Revision of Middle Miocene holoplanktonic gastropods from Poland, published by the late Wilhelm Krach

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In the early thirties the late Polish palaeontologist Wilhelm Krach started the publication of a long series of papers on the mollusc faunas and the biostratigraphy of the Tertiary deposits in Poland, predominantly focusing on the Miocene of the Carpathian Foredeep. In several of these papers holoplanktonic molluscs ('pteropods') are mentioned. Gradually Krach realised the potential value of these organisms in regional and interregional biostratigraphy, resulting in a special paper on the subject, published in 1981.
In the present paper a substantial part of Krach's pteropod material, housed in the Institute of Geological Sciences at Kraków, is systematically revised and biostratigraphically interpreted according to modern standards and in accordance with research outside Poland.

Contents

Introduction

Wilhelm Krach

The scientific work of Wilhelm Krach in the field of molluscan systematics and biostratigraphy started already in 1933 and continued until his decease in 1985. During this period he produced a substantial number of papers, mainly concentrating on the Miocene deposits around his residence Kraków, in SE Poland.

As far as we know only an obituary in Polish language was published after Krach's decease (Urbaniak, 1985). Therefore we asked Professor A. Radwanski in Warszawa to supply us with some information on the person of W. Krach. Here we include the data sent by him, together with a photograph (Fig. 1).

Wilhelm Krach was born on the 23rd of January 1907 at Nisko-on-San in the Carpathians. He passed away on the 6th of February 1985 in Kraków. Krach finished high school at Nisko in 1925 and studied biology at the Poznan University from 1925 to 1929. He was an assistant of Professor W. Friedberg at the Jagiellonian University in Kraków from 1930 to 1935 and senior assistant since 1935 until WW II. He spent the wartime as a teacher at Baranow. Since 1942 he was a geologist in the 'Amt für Bodenforschung', working as a cartographer in the Miechów Upland. Since February 1945 he was adjunctus at the Jagiellonian University, Palaeontology Department (with Professor F. Bieda) and subsequently moved to the Academy of Mining and Metallurgy in Kraków. Since 1954 he was employed in the Department of Stratigraphical Geology of the Polish Academy of Sciences, Kraków Division, since 1956 as head of the department. The title of extraordinarius professor was obtained in 1954, that of ordinarius professor in 1965. Wilhelm Krach retired on the 1st of January 1978.

The material

Material studied by Krach is housed (collection no. A-I-75) in the Instytut Nauk

Fig. 1. Portrait of Wilhelm Krach (by courtesy of his son, Julian Krach).

Geologicznych of the Polish Academy of Sciences at Kraków, the same institute in the Ulica Senacka 3 where also the famous Friedberg collection is kept. This latter collection, by the way, is considered to be a 'national monument' by the INGK authorities, which means that the collection is available for study, but no samples are allowed to be sent on loan.

The senior author of the present paper (AWJ), during a three weeks visit to Poland, met Professor Krach in October 1979. At that time Krach's health condition was deteriorating already, which did not prevent him from demonstrating the Friedberg collection and his own magnificent material. Krach was especially interested then in a fine collection of pteropods collected from a large number of boreholes and some outcrops, mainly in southern Poland. He emphasized the importance of these holoplanktonic organisms in the field of molluscan biostratigraphy, on which subject he had lectured during the 7th International Congress on Mediterranean Neogene, in Athens, Greece (Krach, 1979a-c), and he explained his intention to publish a special paper on this subject in the near future. That paper appeared two years later (Krach, 1981).

In the North Sea Basin a similar interest in holoplanktonic molluscs had developed within the framework of I.G.C.P.-project 124 'The NW European Tertiary Basin' and the visit to Professor Krach was not in the last place intended to get in contact on that subject. Krach's health condition, however, prevented a prolonged stay and the visit had to be restricted to half a day only.

Afterwards Professor Krach substantiated a promise made during the 1979 visit by donating a collection of Polish pteropod material to the Leiden museum. This collection comprised 22 samples belonging to 14 species, together giving a fair impression of the holoplanktonic mollusc faunas from this part of the Central Paratethys. This collection was received at Leiden in January 1982, shortly after the appearance of Krach's 1981 paper in which the complete pteropod collection was published.

During the study of the samples donated by Krach it was noted, that among this shipment syntypes and illustrated specimens were present. It has never been possible to find out whether or not Krach sent them deliberately, as correspondence stopped shortly after receipt of the material. The samples were still at Leiden when the present paper was written.

After Krach's decease the first author found the director of the Kraków institute, Professor S. Kwiatkowski, prepared to make the pteropod material studied by Krach available for a revision. It was collected from the institute in Kraków by the junior author (IZ) in December 1989.

In the course of this study we decided that at least all primary type specimens should be returned to Kraków, as the changed political situation in Poland now guarantees a future accessibility of the collections, as well as a proper curation of type material. With the assent of the Kraków institute some material is kept in the Leiden museum (registration numbers RGM 393 000-028) as a comparison collection.

Krach kept the smaller specimens of his samples in traditional slides, on which the sample data are often written in pencil (Fig. 2). Most specimens, especially the limacinids, are preserved as pyritic casts or are filled with pyrite, and part of the material shows signs of pyritic disintegration already. Therefore we decided to transfer all pyritic samples to vials with silicone oil, thus preventing a further oxidation of the pyrite, guaranteeing a long lasting future preservation of this important material.

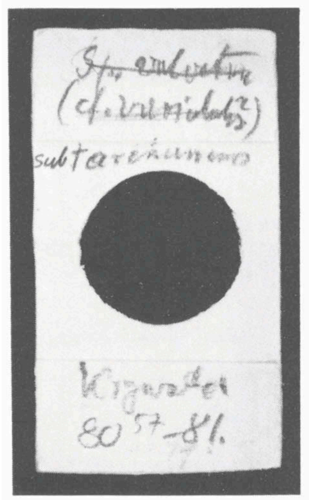


Fig. 2. Label of a traditional slide used by W. Krach. Identifications are written in pencil. Note the frequent re-identification of this sample!

We use the following abbreviations in this paper:

INGK	-	Instytut Nauk Geologicznich PAN, Kraków (Poland)
NHMW	-	Naturhistorisches Museum, Wien (Austria)
RGM	-	Nationaal Natuurhistorisch Museum (National Museum of Natural History, Palaeontology Department), Leiden (The Netherlands) (formerly Rijksmuseum van Geologie en Mineralogie)
H	-	shell height
W	-	shell width
H/W-ratio	-	parameter calculated as: (height/width) X 100.
ex.	-	specimen
reg. no.	-	registration number.

All measurements are given in mm.

From Krach's papers, as well as from the actual samples it is very clear that his work as a scientist in molluscan systematics and biostratigraphy was severely hampered by his isolated position in Kraków and, of course, by the political climate in Poland at those times. Literature, especially from the free world, was particularly difficult to obtain, and the lack of contact with and a sound criticism of other malacopalaeontologists obviously prevented him from developing a modern species concept. A clear indication for this is the fact that he accepted the co-occurrence of *Vaginella austriaca austriaca* and *V. austriaca brevior*, e.g. in the Brzeszcze-1 borehole, depths 56 and 57 m (compare Table 6).

Therefore it is no surprise that a revision of his pteropod work has to be undertaken already now, just to bring it in concordance with similar work outside Poland and to make it comparable and accessible in a wider framework.

This revision reduced the eight species of Limacinidae recognised by Krach (1981) to three Limacinidae and two Pseudothecosomata (Peraclididae), and the seven species of Cavoliniidae to five (Tables 1-2).

Polish holoplanktonic molluscs in the literature

The following literature references (in chronological order) concerning Polish pteropod material are known to us. Localities, borehole depths and stratigraphy are given as published, as well as the actual whereabouts of the material as far as known. Species names are cited as in the paper referred to.

Reuss (1867) — *Cleodora (Creseis) spina* Reuss (1867, p. 145, pl. 6, fig. 9), 2 ex., referred by Krach (1981, p. 124) as probably belonging to *Vaginella lapugyensis*, redescribed by Janssen (1984, p. 66, pl. 1, figs. 1-2, with lectotype designation). Lectotype and paralectotype present in NHMW (reg. 1867.VII.40), illustrated in Zorn (1991b, p. 110, pl. 5, figs. 13, 14).

Cleodora (Creseis) subulata Quoy & Gaimard (Reuss, 1867, p. 145, pl. 6, fig. 10), 2 ex., referred by Krach (1981, p. 124) as probably belonging to *Vaginella lapugyensis*, redescribed by Janssen (1984, p. 67, pl. 1, fig. 3). Both specimens (one of which almost completely disintegrated) present in NHMW (reg. no. 1867.VII.41), discussed in Zorn (1991b, p. 110).

Spirialis valvatina Reuss (1867, p. 146, pl. 6, fig. 11a-b), 8 ex., redescribed by Kittl (1886, p. 69, pl. 2, fig. 38 = same specimen as illustrated by Reuss), Janssen (1972, p.

Table 1. Limacinid species from the Miocene of Poland recognised by W. Krach, 1981, and their revision in the present paper (in alphabetical order).

Krach (1981)	present paper
Spiratella andrussovi	Euthecosomata, Limacinidae
Spiratella koeneni	*Limacina gramensis*
Spiratella lata	*Limacina miorostralis*
Spiratella stenogyra	*Limacina valvatina*
Spiratella subtarchanensis	
Spiratella tarchanensis	Pseudothecosomata, Peraclididae
Spiratella valvatina	*Peracle lata*
Spiratella variabilis	*Peracle* sp. nov.

Table 2. Cavolinid species from the Miocene of Poland recognised by W. Krach, 1981, and species accepted in the present paper (in alphabetical order).

