeri* (WENZ’s figures are not quite precise). Nonetheless, both species differ clearly; *S. fischeri* has a bigger and more flattened shell, its umbilicus quickly expands (the last half whorl deflects rapidly from the shell axis) and, first of all, the body whorl is distinctly angled at the periphery and narrowed toward the base (Fig. 48).

STEKLOV (1966) described *S. caucasica*, very similar to *S. fischeri*, from the Upper Miocene of Ciscaucasia, and noted that the former species differed in being bigger and having three basal lamellae. However, the measurements of only five out of 34 well preserved specimens of *S. caucasica* given by STEKLOV (1966) are similar to those of the biggest specimens of *S. fischeri* from Belchatów. The basal lamellae of both species are similar. On the other hand, STEKLOV’S (1966: Pl. 5: Fig. 96) figure of the umbilical view of *S. caucasica* is hardly legible, thus precluding a detailed comparison of umbilicus of both these species.

*S. fischeri* was recorded only from the Lower Miocene deposits of Tuchořice and the investigation of the Belchatów deposits significantly extends its stratigraphic range in the Miocene.
Family: Chondrinidae Steenberg, 1925  
Subfamily: Gastrocoptinae Pilsbry, 1918  
Genus: Gastrocopta Wollaston, 1878

Gastrocopta turgida (Reuss, 1849)

Figs 51–54

1849 Vertigo turgida REUSS: 30, Pl. 3: Fig. 8.  
1858 Pupa lamellidens SANDBERGER: 55, Pl. 5: Fig. 8a–c.  
1860 Pupa (Pupilla) turgida – REUSS: 71.  
1870 Pupa (Leucochila) lamellidens Sandb. = Pupa turgida Rss. – BOETTGER: 295.  
1889 Leucochilus quadripli-catus var. lamellidens – BOETTGER: 280.  
1891 Leucochilus quadripli-catus var. lamellidens – KLIKA: 88, Textfig. 87.  

Material examined: Belchatów: Bel-C – 35 specimens mostly damaged MI/1026/98, Bel-B – ~ 200 specimens mostly with broken lip ML/1027/98; Hochheim (Upper Oligocene) – 152406/3 (BSP); Tuchóvice (Orleanian, MN 3) – some specimens No. 1190 from KLIKA’s coll. (NMP), XII 1712a (SMF, BOETTGER’s coll.), 1971 XXVII (BSP), 1909.1.73 (NMW), some specimens labelled G. quadriloculata var. lamellidens (NHML).

Measurements. 5 specimens from Bel-C; shell: H = 2.60–3.09, W = 1.65–1.79; aperture: h = 1.05–1.30, w = 1.03–1.13; H of body whorl = 1.56–1.80; number of whorls: 5.2–5.5. 20 specimens from Bel-B; shell: H = 2.25–2.60, W = 1.44–1.58; aperture: h = 0.94–1.16, w = 0.83–0.96; H of body whorl = 1.40–1.56; number of whorls: 4.8–5.3.

Comparative remarks: Specimens from Belchatów are ovate to short ovate, rarely elongatedly ovate, with moderately convex whorls covered with very fine, irregular striae. The aperture is rounded triangular with reflexed lip, almost occluded by large teeth. The edge of the parietal callus is distinctly raised across the parietal wall. Inside the body whorl a distinct palatal-basal callus runs obliquely from the sinusus region to the columella (hence it is deeply situated) and is also visible on the outer surface of the whorl. There are 5, rarely 4 teeth. The inner end of the very solid parieto-angular tooth is deflected towards the periphery. The columellar tooth is large, ear-shaped (Fig. 53), very deeply placed. Two knob-shaped palatal teeth, of which the lower one is distinctly thicker and somewhat flattened (Fig. 54), are situated on the palatal-basal callus, similarly to the rather small basal tooth; rarely the basal tooth is absent. None of these teeth extends beyond the callus. The umbilicus is open, deep and slit-like.

Specimens from two horizons of Belchatów (B and C) differ somewhat. First of all, those from the older horizon (Bel-C) are slightly larger and somewhat more elongated.

