Acta Geologica Polonica, Vol. 59 (2009), No. 2, pp. 261–267

A new rissoid gastropod with lecithotrophic development from the Miocene of Paratethys

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ABSTRACT:

Anistratenko, V. 2009. A new rissoid gastropod with lecithotrophic development from the Miocene of Paratethys. *Acta Geologica Polonica*, **59** (2), 261–267. Warszawa.

The results of detailed morphological studies on *Rissoa sobieskii* from the Badenian of the eastern Central Paratethys are presented. Its paucispiral protoconch with a bulbous embryonic shell indicates it to have had a lecithotrophic (non-planktotrophic) larval development, apparently lacking even a short free-swimming larval stage. This contrasts with all other known Miocene *Rissoa* species, which have shell features indicating a planktotrophic larval stage. The peculiarity of *R. sobieskii* is also supported by its characteristic narrowing of the aperture and almost complete lack of teleoconch sculpture. The time coincidence of the appearance of the non-planktotrophic species with distinct changes in salinity of the Badenian basin suggests that the alteration (“switching”) of the type of early ontogeny from planktotrophic to non-planktotrophic development could have been an environmentally induced phenomenon.

Key words: Gastropoda; Rissoidae; *Rissoa*; Protoconch morphology; Early ontogeny; Badenian; Sarmatian; Paratethys.

INTRODUCTION

The early ontogeny of most species of the family Rissoidae Gray, 1847 is characterized by planktotrophic or lecithotrophic (non-planktotrophic) development (e.g., Fretter and Graham 1962; Ponder 1985; Warén 1996; Harzhauser and Kowalke 2004; Kowalke and Harzhauser 2004).

So far, only a single rissoid species with an undoubtedly lecithotrophic development has been recorded from the Miocene of the Paratethys. This is the species *Mohrensternia friedbergi* Anistratenko, 2005, described from the Late Badenian/Sarmatian near the village of Zaleśce (Zbarazhsky district: Khmelnitsky region) in the Western Ukraine (Anistratenko 2005). Its non-planktotrophic larval development is clearly indicated by the paucispiral protoconch with a bulbous embryonic shell.

The generic affiliation of *M. friedbergi* is, however, provisional as all species of this genus are characterised by a protoconch morphology indicative of its indirect development, including a free-living, and usually relatively long, planktotrophic larval stage (Kowalke and Harzhauser 2004; Anistratenko 2005). The type of larval development (taken as an isolated character), however, is not necessarily stable in phylogeny (and consequently in taxonomy).

New data on the protoconch and teleoconch morphology of the Late Badenian species *Rissoa sobieskii* Friedberg, 1923, presented herein, indicate that this is the second rissoid species with non-planktotrophic embryogenesis. This is evidenced by morphological comparisons with other rissoid species as well as by palaeoecological analysis.

MATERIAL AND METHODS

The present investigation is based on the type material of *Rissoa sobieskii* Friedberg, 1923 from the original collection of Wilhelm Friedberg, housed at the Geological Museum of the Institute of Geological Sciences of the Polish Academy of Sciences, Kraków, Poland. This syntype collection comprises thirteen specimens from the Late Badenian of the Western Ukraine (Text-figs 1, 2) and was the basis of the description by Friedberg (1923, pp. 373–374, pl. 22, fig. 6). The comparative material consists of fifteen specimens of *Rissoa labiosa* (Montagu, 1803) from the collection of the Zoological Institute of Russian Academy of Sciences, S.-Petersburg, Russia (ZIN RAS 10109/4), from the Karkinit Bay, Black Sea, northern Crimea.

Shell characters were studied with an optical stereomicroscope. Standard dimensions were measured using the Nikon Measurescope MM-11C. Morphological features of the protoconch were examined by SEM, with four parameters measured: (1) the maximum diameter and (2) height of the protoconch shell, (3) the number of whorls, and the (4) width of the initial cap-like part of the embryonic shell. For method of measurement see Anistratenko (2005).