Krach (1981)	present paper
Clio fallauxi	*Clio fallauxi*
Clio pedemontana	*Clio pedemontana*
Styliola lamberti	*Creseis spina*
Vaginella austriaca	*Styliola subula*
Vaginella austriaca brevior	*Vaginella austriaca*
Vaginella lapugyensis	
Vaginella rzehaki	

61, figs. 31-37), Janssen (1984, p. 72, with lectotype designation) and Zorn (1991b, p. 97, pl. 1, fig. 5). Lectotype and six paralectotypes present in NHMW (reg. no. 1867.VII.42), one syntype (presumably the specimen illustrated by Reuss and Kittl) is lost. All specimens from rock salt deposits at Wieliczka near Kraków (see Fig. 3).

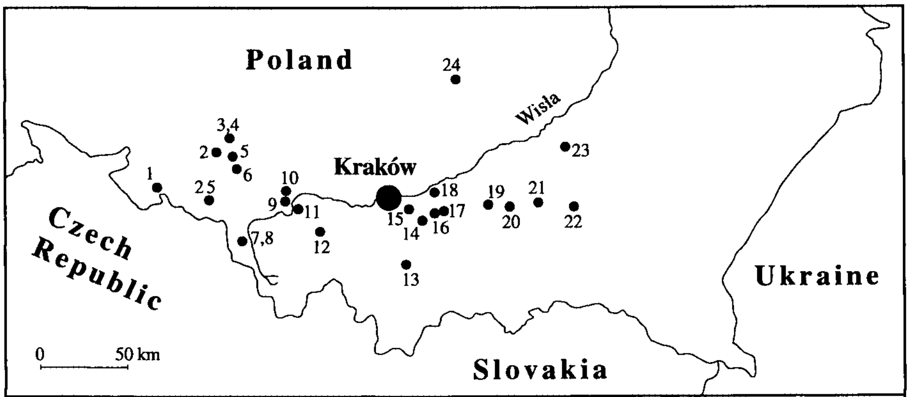
Niedźwiedzki (1883) — *Spirialis valvatina* Reuss, *Vaginella depressa* Daudin and *Cleodora spina* Reuss were recorded from Wieliczka.

Kittl (1886) — The type sample of *Spirialis valvatina* Reuss from Wieliczka is also discussed in this paper.
Creseis (?) *spina* (Reuss), 5 (sic!) ex. (according to Kittl's text this are the same specimens from Wieliczka described as *Cleodora (Creseis) spina* and *Cleodora (Creseis) subulata* by Reuss (1867) (see above).

Bukowski (1932) — The presence of Pteropoda in the Miocene Chodenice Beds in Poland is mentioned.

Friedberg (1938a) — *Vaginella austriaca* Kittl, 2 ex. from the 'Upper Tortonian' of Korytnica, donated to the Physiographical Museum PAN.

Friedberg (1938b) — *Spirialis valvatina* Reuss, 1 ex. from the Chraplice-1 borehole, depth 89.8 m ('Tortonian').
From the Hucuł borehole (Ukraine, boundary stratotype Wielician/Kosovian!) Friedberg mentioned: *Spirialis* cf. *valvatina* Reuss, 7 samples (depth 1314 m: 22 ex.;



Outcrops and boreholes:

1: Kietrz-4,-5	7: Simoradz-26, -27	13: Mszana-1	19: Biadoliny-1
2: Sierakowice-1	8: Dębowiec-45	14: Gdów-1	20: Koszyce Małe
3: Łabędy	9: Międzyrzecze-1	15: Wieliczka	21: Łęki Dolne
4: Niepaszyce-1, -2	10: Świerczyniec	16: Siedlec-2	22: Grudna Dolna-2,-4,-5
5: Gliwice Stare	11: Brzeszcze-1	17: Łapczyca-1, -2	23: Mielec-5
6: Krywałd	12: Roczyny-1,-2	18: Kolanów-1	24: Korytnica
			25: Czernica

Fig. 3. Location of Polish localities mentioned in this paper.

1315 m: 40 ex.; 1321 m: 17 ex.; 1326 m: 30 ex.; 1326.8 m: 24 ex.; 1341 m: 40 ex.; 1344 m: 1 ex.); *Spirialis* cf. *koeneni* Kittl, 2 samples (depth 1315 m: 60 ex.; depth 1326 m: 2 ex.); *Spirialis* cf. *stenogyra* (Philippi), two samples (depth 1321 m: 3 ex.; depth 1344 m: 1 ex.) ('Tortonian').

Spirialis cf. *valvatina* Reuss was recorded from the 'Upper Tortonian' of the Przyczynki-1 borehole (at Ujście, Ukraine), depth 52.95-53.3 m (100 ex.), together with 80 ex. of *Spirialis* sp.

The whereabouts of all these samples are unknown to us.

Friedberg (1939) — *Vaginella austriaca* Kittl was recorded in this paper from Korytnica. Material from this locality in the Friedberg collection was available to us.

Krach (1947) — *Vaginella austriaca* was mentioned from Częstoszowice, Giebułtów, Boczkowice, and Małoszów, in calcareous marls of 'Early Tortonian' age. These localities are not represented in the material now available to us.

Krach (1954a) — The genus *Spirialis* is recorded from the 'Tortonian' of the localities Łabędy, Niepaszyce and Racibórz. The material from the two first mentioned localities has been available to us.

Krach (1954b) — The species *Spirialis koeneni* Kittl and *S. valvatina* Reuss are mentioned from the 'Tortonian' of Gliwice Stare.

Łuczkowska (1955) — The species *Spirialis valvatina* Reuss, *S. koeneni* Kittl and *S. stenogyra* (Philippi) are recorded from 'Tortonian' deposits at Grabowiec, and *Spirialis* sp. from Chodenice, Bochnia (Trinitatis brickyard) and from Chełm, on the Raba river. At the contact of the Chodenice and Grabowiec beds a mass-occurrence of *Spirialis* was mentioned. The whereabouts of the material are unknown to us.

Krach (1956a) — Pteropods were mentioned from three localities, viz. Krywałd, Roczyny and Mielec. The presence of the species *Vaginella austriaca* Kittl and *V. depressa* Daudin in the 'Helvetian' is given, *Balantium fallauxi* Kittl is recorded from the 'Helvetian' of Roczyny, from Krywałd and Mielec *Spirialis* sp., and the taxa *S. valvatina* Reuss and *S. stenogyra* (Philippi) are mentioned from the Grabovian in general.

Krach (1956b) — In this paper a large number of pteropod records are given from three localities, viz. Gliwice Stare (*Spirialis valvatina* Reuss, *S. koeneni* Kittl), Wieliczka (*S. valvatina* Reuss) and Krywałd [*S.* sp., *S. koeneni* Kittl, *S. stenogyra* (Philippi), *S. valvatina* Reuss, and *Vaginella austriaca* Kittl]. From Krywałd specimens are mentioned down to a depth of 156 m, but we had only material available from 113 m upwards, exclusive of the only record of *Vaginella austriaca* from this borehole, mentioned from a depth of 154-156 m.

Krach & Nowak (1957) — From Roczyny, borehole section Y ('Helvetian? - Upper Tortonian') these authors mentioned: *Vaginella austriaca* Kittl (depths 0-182 m, ? 230-340 m and ? 340-351 m), *Vaginella depressa* Daudin (depth 0-182 m), *Vaginella rzehaki*

Kittl (depth 0-182 m), *Balantium fallauxi* Kittl (depths 0-182 m and 230-340 m). From the same locality, borehole section X (Opolian), is recorded: ? *Vaginella austriaca* Kittl (depth 95-176 m).

Many samples labelled 'Roczyny-1' and some samples 'Roczyny-2' are present among the material studied in the present paper, but the depth indications are not concordant. Thus it remains unclear if these are the same samples as mentioned by Krach & Nowak.

Jurkiewicz & Karnkowski (1961) — These authors mentioned the presence of a mass occurrence of *Spirialis*, and the species *S. valvatina* Reuss and *S. stenogyra* (Philippi) in the Polish 'Tortonian', above the gypsum horizon.

Alexandrowicz (1963) — The pteropods *Spirialis valvatina* Reuss, *Balantium fallauxi* Kittl, *Vaginella austriaca* Kittl, *V. depressa* Daudin, and *V. rzehaki* Kittl were mentioned from the Miocene of Upper Silesia. A distinct mass occurrence of limacinids is illustrated in pl. 9, fig. 1.

Krach (1967) — Pteropod material was mentioned from several boreholes at Grzybów (Kaiserwaldzone, Holy Cross Mountains). *Spirialis* sp. is recorded to occur in various boreholes ('Upper Tortonian'), and *Vaginella* sp. was mentioned from the 'Lower Tortonian'. A mass occurrence of *Spirialis* is mentioned on p. 182 and illustrated on pl. 2, fig. 1. The material has not been available to us.

Krach et al. (1971) — For the Opolian these authors mentioned the species *Vaginella austriaca* Kittl as typical for sublittoral deposits of the Early Opolian, and *Clio fallauxi* (Kittl), *Vaginella austriaca* and *V. depressa* as typical for the Carpathian Foredeep. From Bochenian deposits (Chodenice Beds) they mentioned *Spirialis* sp.

Krach (1973) — *Clio fallauxi* (Kittl) is recorded from Dębowiec-45 (depth 440-520 m), Simoradz-26 (depths 450-510 m and ? 610-700 m), Simoradz-27 (depth 338-370 m), Brzezówka, Andrychów-Roczyny, and Grudna Dolna-2; *Vaginella austriaca* Kittl is mentioned from Dębowiec-45 (depths 366-400 m, 400-440 m and 440-520 m), Simoradz-26 (depths 450-510 m and 610-700 m), Simoradz-27 (338-370 m), Brzezówka, and Grudna Dolna-2; *Vaginella rzehaki* was recorded for the localities Simoradz-26 (depth 450-510 m), Andrychów-Roczyny, and Grudna Dolna-2.

From the localities Dębowiec-45, Simoradz-27, and Grudna Dolna-2 samples are available to us, but their depth indications differ from the ones mentioned by Krach (1973). All these localities are of Early Opolian age.

Urbaniak (1974) — This author mentioned *Spirialis* sp. from the 'Tortonian' of the Błonie-1 and -2 boreholes in the Dunajec valley near Tarnów.