The original description of G. turgida from Tuchóvice (type locality of Vertigo turgida) by REUSS (1849) is very poor. Later REUSS (1860) complemented it on the basis of very well preserved specimens of the same species from Lipno, a site located near Tuchóvice. On the other hand, SANDBERGER (1858) described Pupa lamellidens from Hochheim and referred it to Pupa contracta Say, 1822, extant in America. Unfortunately, it is now impossible to locate the type specimens of both forms, and I am forced to base my conclusions on other, very scanty, material and literature data. In his revision of the Bohemian Tertiary mollusc fauna, BOETTGER (1870: 295) wrote: “Ich besitze über 20 Exemplare von Tuchóvie, die in nichts von den mir direct verglichenen Hochheimer Formen unterschieden sind...”. Thus he was the first to regard both forms as conspecific and referred Pupa lamellidens Sandb. = Pupa turgida Rss. to Leucochila (for status of Leucochila Martens and Leucochilus Boettger see PILSBRY 1916–1918: 8). However, he did not take into account that REUSS’S turgida was a senior name and thus should be valid (the problem was explained later by GOTTSCHELL & WENZ 1916: 63). In his next paper BOETTGER (1889; 280) changed his previous opinion and assigned Pupa lamellidens [= Pupa turgida] as a variety to Pupa quadriloculata described by SANDBERGER (1958) from Wiesbaden, but remarked that those two forms differed in the shape and position of the columellar tooth. KLIKA’S (1891) opinion is similar. In Pupa lamellidens the columellar tooth is deeply and more obliquely located. According to BOETTGER (1889), also palatal teeth are deeply situated and more solid in the latter species. Those characters are very well visible in a big series of specimens of the species from Belchatów.

WENZ (1923) recorded G. turgida from some Upper Oligocene and Lower Miocene localities in France, besides those from Hochheim and Tuchóvice, as well as from Opole. Specimens from Tuchóvice, seen by me in some collections, are very similar to those from Belchatów (Figs 51 and 52), contrary to specimens from Hochheim stored at the Senckenberg-Museum, which are in a very bad condition making a comparison difficult. Specimens from Opole kept in Munich (1954 XV 7, BSP) have turned out to be G. edlaueri.

Gastrocopta edlaueri (Wenz, 1921)

Fig. 55

1921 Leucochylus (sic!) edlaueri WENZ: 30, Textfig. 3.  
1973 Gastrocopta (Albinula) steklovi PRISYAZHNYUK: 64, Pl. 2: Fig. 2.
Figs 51–54. *Gastrocopia turgida* (Reuss): 51 – specimen from Belchatów with broken peristome, H = 2.45 mm; 52 – specimen from Tuchořice, phot. P. Čejchan; 53 – side view of columellar and parieto-angular teeth; 54 – top view of palatal wall fragment with palatal teeth (lower palatal is the most massive)
Material examined: Belchatów: Bel-B – 18 specimens + 2 damaged Ml/1028/98; Opole (Astaracian, MN 7+8): 152404/5 (SMF), 1966 XXVI (BSP); Leobersdorf (Vallesian, MN 9): two paratypes from coll. EDLAUER (NMW); Oberdorf/Wies (Upper Miocene): 274533/2 (SMF); Zamechov and Letitshev (Upper Miocene): (IGS).

Measurements of 18 specimens from Be³-B and (in brackets) 4 specimens from Letitshev; shell: H = 1.83–2.20 (1.84–2.10), W = 1.17–1.28 (1.17–1.27); aperture: h = 0.68–0.88 (0.64–0.78), w = 0.68–0.80 (0.60–0.72); H of body whorl = 1.15–1.27 (1.06–1.21); number of whorls: 4.5–5 (4.5–5).

Comparative remarks: Specimens of G. edlaueri from Belchatów are somewhat smaller than those from Leobersdorf and Oberdorf – LUEGER (1981) gave the size: H = ca. 2.5 mm, W = ca. 1.4 mm – but do not differ in other characters. They are all conical rather than ovate-conical, with tapered spine and moderately convex whorls, more or less distinctly striated. The aperture is rounded triangular with poorly reflected lip. There are 4 teeth: the angular part of parieto-angular tooth is short and somewhat bent toward the palatal wall; the columellar is rather deeply situated, oblique in front view (although in WENZ’S figure it looks horizontal, since he probably missed its inner part) like in G. iurgida, but it is rather short and only slightly arched. There is a distinct difference between the palatal teeth, the lower being always solid and hooked, and the upper very thin, knob-like. On the outer surface of the body whorl, a deep gutter-like concavity (corresponding to the lower palatal tooth) perpendicular to the crest is marked. On the inner lip, in basal position, a small but distinct swelling is marked instead of basal tooth. The umbilicus is deep and very narrow but circular.

A close comparison of specimens from Belchatów with four shells of G. steklovi indicates that they are conspecific. The only difference is a somewhat more distinct microsculpture (striaition) on the shell surface of G. steklovi.

G. edlaueri was regarded as a species of younger periods of Miocene and the finding in the mid horizon of Belchatów distinctly changes its stratigraphic range.