The SEM micrographs were made in the Laboratory of Field Emission Scanning Electron Microscopy and Microanalysis, Institute of Geological Sciences, Jagiellonian University, Kraków (Poland). Shells were mounted on stubs, sputter-coated with carbon and then photographed using a Hitachi S-4700 scanning electron microscope. The photographs were taken with a digital camera "Canon D30".

Institutional abbreviations. ZNG PAN – Geological Museum of the Institute of Geological Sciences of the Polish Academy of Sciences (Kraków, Poland); ZIN RAS – Zoological Institute of the Russian Academy of Sciences (St. Petersburg, Russia).

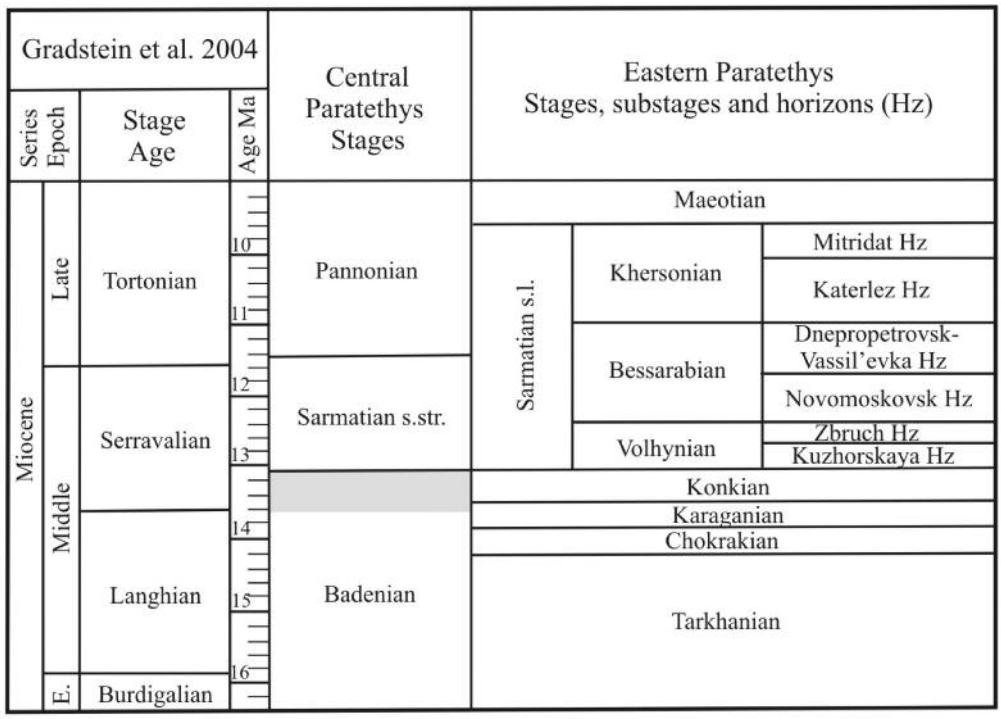
SYSTEMATIC PALAEONTOLOGY

Class Gastropoda Cuvier, 1797
Family Rissoidae Gray, 1847
Genus *Rissoa* Desmarest, 1814

Rissoa sobieskii Friedberg, 1923
(Text-fig. 3A)

1923. *Rissoa (Schwartzia) sobieskii* n. sp.; Friedberg, p. 373–374, pl. 22, fig. 6.

TYPES: ZNG PAN A-I-50/1092.1 is designated here the lectotype (Text-fig. 3A). The twelve remaining