Krach & Ney (1978) — The presence of the genus *Spirialis* is mentioned for the Polish Chodenice Beds (Kosovian).

Krach (1979a) — *Vaginella austriaca brevior* Krach, mentioned from the Moravian of

Łęki Dolne, Międzyrzecze-1, Grudna Dolna-2, -4 and -5, Brzeszcze-1, Łapczyca-1 and -2, Świerczyniec, and Mszana-1; *Spiratella variabilis* Krach, from the Kosovian of Ujście, Wierzbowiec, and Krywałd; *S. lata* Krach, from the Moravian of Brzeszcze.

With the exception of the samples from Grudna Dolna-4 and Wierzbowiec all this material was available to us for the present study.

Some more general notes were made in this paper concerning the occurrence of pteropod species. *Spiratella* and *Vaginella* are recorded as monogeneric mass occurrences, *Vaginella* being typical for the Moravian and Lower Wielician, *Spiratella* being typical for the 'Upper Wielician' and the Kosovian. The *Spiratella* concentrations are connected with the salt-bearing beds and the overlying Chodenice Beds, disappearing towards the east and north.

Krach (1981) — In this paper Krach summarised his knowledge on the Polish pteropods, repeating some localities mentioned earlier and adding quite a lot of new records: *Styliola lamberti* Checchia-Rispoli, 1 ex. from Brzeszcze-1*; *Clio fallauxi* (Kittl), 10 ex. from Roczyny-1*, Siedlec-2*, Grudna Dolna-2*, Grudna Dolna-5*, Simoradz-27*, Dębowiec-45*, Międzyrzecze-1*, Gdów-1; *C. pedemontana* (Mayer), 4 ex. from Grudna Dolna-2*, Biadoliny*, and Simoradz-27*; *Vaginella lapugyensis* Kittl, 7 ex. from Sierakowice-1*, Koszyce Małe, and Brzeszcze-1*; *V. rzehaki* Kittl, several tens of specimens, from Grudna Dolna-2*, -4* and -5*, Łapczyca-1*, Brzeszcze-1, Międzyrzecze-1*, and Świerczyniec; *V. austriaca* Kittl, common species, from Łapczyca-1* and -2, Roczyny-1*, Siedlec-3, Suchoraba-1, Gierczyce-1, Gdów-1, Dąbrowica-1, Bochnia-1, Bilczyce-2, Jadowniki-3, Jastrzębie-1, Kolanów, Moszczenica, Raciborsko-3, Iwkowa, Świerczyniec*, Międzyrzecze, Brzeszcze-1*, Dębowiec-45*, Simoradz-26, Brzezówka, Przeciszów, Mszana*, Krywałd, Borzęta, Łęki Dolne*, Grudna Dolna-2*, -4* and -5*, and Korytnica*; *V. austriaca brevior* Krach, several tens of specimens, from Łęki Dolne*, Międzyrzecze-1*, Brzeszcze-1*, Grudna Dolna-2*, -4 and -5*, Łapczyca-1* and -2*, Świerczyniec*, and Mszana-1*; *Spiratella valvatina* (Reuss), hundreds of specimens, from Gliwice Stare*, Mielec-5*, Kietrz-4, and -5*, Mszana-1*, Brzeszcze-1*, Łapczyca-1*, Krywałd*, Winiary, Wierzbowiec, and Ujście; *S. koeneni* (Kittl), several tens of specimens, from Gliwice Stare*, Krywałd*, Winiary, Wierzbowiec, and Ujście; *S. stenogyra* (Philippi), number of specimens not mentioned, from Krywałd*, Wierzbowiec, and Ujście; *S. tarchanensis* (Kittl), number of specimens not mentioned, from Łabędy*, Niepaszyce*, Łapczyca-1*, Krywałd*, Niepaszyce-2*, and Ujście; *S. subtarchanensis* (Shizhchenko), 1 ex., from Krywałd*; *S. andrussovi* (Kittl), over a dozen specimens, from Mszana-1*, Łapczyca-1*, Krywałd*, and Winiary; *S. variabilis* Krach, several tens of specimens, from Ujście*, Wierzbowiec, and Krywałd*; *Spiratella lata* Krach, 3 ex., from Brzeszcze*.

From the localities indicated with * material was available to us, but it could not be established in how far it was complete, as Krach usually did not specify sample depths and numbers of specimens in his 1981 paper. The whereabouts of the other samples are unknown to us.

Krach (1985) — *Clio* sp. indet., 1 ex., and *Vaginella* sp. indet., 3 ex., were recorded from Late Eocene deposits at Koniusza near Przemysl. The specimens have not been available to us.

From the above specification it is clear that only a part of the samples published by Krach (and earlier authors) has been available to us. On the other hand the material comprised several samples that apparently have never been mentioned in the literature:

Vaginella rzehaki Kittl, 3 ex. from Łapczyca-2 (depth 1086.4-1092.6 m), 3 samples (2 ex. each) from Roczyny-1 (depths 156-158 m, 158.2-160.2 m and 162-163 m) and 1 ex. from Mszana-1 (depth 162-163 m).

Vaginella austriaca Kittl, 3 samples from Roczyny-2 (depths 69.5-71.5 m: 3 ex.; 153-156 m: many ex., without depth indication: 4 ex.), and 2 samples from Kop. Zofiówka (depth 30 m: 3 ex.; 610 m: 1 ex.).

Spiratella valvatina (Reuss), 1 ex. from Czernica, 1 ex. from Korytnica and 2 samples from Kolanow-1 (depths 1004.4-1011 m: 5 ex.; 1017-1027 m: 4 ex.).

Spiratella andrussovi (Kittl), 1 ex. from Brzeszcze-1 (depth 61 m).

Spiratella sp., 10 ex. from Łapczyca-1 (no depth indication).

Systematic part

In the lists of synonyms we apply Richter's (1948, p. 54) symbols:

1881 (year in italics) name cited without description or illustration;
1881 (year in roman) the cited reference contributes to the knowledge of the taxon;
* first valid introduction of the taxon;
. responsibility for the identification is accepted by the present authors;
(no symbol) responsibility for the identification is not accepted by the present authors, but there is no reason for doubt;
? in the opinion of the present authors there is reason to doubt the identification;
v the original material of this reference was studied by the present authors;
(1881) (date between brackets) the year of publication is uncertain (or the paper has not been published officially, e.g. thesis).

In the paragraphs 'material studied' in the following systematic descriptions the samples are only briefly specified. More detailed information is to be found in Table 6.

Phylum MOLLUSCA
Classis GASTROPODA
Subclassis OPISTHOBRANCHIA
Ordo THECOSOMATA
Subordo EUTHECOSOMATA
Familia LIMACINIDAE Gray, 1847
Genus *Limacina* Bosc, 1817 (= *Spiratella* de Blainville, 1817)

Note — The quite annoying and without a decision of the I.C.Z.N. unsolvable confusion around the synonymous taxa *Limacina* and *Spiratella* (for part of which in older papers also the name *Spirialis* Eydoux & Souleyet, 1840, as well as various other names are found) makes the discussions on species of this genus rather incomprehensive. As a general rule we state to accept the use of the name *Limacina* (in agreement with its application by biologists), but in discussions we mention the genus name as it was used in the literature cited.

Krach's interpretation of Limacinidae from the Krywałd borehole — In his 1981 paper Krach distinguished eight species of Limacinidae in the Miocene deposits of Poland (Table 1), viz. *Spiratella andrussovi* (Kittl, 1886), *S. koeneni* (Kittl, 1886), *S. lata* Krach, 1979, *S. stenogyra* (Philippi, 1844), *S. subtarchanensis* Zhizhchenko, 1936, *S. tarchanensis* (Kittl, 1886), *S. valvatina* (Reuss, 1867), and *S. variabilis* Krach, 1979.

Among these taxa, however, *S. koeneni* must be considered a nomen dubium (Janssen, 1984, p. 70, pl. 1, fig. 7) and *S. stenogyra* is a junior synonym of the Recent species *Limacina retroversa* (Fleming, 1823). It was applied by Krach (as it was already by Kittl, 1886, and various subsequent authors) for relatively highly coiled Miocene limacinid specimens, that to a certain degree indeed resemble the Recent species, but certainly are not identical (Fig. 4). The taxon introduced by Krach as *S. lata* is considered here to belong in the genus *Peracle* of the Pseudothecosomata.

It is rather difficult to find out, from his papers as well as from the actual material, which characteristics Krach relied upon to distinguish between the taxa recognised by him. Generally, the shells of Limacinidae are devoid of surface sculpture, and the

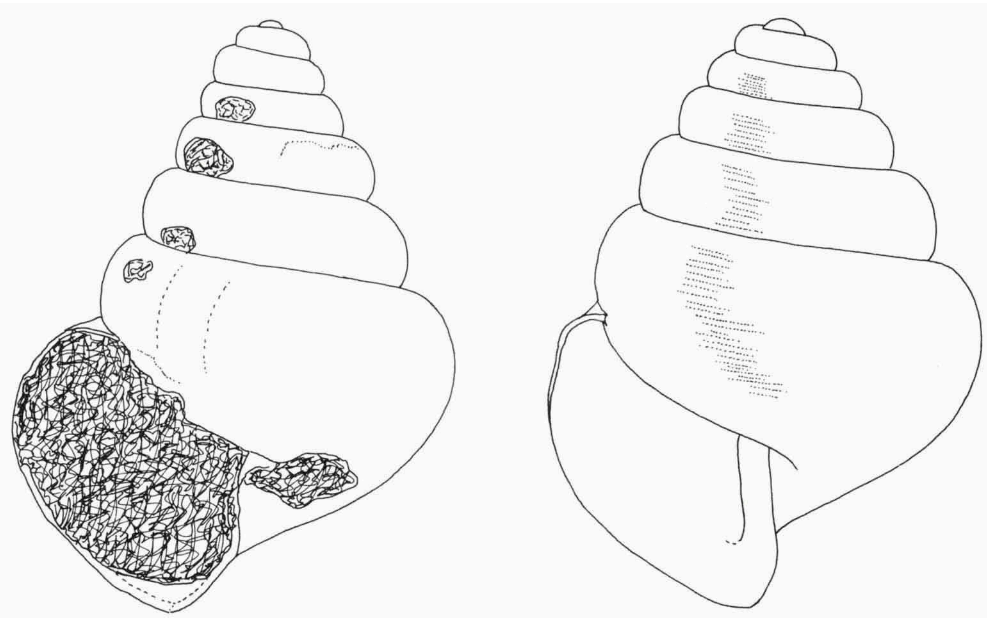


Fig. 4. Comparison of '*Spiratella stenogyra* (Philippi, 1844)' [sensu Kittl, 1886 = *Limacina gramensis* (Rasmussen, 1968)] from the Krywałd borehole, depth 94-95 m (left) and a Holocene specimen of *Limacina retroversa* (Fleming, 1823), from the North Sea (RGM 393 015 and RGM 393 029, respectively). Magnification X 40.