Gastrocopta acuminata (Klein, 1846)

Fig. 56–58

1846 Pupa acuminata KLEIN: 75, Pl. 1: Fig. 19.
1853 Pupa quadridentata KLEIN: 216, Pl. 5: Fig. 13.
1889 Leucochilus quadruplicatum mut. quadridentata – BOETTGER: 278.
1900 Pupa (Leucochilus) quadridentata – MILLER: 399, Tab. 7 Fig. 17.
1923 Gastrocopta (Albinula) acuminata larteti (Dupuy) – WENZ: 919.
1923 Gastrocopta (Albinula) acuminata wenziana Pilsbry – WENZ: 921

Material examined: Belchatów: Bel-B – 20 specimens MI/1029/98 + ~ 300 specimens mostly with broken lip MI/1030/98; Undorf (Orleanian, MN 5): 152395/2, 152397/3 (SMF); Zwiefältendorf (MN 5–6): 274519/3 (SMF); Ciscaucasia (Upper Miocene): 1872/95–96, 1872/325-326 (PIM); Ukraine: Bogdanovsky Karier and Michailovsky Karier (Upper Miocene): 9 specimens (IGS).

Measurements of 20 specimens with relatively well preserved lip; shell: H = 2.56–3.24, W = 1.53–1.93; aperture: h = 1.09–1.30, w = 1–1.16; H of body whorl = 1.50–1.84; number of whorls: 5–5.75.

Comparative remarks: G. acuminata is one of the most abundant pupilloid snails in Belchatów and one of the most variable. Such a big series makes it possible to recognize the variability range of some characters, which is significant for ascertaining the taxonomic status of some forms described within G. acuminata group.
1. Shell shape. In his description of *Pupa acuminata* KLEIN (1846) stated: “testa ... acuminato-ovata”, and his remark is correct, also for specimens from Belchatów, with an addition: more or less elongated. There are no other details useful for the identification of the species in KLEIN’S (1846) paper (for explanation of the problem of KLEIN’S material – see GOTTSCHICK & WENZ 1916, STEKLOV 1966). Further characters were discussed by MILLER (1900) on the basis of Steinheim specimens assigned to *Pupa (Leucochilus) quadridentata*, described later by WENZ (1923) as *G. acuminata procera* [=*G. acuminata wenziana* Pilsbry, 1921]. Unfortunately, I have failed to locate the type material of the subspecies. The only specimens labelled as *G. acuminata wenziana* from Steinheim that I have examined (1966 XXVI BSP) did not correspond to GOTTSCHICK & WENZ’S (1916) description. On the other hand, figures of the subspecies presented by those authors in two papers (1916: Pl. 1: Fig. 5 and 1919: Pl. 1: Figs 18–19) show two somewhat different forms – more and less ova-

Figs 56–58. *Gastrocopta acuminata* (Klein): 56 – shell, front view, H = 3.1 mm; 57 – side view of columellar and parieto-angular teeth; 58 – top view of palatal wall fragment with palatal teeth (lower palatal is the longest)
te-longated. Both forms, as well as some other of various degree of "inflation" (with exception of those regarded as larteti), are found among the specimens of *G. acuminata* from Belchatów. Another different, more elongated form, was presented by MILLER (1900: Pl. 7: Fig. 17) although in his description it has fewer whorls than that in the figure. With respect to the shell shape and size, *G. acuminata* is somewhat similar to specimens of *G. turgida* from Belchatów C, but differs in apertural barriers.

2. Aperture shape. The aperture of *G. acuminata* is most often semi-oval or rather horseshoe-shaped according to the previous authors, and it is, in my opinion, one of the differences between that species and *G. turgida* from Belchatów, which has a rounded triangular aperture.

3. Umbilicus. The umbilicus is open but narrow, deep, partly covered with the body whorl, clearly wider than that in *G. turgida*.

4. Parieto-angular tooth. The parieto-angular tooth is the most constant both in *G. acuminata* and in *G. turgida*. Its angular part in the former species is generally somewhat more arched, hence its inner end seems to be "detached" from the parietal part in front view.

5. Columellar tooth. The columellar tooth is the most variable tooth in *G. acuminata* (Fig. 57). In specimens from Belchatów all types of columellar tooth described by various authors are found. Generally it is large and lamellate, its anterior part is horizontal and extends to the peristome, whereas the posterior part is more or less bent towards the base. Sometimes the anterior part is somewhat folded and then it may be visible in front view as an oblique tooth. The posterior part, not always well visible in front view, in some specimens is much bent, so that it comes to resemble the ear-like columellar tooth in *G. turgida*.

6. Palatal teeth. There are 2–4 palatal teeth, most often 2. Only a few out of over 300 specimens have a very small interpatal tooth and only a few have a barely marked suprapatal tooth. The teeth are placed on not very well marked callus and it is one of the distinct differences between this species and *G. turgida*. The second difference, in my opinion, is the shape of the lower palatal tooth which in *G. acuminata* is lamellate and clearly emerging towards the aperture margin (Fig. 58) whereas in *G. turgida* it is knob-shaped and "sitting" on the callus (Fig. 54).

7. Basal tooth. Almost all specimens have a more or less developed knob-shaped basal tooth, only exceptionally it is absent.