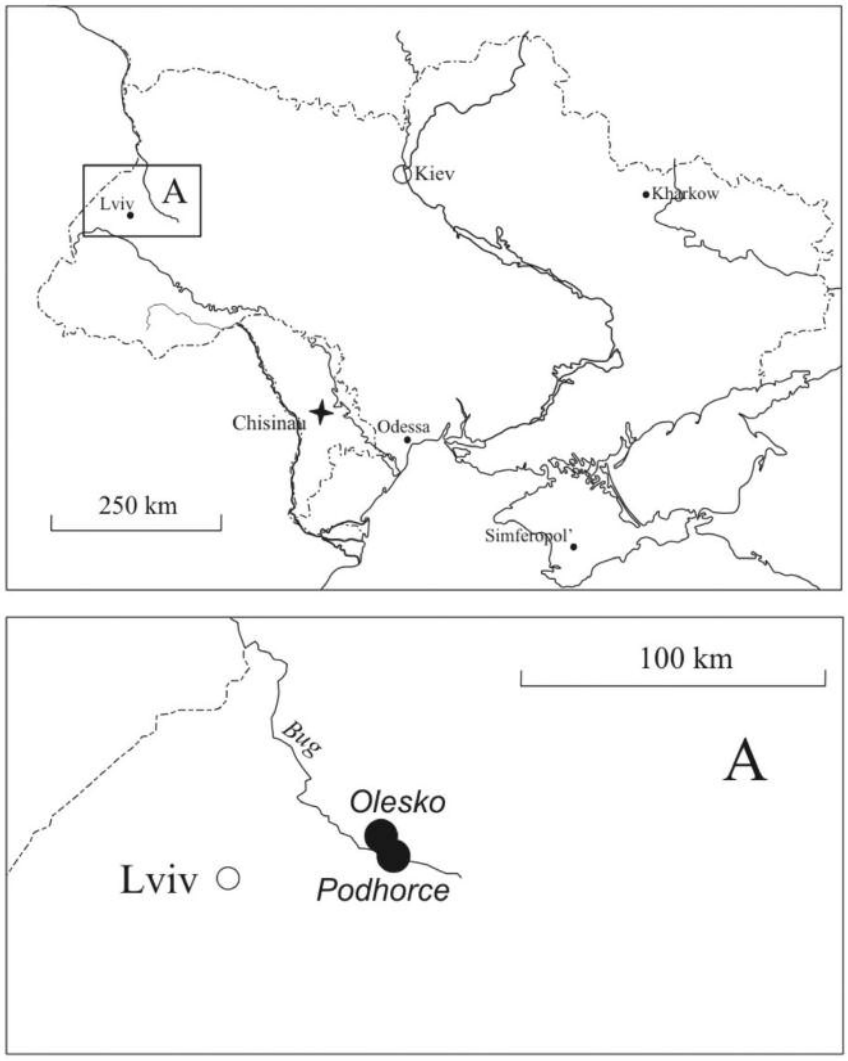
Text-fig. 1. Stratigraphic correlation chart of the standard scale with the Central Paratethys and the Eastern Paratethys (after Rögl 1988). The horizon from which the study material came is indicated with a grey belt

specimens (ZNG PAN A-I-50/1091, A-I-50/1092.2-11 and 1093) according to Art. 74 of the ICZN (1999) are paralectotypes; one of them [ZNG PAN A-I-50/1091 was illustrated in Friedberg (1923, 373-374, pl. 22, fig. 6)].