morphology of the apertural parts of the shell can only occasionally be observed, as practically all material is preserved as pyritic casts with more or less strongly defective apertures. So, in the end, it must be concluded, also from the short descriptions in his 1981 paper, that in fact Krach applied mainly the height/width-ratio to distinguish between the various species. Forms with an elevated spire, but which are wider than high, or about as high as wide, were identified *S. valvatina*. The very slender shells were indicated *S. stenogyra*, and a large number of intermediate shells were named *S. koeneni*. The remaining names were used to indicate either juvenile specimens, or specimens with very depressed or irregular shells. At several places Krach (1981) stressed the difficulties experienced by him in the delimitation of the species.

The greater part of the available limacinid material in the Krach collection originates from two boreholes, viz. Krywałd and Łapczyca-1. The samples from these sections render a good impression of Krach's interpretations, of the ranges of variability accepted by him, and of the stratigraphical distribution of the taxa he recognised. The vertical ranges of the species recognised in these boreholes by Krach are illustrated in Figs. 5-6.

Stratigraphical and palaeontological information on the Krywałd borehole is to be found in Krach (1956b) and Alexandrowicz (1963), some material from the Łapczyca-1 borehole was mentioned by Krach (1979a), but a lithological description of the section has not been available to us.

From Krywałd 30 samples were present, identified as *S. valvatina* (15 samples), *S. koeneni* (4 samples), *S. stenogyra* (3 samples), *S. tarchanensis* (1 sample), *S. subtarchanensis* (3 samples), *S. andrussowi* (1 sample), and *S. variabilis* (3 samples). The number of specimens per sample varies between 1 and 85 (Table 3). The distribution of the limacinid taxa in the Łapczyca-1 borehole (according to Krach) is given in Table 4.

From the data in Table 3 it can be seen that from the Krywałd borehole limacinid material is available from the interval 68-113 m. The gypsum beds in this borehole are present in the depth interval 101.80-111.80 m (Krach, 1956b). In the Łapczyca-1 borehole (Table 4) limacinids are available from the interval 25-312 m. The position of

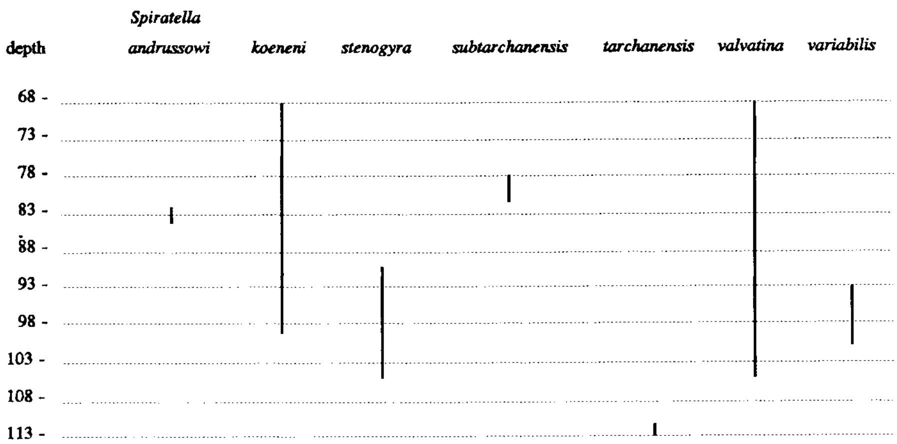


Fig. 5. Vertical ranges of limacinid species in the Krywałd borehole, as identified by W. Krach.

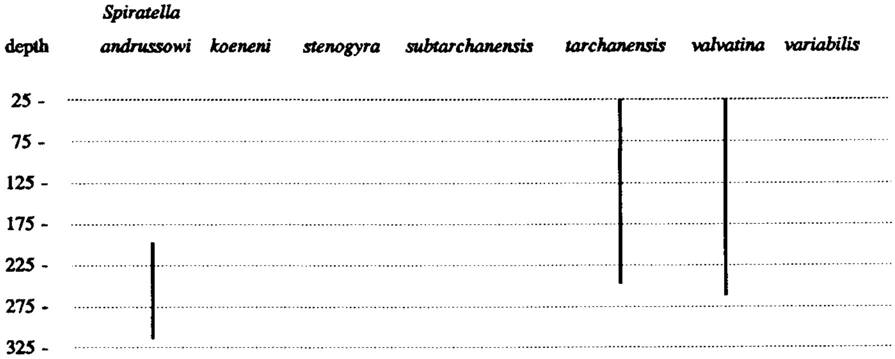


Fig. 6. Vertical ranges of limacinid species in the Łapczyca-1 borehole, as identified by W. Krach.

the gypsum layers in that borehole is not known to us.

As can easily be seen, the depth indication of the various samples is very irregular, with gaps and overlaps; apparently the series of samples are not complete and obviously specimens from various samples have been united. Generally, however, the sample distribution agrees with Krach's data as published.

The species *S. andrussowi* was identified in one specimen only from Krywałd, whereas five specimens are recorded from the lower half of the Łapczyca-1 section, depth range 183-312 m.

S. koeneni, *S. stenogyra* and *S. subtarchanensis* are only represented in Krywałd. Apart from one *S. koeneni* sample (13 ex. from 68-79 m) the two first mentioned species are restricted to depths below 90 m. *S. subtarchanensis* was recorded in three samples in the interval 78-81 m.

The species *S. tarchanensis*, according to Krach, occurs only in the lowermost sample (111.3-113 m) at Krywałd (1 ex.), whereas it was identified in five samples from Łapczyca-1, covering almost the entire depth interval (25-234 m).

With a few small gaps *S. valvatina* is regularly represented in both series of samples. *S. variabilis*, on the other hand, was only recognised at Krywałd (three samples, depths 93-101 m). Finally a sample of 10 unidentified *Limacina* specimens is available from Łapczyca-1 (without depth indication).

From Tables 3-4 it can be concluded that the species distribution as identified by Krach (1981) is at least curious. For example, in the depth interval 90-95 m of the Krywałd borehole Krach recognised the taxa *S. koeneni* and *S. valvatina*, respectively with 85 and 21 ex. In the sample 90-101 m, largely overlapping the first mentioned sample, the only recognised species is *S. stenogyra* (33 ex.).

If we look at the height/width-ratios of these three samples (measurable specimens, see Figs. 7-8), we note that Krach identified specimens with a H/W-ratio between 80 and 110 as *S. valvatina*, with a H/W-ratio between 100 and 125 as *S. koeneni* and with a H/W-ratio between 110 and 145 as *S. stenogyra*. Realising the lack of other characteristics it is apparent that the boundaries between the taxa are vague and, in fact, unrealistic.

Also, from the identifications written on the slides in which the specimens are

Table 3. Available numbers of limacinid species in the Krywald borehole, as identified by W. Krach (numbers of measurable specimens between brackets). Samples identified *Spiratella valvatina* → *koeneni* are included in *S. valvatina*. Double lines deliniate composite measured samples.

Depth in m	*Spiratella* *andruss.*	*koeneni*	*stenogyra*	*subtarch.*	*tarchan.*	*valvatina*	*variab.*
68 - 70	-	-	-	-	-	4 (2)	-
68 - 79	-	13 (10)	-	-	-	-	-
70 - 72	-	-	-	-	-	29 (19)	-
72 - 73	-	-	-	-	-	30 (21)	-
74 - 76	-	-	-	-	-	31 (24)	-
78 - 79	-	-	-	1 (0)	-	-	-
78 - 80	-	-	-	-	-	46 (32)	-
80 - 82	-	-	-	-	-	38 (31)	-
80 - 88	-	-	-	-	-	42 (32)	-
80.52 - 81	-	-	-	3 (2)	-	2 (2)	-
80.57 - 81	-	-	-	7 (7)	-	-	-
81 - 82	-	-	-	-	-	18 (16)	-
82 - 84	1 (0)	-	-	-	-	-	-
90 - 95	-	85 (61)	-	-	-	21 (9)	-
90 - 101	-	-	34 (23)	-	-	-	-
93 - 94	-	-	-	-	-	-	2 (2)
94 - 95	-	-	28 (23)	-	-	-	-
95 - 97	-	-	-	-	-	16 (13)	-
95 - 101	-	42 (31)	-	-	-	-	-
97 - 99	-	17 (16)	-	-	-	42 (31)	3 (1)
99 - 101	-	-	-	-	-	34 (21)	4 (0)
102 - 104	-	-	-	-	-	11 (9)	-
104 - 105	-	-	2 (2)	-	-	5 (4)	-
108 - 109	1 (0)	-	-	-	-	-	-
111.3 - 113	-	-	-	-	1 (1)	-	-

kept it is clear that Krach had great difficulties in naming his specimens. As an example (Fig. 2) the seven specimens from the Krywałd borehole (depth 80.57-81 m, listed in Table 3 as *S. subtarchanensis*) initially were identified *S. valvatina*, later changed in *S.* cf. *variabilis*. But also this latter name was changed on the slide and became *S. tarchanensis*. Still, Krach was not satisfied with this name and added the prefix '*sub*', by which the name changed to *S. subtarchanensis* ultimately. Also various other slides demonstrate this wavering identification.