*G. acuminata* is one of the most frequent gastrocoptine snails in European Neogene, known from the biozone MN 5 to the end of Pliocene and even to the younger horizons of Early Pleistocene. It was also recorded from Poland on the basis of only one specimen from a Plio/Pleistocene site in Kielniki (STOWARZEWICZ 1981, 1989 as *G. turgida quadruplicata*).

**Gastrocopta nouletiana** (Dupuy, 1850)

**Figs 59–61**

1850 *Pupa Nouletiana* DUPUY: 309, Pl. 15; Fig. 6.
1875 *Pupa (Leucochila) nouletiana* – SANDBERGER: 549, Pl. 29; Fig. 22.
1875 *Pupa gracilidens* SANDBERGER: 600.
1923 *Gastrocopta (Sinalbinula) nouletiana nouletiana* – WENZ: 930.
1923 *Gastrocopta (Sinalbinula) nouletiana gracilidens* – WENZ: 930.
1966 *Gastrocopta (Sinalbinula) nouletiana* – STEKLOV: 140, Textfig. 48, Pl. 2: Figs 40–42.
1966 *Gastrocopta (Sinalbinula) gracilidens* – STEKLOV: 141, Pl. 2: Figs 43.
1998 *Gastrocopta nouletiana* – FINGER: 19, Pl. 8: Figs A–C.

**Material examined**: Belchatów: Bel-B – 200 specimens mostly with broken lip ML/1031/98, Bel-A – 20 damaged specimens ML/1032/98; Undorf (Orleanian, MN 5): 152367/5 (SMF); Sansan (Astaracian, MN 6): 5 specimens (MHN), 8 specimens (MNHN), 6 specimens 274734/7 (SMF); Frankfurt (Upper Miocene): 152326/1 (SMF), 31A/40 (NHML); Ciscaucasia (Upper Miocene): 1872/352-358 as *G. nouletiana*, 1872/359-364 as *G. gracilidens* (PIM); Ukraine: Bogdanovsky Karier (Upper Miocene): 32 specimens (IGS); Öcs (Vallesian, MN 10): Pl. 203, 209, 215, 230, 259, 297, 481 (MAFI).

**Measurements**: 20 specimens of nouletiana-type; shell: H = 1.90–2.45, W = 1.05–1.32; aperture: h = 0.71–0.95, w = 0.68–0.85; H of body whorl = 1.15–1.48; number of whorls: 4.75–5.25. 20 specimens of gracilidens-type; shell: H = 1.85–2.53, W = 1.16–1.36; aperture: h = 0.75–0.98, w = 0.71–0.87; H of body whorl = 1.15–1.53; number of whorls: 4.5–5.25.

**Comparative remarks**: *G. nouletiana* is one of the most variable Miocene gastrocoptines, of the group regarded by some authors as subgenus *Sinalbinula*. In Belchatów there are two forms of the species – nouletiana and gracilidens, earlier having a status of subspecies or even distinct species (see synonyms). They differ mainly in their shell shape and the number of palatal teeth. One (nouletiana) is as a rule ovate, with three palatal teeth (Fig. 59), whereas the other (gracilidens) is more elongate, sometimes strongly elongate, with four palatal teeth (interpatal tooth present) (Fig. 60). Both forms were found together in most of the known localities including Sansan – type locality of the species, although DUPUY (1850) based his description of *Pupa Nouletiana* on elongate ovate specimens with three palatal teeth (Fig. 61).
Some other taxa similar to *G. nouletiana* were described from younger Neogene horizons, but the taxonomic status of *G. nouletiana* has never been precisely determined. A review of the forms of *G. nouletiana*, as well as of closely related species, with an analysis of their variability will be published separately (in preparation).

*G. nouletiana* is common in the deposits of European Neogene since the Mid Miocene (Be³chatów B is one of the oldest sites where the species was found), and widespread from France to the Caucasus.

**Gastrocopta suevica** (Sandberger, 1875)

**Fig. 62**

1875 *Pupa (Vertigo) suevica* SANDBERGER: 654.
1900 *Pupa (Leucochilus) suevica* – MILLER: 398, Pl. 7: Fig. 16.
1923 *Gastrocopta (Sinallbinula) suevica* – WENZ: 937.
1998 *Gastrocopta suevica* – FINGER: 19, Pl. 8: Figs D-F.

**Material examined:** Belchatów: Bel-B – 20 specimens MI/1033/98; Steinheim (Astaracian, MN 7+8) – 152387/3, 217604 (SMF), 1966 (BSP), 10815 (MNHN).

**Measurements** of 20 specimens; shell: H = 1.90–2.17, W = 1.02–1.09; aperture: h = 0.71–0.80, w = 0.66–0.77; H of body whorl = 1.08–1.25; number of whorls: 4.8–5.5.