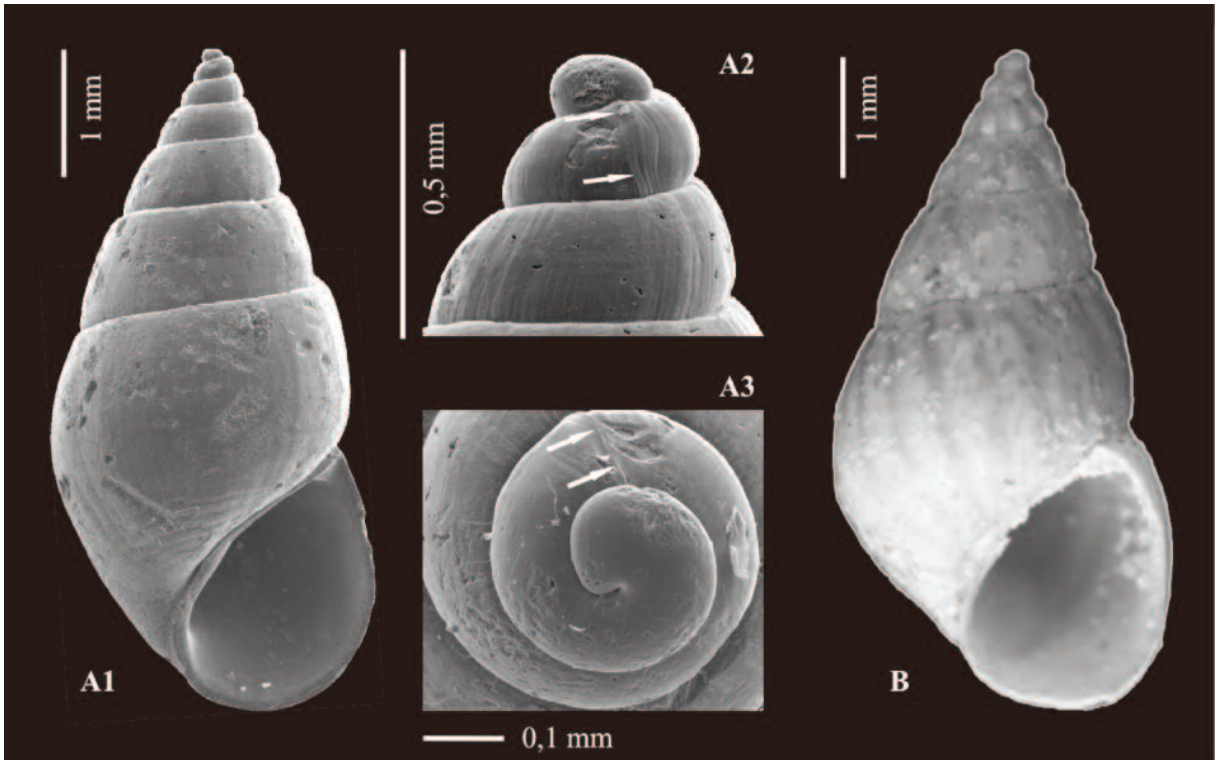
MATERIAL: Twelve specimens from Olesko, Ukraine [ZNG PAN A-I-50/1091; ZNG PAN A-I-50/1092.1-11]; one specimen from Podhorce, Ukraine [ZNG PAN A-I-50/1093]; all are from the Late Badenian.

DESCRIPTION: The shell is comparatively large (height up to 5.5 mm), stout, broad conical in shape, thin, comprising 7.0–7.5 flattened and regularly increasing whorls separated by deep, distinctly but moderately incised and inclined sutures. The teleoconch is ornamented with delicate, usually 5–7 spiral striae, best developed at the base of the last adult whorl. The spiral sculpture is much weaker on earlier whorls. Axial ribs are numerous (no less than 40 on the last whorl in the lectotype), very fine, developed most strongly at the base of the last adult whorl. An additional sculpture consists of regular, closely-spaced growth lines. The last adult whorl is inflated, occupying 50–55 % of the total shell height. The aperture is drop-shaped, of moderate size, slightly narrowed in the middle part with thin outer lip. The parietal portion is not prominent. The apical angle is about 45º; the tangent-line is straight.

The protoconch is small, high-conical, comprising 1.25–1.30 whorls measuring 0.25 mm in height and 0.32 mm in maximum diameter. The initial cap-like part of the embryonic shell is large and bulbous (width 0.16 mm). Superficially it is smooth, although some rem-



Text-fig. 2. *Rissoa*-bearing localities in West Ukraine. Olesko – outcrop near the village of Olesko, Zolochev district, Lvov region (Late Badenian); Podhorce – outcrop near Podhorce settlement, Zolochev district, Lvov region (Late Badenian)