It must be stated furthermore, that it is unknown in how far the samples available to us represent the complete material from the Krywałd borehole. In his 1981 paper Krach did not mention the numbers of specimens, or even the sample depths, restricting himself to localities only. Therefore it cannot be excluded that we are working with biassed samples!

Limacinid development in the Miocene of the North Sea Basin — In Early and Middle Miocene deposits of the North Sea Basin *Limacina valvatina* is a common con-

Table 4. Available numbers of specimens of limacinid species in the Łapczyca-1 borehole, as identified by W. Krach.

Depth in m	*Spiratella* *andruss.*	*koeneni*	*stenogyra*	*subtarch.*	*tarchan.*	*valvatina*	*variab.*	sp.
25	-	-	-	-	1	4	-	-
51 - 60	-	-	-	-	-	5	-	-
97	-	-	-	-	-	2	-	-
154 - 159	-	-	-	-	-	32	-	-
167	-	-	-	-	42	-	-	
171 - 178	-	-	-	-	-	44	-	-
177	-	-	-	-	1	-	-	-
178	-	-	-	-	1	-	-	-
180	-	-	-	-	10	-	-	-
181 - 184	-	-	-	-	-	9	-	-
183	1	-	-	-	-	-	-	-
184	1	-	-	-	-	-	-	-
187	-	-	-	-	-	16	-	-
227	1	-	-	-	-	-	-	-
231 - 232	-	-	-	-	-	2	-	-
234	-	-	-	-	1	-	-	-
267	-	-	-	-	-	2	-	-
312	2	-	-	-	-	-	-	-
no depth	-	-	-	-	-	-	-	10

stituent of the marine mollusc fauna. In these populations a rather high variability with respect to the H/W-ratios is found, ranging from below 85 to 110. At the beginning of the Langenfeldian suddenly *Limacina* populations occur in which also relatively higher specimens are present, with H/W-ratios up to 126.

Rasmussen (1968, p. 244, pl. 27, figs. 4-7) introduced the name *Spiratella gramensis* for such slender specimens. The most elongate specimen in his type sample (in which the H/W-ratios range from 85 to 126) from the Gram Teglvaerk borehole in Denmark (DGU 141.277, depth 21.00-21.50 m below surface) was chosen as the holotype.

Subsequent (yet unpublished) research by the senior author revealed that a practical boundary between *L. valvatina* and *L. gramensis* is found at H/W-ratio = 110, which resulted in the conclusion that only few specimens from the type sample of *L. gramensis* in reality can be reckoned to that taxon. Also other species (*L. ingridae* Janssen, 1989 and *L. irisae* Janssen, 1989) were recognised among the type material of *L. gramensis*. As a conclusion it may be noted that the species *L. valvatina* remains more or less constant for quite some time, with a H/W-ratio varying between 85 and 110 (depending on the population). At the Reinbekian/Langenfeldian boundary suddenly a radiation appears, resulting in the occurrence of two sympatric species, *L. valvatina* and *L. gramensis*, which disappear already in the course of, or certainly before the end of the Langenfeldian. At the same time, however, a new species group of Limacinidae appears in the North Sea Basin, starting with the very depressed species *L. ingridae*, which develops quickly into two succeeding species, viz. *L. wilhelminae* and *L. atlanta*.

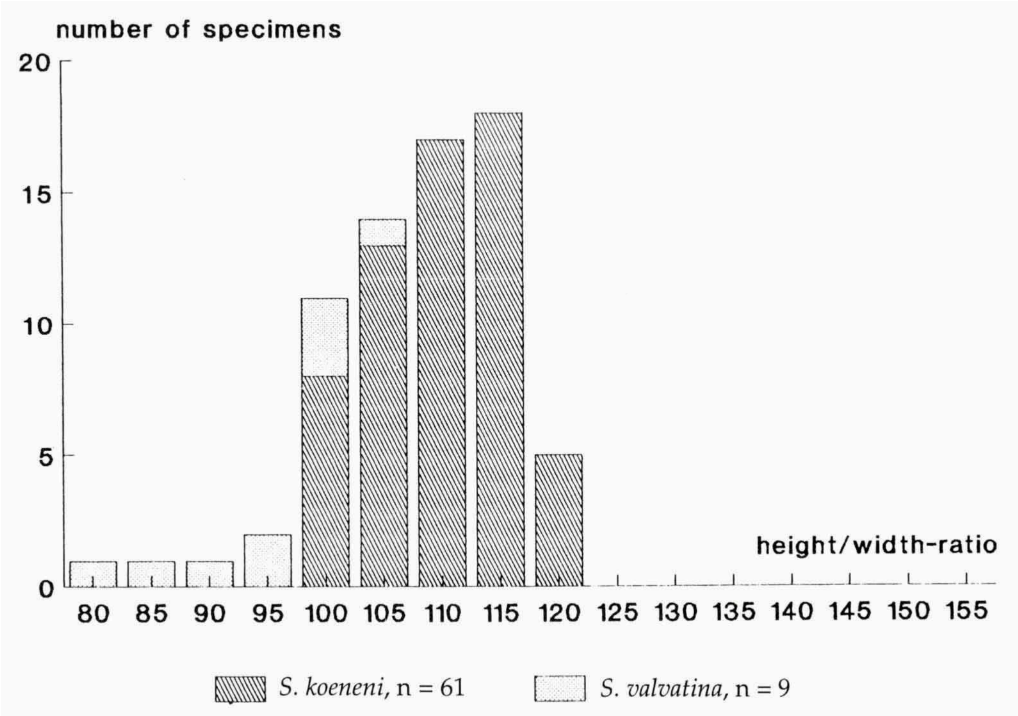


Fig. 7. Height/width-ratio distribution of *Spiratella koeneni* and *S. valvatina* in the Krywałd borehole, depth 90-95 m, as identified by W. Krach.

The first appearance datum (FAD) of *L. gramensis* was taken as the starting point of Pteropod Zone 20 in Janssen & King's (1988) pteropod zonation for the North Sea Basin.

Around the boundary between the Langenfeldian and the Gramian *L. wilhelminae* changes into a succeeding form, *L. atlanta*, which continues into the Pliocene. The FAD of *L. atlanta* is taken as the starting point of Pteropod Zone 21 (Janssen & King, 1988). All these forms are exclusively known from the North Sea Basin, with the exception of the final evolutionary stage, *L. atlanta*, which is also found in Pliocene (Zanclian and Piacenzian) deposits of the Mediterranean area (northern Italy and southern France, RGM collections).

Interpretation of the Polish limacinids — When starting the study of Krach's material from the Kraków area and noting the presence of such highly coiled specimens of *Limacina*, it was logical to presume that a similar evolutionary trend was present in the *L. valvatina* development in the Carpathian Foredeep as observed in the North Sea Basin. To approach this possibility in an objective way measurements were taken from all measurable specimens from the Krywałd borehole, the most complete section, from which sufficient samples of all taxa are available.

For this purpose the samples were united into four composite groups (double lines in Table 3), to obtain samples of sufficient size, still capable of indicating trends

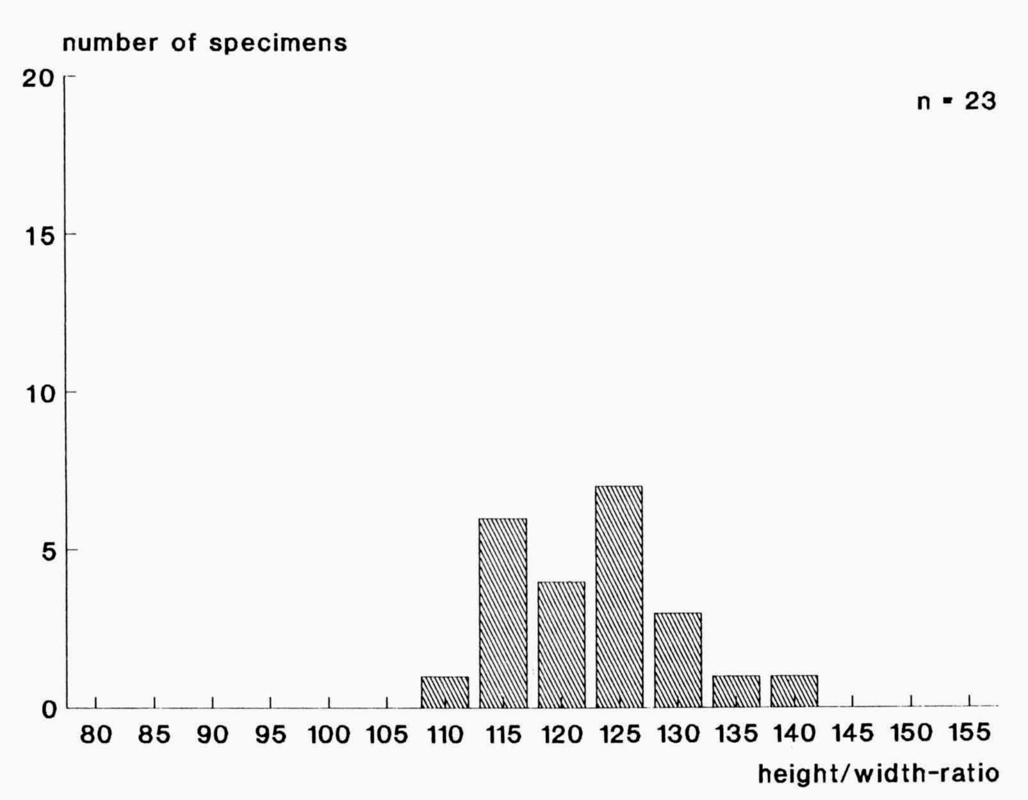


Fig. 8. Height/width-ratio distribution of *Spiratella stenogyra* in the Krywałd borehole, depth 90-101 m, as identified by W. Krach.

in the development of the populations. Almost all specimens from this section are preserved as pyritic casts, but in some cases still possessing (remnants of) their thin-walled shells. Frequently the specimens are damaged or distorted, but in practically all samples more than half the number of specimens is sufficiently complete for a measurement of height, width and number of whorls. In Table 3 the number of such measurable specimens is indicated between brackets.