**Comparative remarks:** Specimens from Belchatów have been compared with those from Steinheim and from Öcs. Of them, only specimens from Steinheim correspond to SANDBERGER’S (1875) very laconic description; none of the 10 specimens from Öcs stored at the Senckenberg Museum (274610/10) is similar to those from Steinheim. On the other hand, there is a great similarity between the specimens from Belchatów and from Steinheim, particularly those figured by FINGER (1998: 42, Pl. 8: Figs D-F).

According to SANDBERGER (1875: 654) *G. suevica* is somewhat similar to form *gracilidens* of *G. nouletiana*, however he did not mention differences between them. In my opinion those two species have apertural barriers of similar type (with exception of somewhat more united parieto-angular tooth in *G. suevica*) but they differ very clearly and consistently in their shell shape. The angular and parietal in *G. suevica* are united into a continuous bifid tooth, the angular part being somewhat shorter and only slightly, if at all, bent to the palatal margin. The columellar tooth is horizontal, short lamellate, and basal – knob-shaped. There are, as a rule, 3 palatal teeth, but specimens with 2 teeth were also, though rarely, found. The parietal calulus in *G. suevica* is very distinctly marked and makes the aperture almost regularly circular. In *G. nouletiana* the parietal aperture margin is distorted by the parietal calulus which is weak and “sunken” into the body whorl.

*G. suevica* differs from *G. nouletiana* at first glance in its slim shape. In contrast to the latter species, *G. suevica* has a smooth surface of the body whorl, with-
out a crest or incision on the palatal wall, corresponding to the lower palatal.

LUEGER (1981) placed *G. suevica* among synonyms of *G. serotina* Ložek, 1964, but his decision seems to be unjustified, particularly on the ground of different shape of parieto-angular tooth in both species.

The older and the only certain finding of *G. suevica* was that in Steinheim, but its occurrence in Belchatów shifts the stratigraphic range of the species to the Lower/Mid Miocene limit.

**Gastrocopta cf. ferdinandi** (Andreae, 1902)

**Fig. 63**

1902 *Leucochilus ferdinandi* ANDREAE: 18, Textfig. 9.
1923 *Gastrocopta (Sinulbinula) ferdinandi* – WENZ: 929.

**Material examined**: Belchatów: Bel-B – 160 + 50 damaged specimens Ml/1034/98; Opole (Astaracian, MN 7+8) – 1966 XXVI (BSP), 1987/43/3 (NMW).

**Measurements** of 30 specimens; shell: H = 1.83–2.40, W = 1.06–1.13; aperture: h = 0.68–0.78, w = 0.66–1.0; H of body whorl = 1.09–1.30; number of whorls: 5–5.6.

**Comparative remarks**: Specimens from Belchatów are referred to *G. ferdinandi* with some doubts because the material from Opole, the type locality of the species, stored at the museums in Vienna and in Munich, does not correspond with ANDREAE’S (1902) description; neither is there any information about type specimen(s) (see: LUEGER 1981: 26).

In his description of *G. ferdinandi* ANDREAE (1902) pointed out that the species was characterized by having very convex whorls and a deep suture, whereas both these characters are quite different in specimens from the mentioned collections. The specimens from Belchatów are turret-shaped, like that figured by ANDREAE (1902: Fig. 9), and have very convex whorls and a deep suture. The size of the Belchatów shells and the number of their whorls also correspond to ANDREAE’S *G. ferdinandi*. However, there are some differences in the apertural barriers between the latter specimens and the shells from Belchatów. ANDREAE (1902) noted that the parieto-angular tooth was bifid in its outer part, whereas in the specimens from Belchatów the angular and parietal parts of the tooth are almost separate and slightly arcuately bent outward. He compared *G. ferdinandi* to *G. fissidens* (SANDBERGER, 1858) and stressed that the latter species had all the teeth more distinct than the former. Thus the apertural barriers of the specimens from Belchatów would be similar to those of *G. fissidens*, but the shape is clearly different, *G. fissidens* being cylindrical.
BIOSTRATIGRAPHY

Because of being mostly long-lived, terrestrial snail species only rarely provide a basis for stratigraphic conclusions. However, some of older species, known since the Oligocene, have survived only till the Lower Miocene and as such they are indicative of horizons of comparatively early age. Some other species appeared as late as the Upper Miocene and also provide information about the horizon age. Both these groups are rather poorly represented among the Be³chatów pupilloids.

The occurrence of pupilloid species in the three horizons of the Be³chatów deposits is presented in Table 1.

Of the three horizons in Be³chatów, the older two: B and C, are not very remote in age, whereas Be³-A is considerably younger. In consequence, the malacofauna of the former two horizons can not be expected to differ significantly. Nonetheless, a certain tendency to size variability is observed in some species. Shells of both Negulus suturalis and Gastrocopta turgida are clearly bigger in the oldest horizon (Be³-C), whereas Strobilops costata shows a reverse tendency – specimens from Be³-C are smaller and more flattened than those from Be³-B.