Text-fig. 3. Two species of *Rissoa* Desmarest, 1814. **A –** The lectotype of *Rissoa sobieskii* Friedberg, 1923. Specimen (ZNG PAN A-I-50/1092.1) from the Late Badenian of Olesko, apertural view (A_1). Lateral view of the protoconch (A_2). Detailed apical view of the embryonic shell and juvenile teleoconch of the same specimen as in A_1 (A_3); arrows show the demarcation between the protoconch and juvenile teleoconch. **B –** *Rissoa labiosa* (Montagu, 1803). Specimen (ZIN RAS 10109/4) from the Black Sea, Karkinit Bay, northern Crimea

nants of the delicate spiral threads typical of the *Rissoa* micro-ornamentation are present in some specimens (Text-fig. 3A). The transition from the protoconch to the teleoconch is quite sharp and marked by a thickened sinusigera notch. The onset of the teleoconch is indicated by the formation of the weak axial and spiral striae that grade into the adult sculptural pattern.

No	HS	WS	HBW	HA	WA	NW
ZNG PAN A-I-50/1092.1 Lectotype	5.23	2.62	3.33	2.22	1.38	7.0
ZNG PAN A-I-50/1091 Paralectotype	5.50	2.75	3.39	2.33	1.44	7.25
ZNG PAN A-I-50/1092.2 Paralectotype	5.03	2.63	3.17	2.08	1.47	6.75

HS – height of shell, WS – width of shell, HBW – height of last (body) whorl, HA – height of aperture, WA – width of aperture, NW – number of whorls; all dimensions in mm

DISCUSSION: The protoconch shape, dimensions and proportions of *Rissoa sobieskii* show it to have been non-planktotrophic (Text-fig. 3A). All of the specimens studied with intact protoconchs have a well-developed bulbous apex, confirming that this 'knob' is a specific feature of *R. sobieskii* associated with its lecithotrophic embryogenesis, rather than an individual abnormality.

The variability of the shell shape and ornament is moderate. In respect of shell outline *R. sobieskii* is similar to the Badenian *Rissoa acuticosta* (Sacco, 1895) (see description in e.g., Bałuk 1975; Kowalke and Harzhauser 2004), differing from it in its more weakly sculptured teleoconch, narrower aperture of the last whorl, and in being significantly larger. In contrast to that of *R. sobieskii*, the protoconch of *R. acuticosta* comprises 2.5–2.6 whorls, suggesting the presence of a free planktotrophic larval stage (Kowalke and Harzhauser 2004).

Of the modern rissoids, the species most similar to *R. sobieskii* is *Rissoa labiosa* (Montagu, 1803) known from the Karkinit Bay of the Black Sea. It has a similar teleoconch outline (apical angle about 43º), weak sculpture and the bulbous apex, which presumably reflects its non-planktotrophic larval development (Text-fig. 3B).

STRATIGRAPHIC AND GEOGRAPHIC RANGE: So far *Rissoa sobieskii* is known from the two localities of the Late Badenian of the eastern part of the Central Paratethys, namely Western Ukraine (see '*Material'*). Kowalke and Harzhauser (2004) listed this species with many other rissoids from the Badenian of the Central Paratethys with no precisely indicated locality.

DISCUSSION AND CONCLUSIONS

The bulbous embryonic shell and short (no more than 1.3 whorls) protoconch of *Rissoa sobieskii* indicates its lecithotrophic larval development and probably the absence of any short free-swimming larval stage following the yolk-rich embryogenesis. This report of a lecithotrophic species of *Rissoa* indicates that another rissoid lecithotrophic-species, *Mohrensternia friedbergi*, described earlier, was not exceptional among the rissoid gastropods of the eastern Central Paratethys. It is evidence that lecithotrophic species occurred in the Badenian Basin both in the normal marine and in the transitional Badenian/Sarmatian deposits.

The Badenian of the Central Paratethys is characterized by an exceptionally rich malacofauna indicating normal marine conditions, with rissoids having their acme (e.g. Steininger 1963; Strausz 1966). Their maximum diversity is noted during the Early Badenian as displayed by the extraordinarily rich faunas of Korytnica (Poland), Coştei and Lăpugiu (Romania) (e.g. Bałuk 1975; Kowalke and Harzhauser 2004).