The rather surprising results are represented in Fig. 9 by means of scatter diagrams and stacked bar graphs for each of these four groups of samples. From the graphs it is obvious that the most elongate specimens occur in the samples between 90 and 101 m below surface, whereas the samples higher in the section remain largely below a H/W-ratio of 110.

Apparently the building of a slender shell is just a temporary feature here: in higher samples almost completely typical *L. valvatina* populations are found again. This is different from what happens in the North Sea Basin. Although information from that area is as yet scattered the distinct impression exists, that *L. valvatina* and *L. gramensis* coexist for some time, but the former species certainly disappears earlier than the latter (Janssen & King, 1988).

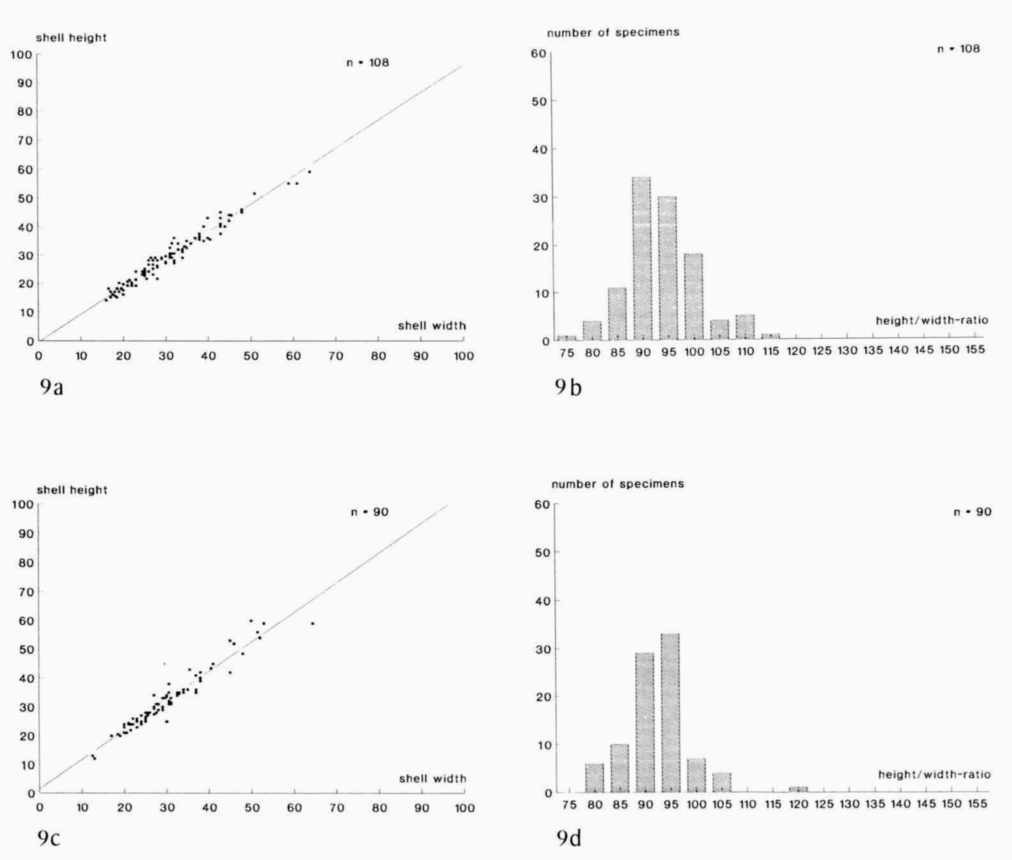
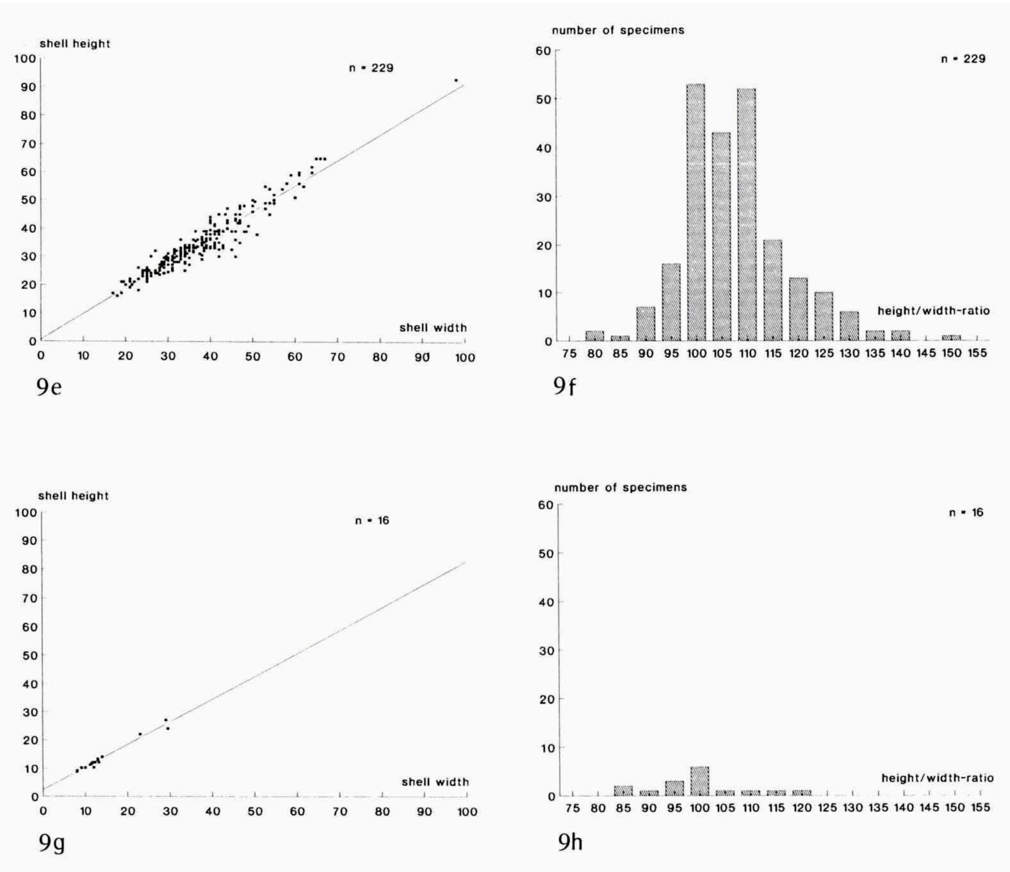


Fig. 9. Height/width-ratio distributions of limacinid species in the Krywałd borehole (combined samples); a-b: depths 68-80 m; c-d: depths 80-84 m; e-f: depths 90-101 m; g-h: depths 102-113 m (compare Table 3).

The question whether or not the occurrence of slender *Limacina* species in the North Sea Basin and in the Central Paratethys is synchronous or not should be answered before a final decision on their conspecificity can be taken. Fig. 1 in Steininger et al. (1990), based on a large number of recent papers, gives a synthesis of the actual knowledge on the correlation of the Paratethys chronostratigraphy with the standard Mediterranean subdivision. The lower boundary of the Badenian coincides with the Burdigalian/Langhian boundary, and thus with the Early/Middle Miocene boundary. The Badenian itself is subdivided in three substages: Early, Middle and Late Badenian. The Early Badenian fits the Langhian, the Middle and the Late Badenian correlate together with the first half of the Serravallian. The Polish limacinid samples discussed here are of Late Badenian age, so we may assume that the development discussed above is of about middle Serravallian age in terms of Mediterranean chronostratigraphy.

The first occurrence of *L. gramensis* in the North Sea Basin is in the basal part of



the Gram Clay in Denmark, which is of Langenfeldian age. For a correlation with the Mediterranean subdivision we depend on a paper published by Herngreen (1987), who effected a first order correlation (based on dinoflagellates) between these deposits and the Piedmont (northern Italy) subdivision, as published by Powell (1983). According to this correlation the sediments yielding the first specimens of *L. gramensis* correlate with the middle part of the Serravallian.

The final conclusion may be that the first appearances of slender *Limacina* species in the North Sea Basin and in the Carpathian Foredeep indeed seem to be roughly synchronous. Apparently a quite similar feature is found here: a development of highly comparable, slender forms, evolving from and next to *L. valvatina*. The name *L. gramensis* Rasmussen, 1968 is the first valid name for the slender form, which should also be applied for similar populations in the Paratethys.

The Polish material of *L. gramensis*, by the way, demonstrates a considerably wider range of variability than the, admittedly, rather few North Sea Basin specimens, among which the most elongate specimens reach a H/W-ratio of 126. In the Paratethys considerably more elongate specimens are present, reaching a H/W-ratio up to over 150.

A natural boundary between *L. valvatina* and *L. gramensis* is difficult to establish. The bar graph for the Krywałd sample 90-101 m gives only a slight indication for the presence of two species, and also the scatter diagram demonstrates this only faintly. Still, we prefer to maintain the same morphological boundaries as found to be practical in the North Sea Basin, just to avoid a different interpretation of the *L. valvatina* taxon in different basins. Therefore we apply the boundary of H/W-ratio = 110 as decisive in this respect.

Krach (and earlier authors) identified the most elongate shells as *S. stenogyra*. As stated above this name is a junior synonym of the Recent *L. retroversa*. In Fig. 4 a specimen of the Miocene form is compared with a Recent *L. retroversa*. It is clear that the spire of *L. retroversa* is comparatively broader and that its whorls increase more quickly in diameter, resulting in a relatively higher aperture. Furthermore, in *L. retroversa* frequently a fine, close-set and regular spiral sculpture is present, which is absent in the Miocene species. Finally, there is an obvious difference in ecology: the Recent species occurs only in relatively cold water (van der Spoel, 1967, p. 350, fig. 337), whereas the water temperatures during the Miocene must have been close to subtropical. *L. retroversa* is not known to occur in deposits older than Quaternary.