In contrast, the morphological similarity of some European Miocene species and those living now in America is so close that it is difficult to find a difference, e.g. Strobilops uniplicata from Tuchofie and Belchatów and recent S. hubbardi from America (cf. p. 156 and STWORZEWICZ & PRISYAZHNYUK 1997).

The lowermost horizon of the Belchatów deposits (Be³-C) contains only seven species, only one of them – Vertigo ovatula – being limited to that horizon. The species, described from the Upper Oligocene, has survived only till the Mid Miocene. Likewise, another species known from the Upper Oligocene – Gastrocopta turgida – has not been found in horizons younger than the Lower/Mid Miocene (Be³-B).

The next horizon, Be³-B, is the richest in pupilloid species (23). Of these, Strobilops tiarula and Gastrocopta nouletiana continue throughout the Mid and till the Upper Miocene. Two species occur throughout the three horizons. The remaining species, though absent from the youngest horizon (Be³-A), have been found at other localities of the Mid Miocene. Stratigraphically, the horizon can be correlated with the locality in Undorf (CLESSIN 1877).

Both of the above fauna-bearing horizons can be placed between the locality in Tuchofie (KLIKA 1891) on one hand and those in Sansan and Opole (DUPUY 1850, ANDREÆ 1902, 1904) on the other. The malacofauna of Be³-C and Bel-B is particularly close to that of Tuchofie in having quite many species in common. These are: Vertigo callosa, V. angulifera, Nesopupa minor, Negulus suturalis, Planogyra nana, Strobilops uniplicata, S. fischeri and Gastrocopta turgida. Somewhat fewer species are shared with the older, Upper Oligocene locality in Hochheim.

Table 1. Pupilloids in the three horizons of the Belchatów deposits

<table>
<thead>
<tr>
<th>Species</th>
<th>Horizons of Belchatów</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aegna oppoliensis (Andreae)</td>
<td>Be³-C MN 4 Be³-B MN 5 Be³-A MN 9</td>
</tr>
<tr>
<td>Vertigo (s. str.) callosa (Reuss)</td>
<td>+</td>
</tr>
<tr>
<td>V. diversidens (Sandberger)</td>
<td>+</td>
</tr>
<tr>
<td>V. protracta (Sandberger)</td>
<td>+</td>
</tr>
<tr>
<td>V. ovatula (Sandberger)</td>
<td>+</td>
</tr>
<tr>
<td>V. (Vertilla) oecsensis (Halaváts)</td>
<td>+</td>
</tr>
<tr>
<td>V. angulifera Boettger</td>
<td>+</td>
</tr>
<tr>
<td>Nesopupa minor (Boettger)</td>
<td>+</td>
</tr>
<tr>
<td>Negulus suturalis (Sandberger)</td>
<td>+ +</td>
</tr>
<tr>
<td>Vallonia subcyclophorella (Gottschick)</td>
<td>+</td>
</tr>
<tr>
<td>Acanthinula trochulus (Sandberger)</td>
<td>+ +</td>
</tr>
<tr>
<td>Spermoea cf. candida Falkner</td>
<td>+</td>
</tr>
<tr>
<td>Planogyra nana (A. Braun)</td>
<td>+</td>
</tr>
<tr>
<td>Strobilops (s. str.) costata (Clessin)</td>
<td>+ +</td>
</tr>
<tr>
<td>S. tiarula (Sandberger)</td>
<td>+ +</td>
</tr>
<tr>
<td>S. cf. joossi (Gottschick)</td>
<td>+</td>
</tr>
<tr>
<td>S. (Discostrobilops) uniplicata (Sandberger)</td>
<td>+</td>
</tr>
<tr>
<td>S. (Eostrobilops) boettgeri (Boettger)</td>
<td>+ +</td>
</tr>
<tr>
<td>S. fischeri Wenz</td>
<td>+ +</td>
</tr>
<tr>
<td>Gastrocopta turgida (Reuss)</td>
<td>+ +</td>
</tr>
<tr>
<td>G. edlaueri (Wenz)</td>
<td>+</td>
</tr>
<tr>
<td>G. acuminata (Klein)</td>
<td>+</td>
</tr>
<tr>
<td>G. nouletiana (Dupuy)</td>
<td>+ +</td>
</tr>
<tr>
<td>G. suevica (Sandberger)</td>
<td>+</td>
</tr>
<tr>
<td>G. cf. ferdinandi (Andreae)</td>
<td>+</td>
</tr>
</tbody>
</table>
(FISCHER & WENZ 1914): Vertigo protracta, V. ovatula, Negulus suturalis and Gastrocopta turgida.

A comparison of the Belchatów fauna with that from not very remote (ca. 100 km) site in Opole is not surprising. They share as many as 10 pupilloid species, besides those of other taxa (STWORZEWSIC 1995, STWORZEWSIC & SOLTYS 1996, STWORZEWSIC & PRISVAZHNYUK 1997). The common pupilloids are: Argna oppolensis, Vertigo callosa, V. ovatula, Negulus suturalis, Planogyna nana, Strobilops costata, S. boettgeri, Acanthinula trochulus, Gastrocopta edlaueri and G. ferdinandi.