At the Badenian/Sarmatian boundary the molluscs showed a marked decrease in diversity, and polyhaline groups disappeared, suggesting significant freshening of the basin. It has been suggested that the salinity drop may have led to "switching" of the early ontogeny from planktotrophic to lecithotrophic in some molluscs. Based on several cases of such changes in larval development in Miocene (mainly Sarmatian) gastropods, it was suggested that this change not only coincided with decreased salinity but was actually triggered by it (Anistratenko and Anistratenko 2005, 2006; Anistratenko *et al.* 2006). Consequently, the presence of *Rissoa sobieskii* may reflect unstable and/or decreased salinity in the Badenian of Western Ukraine. The territory of Western Ukraine (Olesko and Podhorce localities) was situated at the margin of the Badenian Basin (e.g. Nevesskaya *et al.* 1986; Rögl 1998; Popov *et al.* 2004). Geochemical and sedimentological study of the Badenian/Sarmatian transition from the adjacent Polish part of the Carpathian Foredeep shows the transition from open deep marine conditions to a shallow basin with fluctuating (normal to lowered) salinity (e.g. Gąsiewicz and Czapowski 2005).

The Recent Black Sea lecithotrophic species *Rissoa labiosa*, similarly to the Badenian *Rissoa sobieskii*, also inhabits regions with unstable salinity, and apparently is predisposed to strong water freshening. The *R. labiosa* shells almost lack teleoconch sculpture, having weak ribs and axial colour strips instead of well-developed costae and specimens with a mammillated apex (i.e. lecithotrophic 'knob' – Fig. 3B) often occur (e.g., Anistratenko and Stadnichenko 1995).

The phenomenon of "switching" (i.e. alteration of the ontogenetic strategy) is not unique neither within the rissoids nor within the gastropods as a whole. It was reported in the Middle Sarmatian (versus Badenian) nassariids (Harzhauser and Kowalke 2004) and was recently discovered in the Badenian/Sarmatian patellogastropods (Anistratenko *et al.* 2006). Several modern lecithotrophic representatives of *Rissoa* and *Alvania* are known from both the Mediterranean Sea and northeast Atlantic (e.g., Oliverio 1994, 1996; Warén 1996). These recent forms have nearly the same protoconch proportions as *Rissoa sobieskii* or *Mohrensternia friedbergi* (see Anistratenko 2005) and could easily be recognized by having a paucispiral protoconch with a more or less bulbous embryonic shell.

Summing up, it could be hypothesized that *Rissoa sobieskii* represents one more piece of evidence that the "switching" of the early developmental stage can actually be considered as an environmentally induced phenomenon in molluscan biology.

Acknowledgements

I am deeply indebted to Barbara Kietlinska-Michalik (Geological Museum of the Institute of Geological Sciences of the Polish Academy of Sciences, Kraków, Poland), who helped me so much during my stay in the Museum. The SEM micrographs were performed by Anna Łatkiewicz, Laboratory of Field Emission Scanning Electron Microscopy and Microanalysis at the Institute of Geological Sciences of the Jagiellonian University, Kraków (Poland). The visits to Kraków and work with the rissoids from the W. Friedberg collection were made possible due to a four-month Scholarship from the Polish Fund of Assistance for Science (Kasa im. Józefa Mianowskiego) in 2006/2007. Study of the material from the Zoological Institute of RAS in St. Petersburg was facilitated by the kind assistance of the Curator of the Molluscan Collection, Lydia L.

Yarochnovich. Vladymir Rayevsky (Kiev) provided the photograph of the snail from ZIN RAS. I am grateful to Bruce A. Marshall (Museum of New Zealand Te Papa Tongarewa, Wellington, New Zealand) and Andrzej Kaim (Institute of Paleobiology of PAS, Warsaw, Poland) who kindly assisted me in the proof-reading of the manuscript and provided some helpful suggestions. The comments and extensive linguistic corrections of the final version by Ireneusz Walaszczyk (University of Warsaw, Poland) are much appreciated.

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Manuscript submitted: 10th October 2007
Revised version accepted: 10th April 2009