Also the name *S. koeneni*, introduced by Kittl (1886, p. 68, pl. 2, fig. 37) for North Sea Basin material (type locality is Langenfelde), cannot be used. Its application for relatively slender specimens is caused by the incorrect illustration published by Kittl. The only remaining syntype of this taxon has suffered severely from pyrite disintegration (Janssen, 1984, pl. 1, fig. 7). Its proportions resemble closely *L. valvatina*, but its condition is so bad that it must be considered a nomen dubium.

Among the further taxa recognised by Krach is a species introduced by himself (1979a; based on a manuscript name of Friedberg), described with the name *S. variabilis*. Under this name Krach united a number of comparatively large specimens, with variable shell forms (hence its name!). When studying the specimens indicated with this name in the available material it becomes clear, that all samples from Krywałd yielding this taxon are restricted to the same interval 90-101 m as the elongate species indicated *S. stenogyra*. The main characteristic of the *S. variabilis* specimens is their relatively large size, and the fact that the spire of the shell is initially very slender, with the one or two final whorls suddenly developing much more widely. This results in specimens with a distinct concave tangent along the sides of the spire and in shells that in the completely adult stage are barely higher than wide. Careful comparison of this material demonstrates that the large *S. variabilis* specimens with widening body whorl are nothing but the completely adult forms of Krach's *S. stenogyra*, and should equally be named *L. gramensis*.

The development, by the way, of such a wide body whorl in the adult stage has never been observed in North Sea Basin populations, in which *L. gramensis* always demonstrates a completely regular set of whorls and remains distinctly smaller. These differences in the populations from the two basins have some analogy with *L. valvatina*, which in the Carpathian Foredeep also reaches considerably larger dimensions than in the North Sea Basin.

The distinction between *L. valvatina* and *L. gramensis* is easy and usually possible at first glance. In some cases, of course, it will be necessary to measure height and width for a correct identification. Still, it is not always possible to rely on these characteristics, as is obvious from the specimens illustrated in Pl. 1, fig. 5 and Pl. 4, fig. 2. Here we have two large specimens from the same sample (Krywałd, 97-99 m), with similar H/W-ratios. One of these, however, is considered to belong to *L. valvatina*, the other to *L. gramensis*. The reason for this is the completely regular spire of the first mentioned specimen, and the concave spire of the second, caused by its slender initial whorls.

For specimens with a very depressed shell form Krach used the names *S. andrussowi*, *S. tarchanensis* and *S. subtarchanensis*. The type material of the first two taxa (both introduced from the Middle Miocene of Crimea) was studied by Janssen (1984). *S. andrussowi* is a species with a usually completely flat spire and a comparatively large and high body whorl. *S. tarchanensis* has a slightly higher spire and indeed resembles very depressed forms of *L. valvatina*. Still, the diameter of its whorls increases more quickly and the species apparently is closely related to the Late Oligocene taxon *L. hospes* Rolle, 1861. *S. subtarchanensis* Zhizhchenko, 1936 is a taxon difficult to interpret without a direct comparison of the type material. It differs from *S. tarchanensis* merely by its somewhat more convex whorls.

None of these three taxa could be identified by us with any certainty in the Krach collection. Most of the specimens incorrectly identified as *S. andrussowi* could be recognised as belonging to *Limacina miorostralis*, a form also described from the North Sea Basin Miocene, and co-occurring there with *L. valvatina* during the Hemmoorian and the Reinbekian.

Limacina gramensis (Rasmussen, 1968)
Pl. 3, fig. 13; Pl. 4, figs. 1-9; Pl. 5, figs. 1-3.

v. 1867 *Spirialis ventricosa* Sowby — Reuss, p. 61 (partim, non Sowerby, only part of the sample from Ronaszék, see discussion below).

v. 1886 *Spirialis stenogyra* (Philippi) — Kittl, p. 67, pl. 2, figs. 35-36 (partim, non Philippi).

. 1958 *Spirialis* cf. *koeneni* Kittl — Venglinskij, p. 74, pl. 1, fig. 1 (partim, non Kittl, non pl. 1, fig. 2 = *Limacina valvatina*).

*v 1968 *Spiratella gramensis* nov. sp., Rasmussen, p. 244, pl. 27, figs. 4-7 (partim, the type material includes various other *Limacina* species, see below).

. 1968 *Spiratella* cf. *koeneni* (Kittl) — Čtyroký et al., p. 132, pl. 4, fig. 13 (non Kittl).

v. 1979a *Spiratella variabilis* (Friedberg) in coll. 1938, Krach, p. 656, figs. 2-3.

v. 1981 *Spiratella koeneni* (Kittl) 1886 — Krach, p. 126, pl. 6, fig. 4 (partim, non Kittl, non pl. 3, figs. 5, 6, 9 = *Limacina valvatina*).

v. 1981 *Spiratella koeneni* (Kittl) - transition to *S. stenogyra* (Phil.) — Krach, p. 126, pl. 5, fig. 3, 5-7 (non Kittl, nec Philippi, non pl. 5, fig. 4 = *Limacina valvatina*).

v. 1981 *Spiratella stenogyra* (Philippi) 1844 — Krach, p. 126, pl. 3, figs. 10-12; pl. 4, fig. 3; pl. 5, fig. 8; pl. 6, fig. 3 (partim, non Philippi, for specimens with H/W-ratio < 110 see *L. valvatina*).

v. 1981 *Spiratella variabilis* (Friedberg) in coll. 1938 — Krach, p. 128, pl. 6, fig. 7 (partim, non pl. 3, fig. 1 = *Limacina valvatina*).

v. 1981 *Spiratella* cf. *variabilis* (Friedberg) in coll. 1938 — Krach, p. 128, pl. 5, fig. 12 (partim, non pl. 5, fig. 13 = *Limacina valvatina*).

v. 1984 *Spirialis stenogyra* (Philippi, 1844) — Janssen, p. 71, pl. 3, figs. 1-2.

Type material — Holotype (Rasmussen, 1968, pl. 27, figs. 4-7) housed in the Geological Survey of Denmark. The type lot comprises 27 ex., but only three of the paratypes are also considered to belong to *L. gramensis*. The other paratypes in this sample belong to *L. valvatina* or still other species. The H/W-ratio distribution in this sample is given here in Fig. 10.

Lectotype designation of *Spiratella variabilis* — Krach (1979a) mentioned as holotype a specimen in a sample from Ujście, indicated in Krach (1981) as 'an assemblage of the Laboratories of the Department of Geological Sciences of the Polish Academy of Sciences in Kraków' (translated). This sample is among the material available to us and comprises three specimens, none of which, however, is indicated as 'holotype'. The larger one of these seems to agree with Krach's (1981) pl. 6, fig. 7. It demonstrates distinctly the spiral sculpture mentioned in the original description. The two smaller specimens are severely distorted, but one of them has the apical angle of *L. valvatina*, whereas the other is conspecific with the first mentioned specimen. Therefore we here designate the largest specimen as the lectotype (Pl. 5, fig. 3).

From Krywałd three samples were considered by Krach to belong to the present species, viz. 4 ex. from depth 99-101 m, 3 ex. from 97-99 m and 2 ex. from 93-94 m. One large shell (H almost 4 mm) from the interval 97-99 m, however, is a distinct specimen of *L. valvatina* (H/W-ratio 105.4).

Samples from Wierzbowiec (Ukraine), mentioned in the original description, have not been available to us. Type locality of *S. variabilis* is Ujście near Snyatyn (Ukraine), borehole, depth (not mentioned in the original publication, but written on the slide): 52.95 - 53.3 m.

Stratum typicum — Gram Clay (Miocene, Langenfeldian).

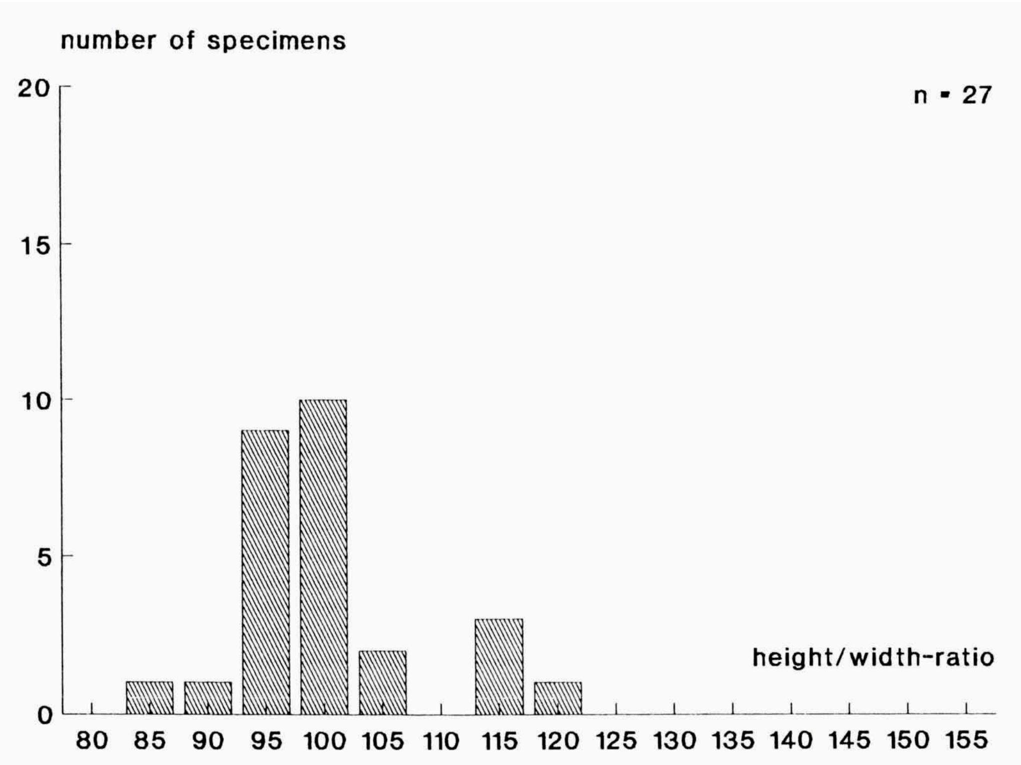


Fig. 10. Height/width-ratio distribution of the type lot of *Limacina gramensis* (Rasmussen, 1968) from the borehole Gram DGU 141.277, depth 21-21.50 m (coll. Danmarks Geologiske Undersøgelse, Copenhagen).