Only two species described from Sansan have been found in Belchatów: Vertigo diversisids and Gastrocopta nouetiana.

The uppermost horizon, Bel-A, contains only five pupilloid species, only one of which – Vertigo oecsensis – may be regarded as an Upper Miocene element. It is known also from other Upper Miocene deposits: Ocs, Eichkogel and Ofesany (HALAVÁTS 1911, LUEGER 1981, FORDINAL 1996). In the light of recent studies, specimens from the Plio/Pleistocene deposits in Kielniki, recorded as Vertigo angustior (STWORZEWSIC 1981), seem to be closer to V. oecsensis, and may represent this species or a very similar form. In this case the stratigraphic range of the species would be slightly wider.

Among the Belchatów pupilloids there are some extremely long-lived species. The Belchatów records of Strobilops boettgeri, previously known only from Opole (MN 7+8; ANDREA 1902), extend its stratigraphic range to ca. 9 My. Likewise, S. fischeri, previously known only from the Lower Miocene in Tuchofice (KLIKA 1891), has turned out to occur also in the Upper Miocene. They provide an example of species which, as far as it can be judged from shell characters, have remained unchanged for almost 10 My.

PALAEOECOLOGICAL ANALYSIS

Ecological requirements of extant pupilloid snails, particularly of the groups extinct in Europe and found in Belchatów, as well as palaeobotanical data allow, in general, for inferring about the habitat, which existed in the present Central Poland over a dozen million years ago. A palaeobiogeographic analysis of the Miocene land snails from Poland, including Pupilloidea, has been presented elsewhere (STWORZEWSIC 1993).

Some of the ten pupilloid genera represented in the Belchatów deposits are still extant in Europe, and constitute the most numerous group. Pupillidae are represented by Argna oppolensis, a species described from Opole. The recent range of the genus Argna is restricted to the mountain forests of Central Europe, mainly the Alps and the Carpathians. In the Tertiary the genus appeared not earlier than the Miocene.

Vertigo is at present a widespread genus of humid habitats or regions, chiefly in the Northern Hemisphere and rather well known. In Poland it is represented by 10 species (POKRSZKO 1990). Members of Vertigo occur both in subarctic woodland of Norway and, much more rarely, in American tropics; hence the group is not very useful for palaeoecological considerations.

Another vertiginid genus, Negulus, is represented in Belchatów by one species only – N. suturalis. The four extant members of Negulus are restricted to the Afrotropical region, not exceeding 20° latitude either north or south. A revision of the genus by VAN BRUGGEN (1994) provides some data on the ecology of this taxon. Members of Negulus are mountain-dwellers living in evergreen forest litter, between 800 and 4,000 m a.s.l. Almost twice as many species are known from the Tertiary of Europe, from the Lower Oligocene to the end of Pliocene.

Nesopupa minor, similarly to the other members of Nesopupa known from the Neogene of Europe, since the Upper Oligocene till Pliocene, seems to be the closest related to the Oriental and Ethiopian groups. According to the very scanty information on the ecological requirements of this group, Ethiopian (and African) Nesopupa are also (like Negulus) mainly mountain snails, living under rotten leaves, wood and stones (PILSBRY & COOKE 1918–1920) between 750 and 4,300 m a.s.l. (ADAM 1957).

Strobilopsids are at present known from humid eastern part of North America, south of ca. 52° N, Central America and northern South America, as well as Far East and New Guinea. They live in moderately humid deciduous and mixed forests, in leaf-litter and under decaying logs. In Europe the group was very speciose (over 30 species) and greatly diversified since the Mid Eocene to the Upper Pliocene. Comprehensive information on recent and fossil Strobilopsidae was summarized by MANGANELLI et al. (1989).

Gastrocoptinae in Belchatów are represented by the genus Gastrocopta, which is at present very widely distributed in tropical and temperate zones of nearly all continents with exception of Europe: in America – south of 53°N and in Far East – south of 45°N. In general, members of Gastrocopta live in habitats similar to those of Strobilops. In the Tertiary of Europe gastrocoptines, like Strobilops, were very numerous and greatly diversified. Six species of
Gastrocopta from Bechátov distinctly fall in two
groups: one refers to American species, such as G. 
armijera (Say, 1821) or G. contracerta (Say, 1822)
which, according to PILSBRY (1916–1918), form the
subgenus Albinula. It includes G. turgida, G. 
acuminata and G. edlaueri. It is noteworthy that in
Bechátov those species are very abundantly repre-
ented in older horizons (Bel-C and Bel-B), whereas
another group, referring to Far-Eastern Gastrocopta
and regarded by PILSBRY (1916–1918) as the subge-

nus Sinalbinula, is particularly numerous in the mid
horizon Bel-B, being less so in the upper horizon
Bel-A. The second group includes G. nouletiana, G.
suevica and G. cf. ferdinandi.

Palaeobotanical research in the open cast mine
Bechátov has been based on pollen assemblages and
macroscopic plant remains (STUCHLIK et al. 1990,
WOROBIEC 1995). In general it may be inferred that
the development of vegetation varied from open
landscape, through swamp forest to forest of dry habi-
tats. The swamp forest facies is more or less similar in
all horizons. There are Taxodiaceae-Cupressaceae
forests with an admixture of Nyssa and Alnus and others. The
facies of drier habitats are differentiated and repre-
sent several types of forests.

The lowermost fauna-bearing horizon (Bel-C) con-
tains only a few species of Gastrocopta, Strobilops and
Vertigo. There is only one taxon of Pupilloidea charac-
teristic of that level – V. ovatula. The composition of the flora with the prevalence of Rhus and Engelhardia
and the high percentage of Quercoidites henrici and
microhenrici, older Myrica types, as well as some palms
indicates a warm and humid subtropical or even
paratropical climate. The age of this flora could be
determined as Ottnangian and this is also confirmed by
radiometric dating of volcanic tuffits which yielded a
date of 18.1±1.7 MA. It should be added that teeth of
a fruit-eating bat, a member of Megachiroptera
(probably Rousettus) were also found in the same hori-
zon, and it is the northernmost locality of Megachiroptera in the world (KOWALSKI 1995).

The mid horizon (Bel-B) contains the most diver-
sified fauna with particularly numerous species of
Gastrocopta, Strobilops, Vertigo, Nesopupa, Negulus,
Acanthinula, Vallonia and Argia. Some of them are
shared with Bel-C horizon. The main vegetation com-
plex is represented by Taxodiaceae-Cupressaceae forests
with an admixture of Nyssa and Alnus, whereas the
facies of drier habitats is represent by mixed forests
with Pinus and some leafed trees like Celtis, Carya,
Ulmus or Quercus. The flora was recognized as
Karpätian, and the dating of overlaying tuffits gave a
date of 16.2 ± 1.3 MA.

The upper horizon (Bel-A) includes, apart from
some species of Gastrocopta and Strobilops found al-
ready in older horizons, the species known only from
the Upper Miocene deposits – Vertigo oecensis. The flori-
sic composition is characterized by a group of
Arcto-Tertiary elements. The main vegetation com-
plex is represented by temperate forests with the pre-
dominance of Pinus, Ulmus, Alnus, Fagus, Quercus, 
Carpinus and others. A small admixture of Tertiary el-
ements, such as Carya, Ilex, Pierocarya, Liquidambar,
Castanea and Taxodiaceae, determines the flora as still
of the Neogene age.

A comparison of the map of vegetation zones and
recent distribution of Gastrocopta and Strobilops shows
that contemporary ranges of these groups overlap
with the zone of subtropical mixed mesophytic forests
and swamp forest. They are essentially evergreen,
associated with a warm and humid climate, but with dis-
tinct changes of temperature during a year. Rainfall is
periodically very rich, associated with the occurrence
of monsoon and trade-winds, which carry along much
humidity from over the sea. At present mixed
mesophytic forests occur in south-eastern Asia, and
swamp forests resembling the fossil ones grow in the
south-eastern states of the USA, mainly in Florida and
Mississippi Delta. In Europe, such a type of forest was
common in the Tertiary. Its remnants are found today
in the Caucasus, where Gastrocopta is still living and,
partly, at higher altitudes in the Canary Islands.

ACKNOWLEDGEMENTS

I owe my sincerest thanks to all the numerous cura-
tors who placed their materials at my disposal: Dr.
GERHARD FALKNER (BSP), Dr. KLEMENT FORDINAL
(Geological Survey of Slovak Republic), Dr. PIERRE
LOZOUÉ (MNHN), Dr. PETER MORDAN (NHML), Dr.
VALENTIN A. PRISYAZHNYUK (IGS), Dr. M. RAGE
(MNHN), Dr. ORTWIN SCHULTZ (NMW), MS.
CLAUDINE SUDRE (MNHN). My special thanks go to Dr.
PETER CEJHAN (Institute of Geology, Academy of
Sciences, Czech Republic) for his kind permission to
publish two of his photographs of specimens from
Tuchořice, to Dr. ADAM SZYNKIEWICZ (Institute of
Geology, Wrocław University) for valuable geological
advice, and to Dr. MARIA NOWOGRODZKA-ZAGÓRSKA
(Collegium Medicum, Jagiellonian University) for
preparing SEM photos. The study was financed by the
State Committee for Scientific Research, grant N°
6P04C 042 12.
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Miocene pupilloids from Bełchatów 169