Revised diagnosis — *Limacina* species with a slender juvenile shell (H/W-ratio varying between 110 - c. 150), and one or two suddenly widening adult whorls (only known from the Carpathian Foredeep area), resulting in distinctly concave tangents of the spire.
Material studied (for a detailed specification see Table 6) — Krywałd borehole, depth 104-105 m: 2 ex.; depth 102-104 m: 3 juvenile ex.; depth 99-101 m: 4 ex.; depth 97-99 m: 7 ex.; depth 95-101 m: 14 ex.; depth 97-99 m: 2 ex.; depth 94-95 m: 27 ex.; depth 93-94 m: 2 ex.; depth 90-101 m: 32 ex.; depth 90-95 m: 31 ex. Ujście borehole (Ukraine), depth 52.95-53.3 m: 2 ex.

Description — The most important feature of this species is the fact that the juvenile shell is slender, with a height/width-ratio varying between 110 and c. 150. This part of the shell shows a regular growth, with straight tangents of the spire. The adult shell reaches 7 whorls and the last one or two of these demonstrate a sudden sideward expansion, as a result of which the tangents of the spire become distinctly concave, and the initially slender shell may finish about as wide as high. The umbilicus of the juvenile shell is small, to almost invisible, but in the adult shell it is wide and distinct.

On the body whorl of the lectotype of *S. variabilis* spaced spiral striae are present, which are cut by almost vertical growth lines, thus forming a kind of irregular reticulation. In other specimens these spirals are absent.

Discussion — The spiral striation as present on the lectotype of *S. variabilis* is by no means typical for the present species. Similar spiral sculpture is found, in the collection studied in this paper, in some large specimens of *L. valvatina.*

The sample from Ronaszék first published by Reuss (1867) and Kittl (1886, p. 67, figs. 35-36), and discussed by Janssen (1984, p. 71, pl. 3, figs. 1-2) could be reinvestigated thanks to the much appreciated cooperation of colleague O. Schultz (Naturhistorisches Museum, Wien). It comprises a total of 138 ex., all in pyrite cast preservation, of which 81 are sufficiently well preserved to be measured. The range of the H/W-ratios is 87-135, with a mean value of 110.0. A stacked bar graph of these ratios (Fig. 11) demonstrates the same features as the one given for the Krywałd 90-101 m sample, with a slight inclination of the curve at value 105. All specimens with a H/W-ratio below 110 we consider to belong to *L. valvatina*, the others to *L. gramensis.*

Limacina miorostralis (Kautsky, 1925)
Pl. 1, fig. 1-2.

Selected synonyms:
- * 1925 *Spirialis miorostralis* nov. spec., Kautsky, pp. 202, 238.
- v. *1967 Spiratella andrussovi andrussovi* — Rögl, p. 36.
- v. 1968 *Spirialis andrussowi andrussowi* (Kittl) — Čtyroký et al., p. 131, pl. 4, fig. 12a-b (partim, non pl. 4, fig. 11a-b = *Limacina valvatina*).
- v. 1972 *Spiratella kautskyi* sp. nov., Janssen, p. 63, fig. 41a-b; pl. 11, fig. 11a-b.
- v. *1975 Spiratella andrussovi andrussovi* (Kittl) — Steininger et al., pp. 16, 61, table 1.
- v. 1981 *Spiratella andrussovi* (Kittl) — Krach, p. 128, pl. 3, fig. 15 (2 figs.); pl. 5, fig. 14a-b (partim, non Kittl).
- v. 1984 *Limacina miorostralis* (Kautsky, 1925) — Janssen, p. 381, pl. 20, figs. 3a-b, 4a-b.

v. 1991a *Limacina miorostralis* (Kautsky, 1925) — Zorn, p. 21, pl. 2, figs. 5-6.
v. 1991b *Limacina miorostralis* (Kautsky, 1925) — Zorn, p. 100, pl. 3, figs. 1-4; pl. 11, fig. 2.

Type material — The whereabouts of Kautsky's type material are unknown to us. It could not be traced in the collections of the Institut für Paläontologie und Geologie, Universität Hamburg (Germany) and according to Dr E. Pietrzeniuk it is also absent in the collections of the Museum für Naturkunde der Humboldt-Universität, at Berlin, Germany.
Type locality — Hemmoor and Basbeck-Osten (Lower Saxony, Germany).
Stratum typicum — 'Im braunen Kalksandstein' and 'im Vaginellenkalksandstein' (Miocene, Hemmoorian, reworked in Quaternary deposits).
Diagnosis — *Limacina* with initial whorls slightly elevated but later whorls planospiral and rising above the apex. Whorls quickly increasing in diameter. Aperture large. Apertural margin with a weak rostrum developed in completely adult specimens, as in the Recent *L. inflata* (d'Orbigny, 1836). Base widely umbilicate.
Material studied (for a detailed specification see Table 6) — Brzeszcze-1 borehole, depth 61 m: 1 ex. Łapczyca-1 borehole, depth 312 m: 2 ex.; depth 184 m: 1 ex.; depth 183 m: 1 ex. Mszana-1 borehole, depth 145-149 m: 2 ex.

Description — The few available specimens are typical representatives of this species, completely agreeing with material from the North Sea Basin (see Kautsky, 1925). They all remain far below the adult state and therefore an apertural rostrum is not

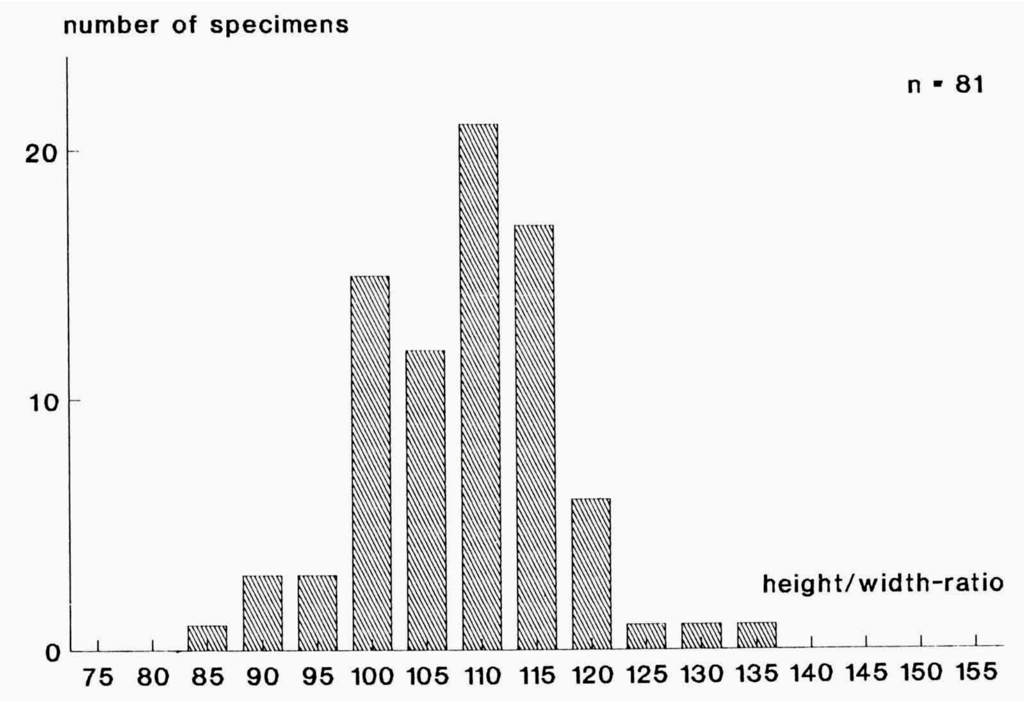


Fig. 11. Height/width-ratio distribution of a limacinid sample from the Ronaszék borehole (NHMW).

developed in any of them. This, by the way, is also the case in most specimens from the North Sea Basin. A distinct rostrum is only very rarely found indeed.

Discussion — Krach (1981) identified the present specimens as '*Spiratella andrussovi*', no doubt because of their flat apical side. Still, the differences are considerable. In *Limacina andrussowi* the whorls increase more slowly in diameter and they are more produced downwards (compare illustrations of the type series in Janssen, 1984, pl. 2, figs. 2-9 and of the lectotype on Pl. 1, fig. 3a-b in the present paper).

The fact that *L. andrussowi* is absent from this part of the Paratethys is in agreement with the observations of Zorn (1991a, b), who also identified earlier records from the Austrian Tertiary of *L. andrussowi* as *L. miorostralis*. Up to now genuine *L. andrussowi* is exclusively known with certainty from the Black Sea Basin Miocene.

Krach illustrated two specimens from the Łapczyca borehole (as usual without indication of the sample depth). At least the photographed one should be recognisable on the configuration of the shell wall remnants, but it could not be traced among the specimens available to us.

From the Krywałd borehole, depths 108-109 m and 82-84 m below surface, two specimens labelled *Spiratella andrussovi* were present in the collection available to us. The first mentioned of these is a very juvenile specimen in shell preservation of *Limacina valvatina*, the second one proved to be a juvenile dextral (benthic) gastropod species. Also another specimen labelled *Spiratella andrussovi*, from the Łapczyca-1 borehole (depth 227 m), appeared to be a dextral benthic gastropod.

Limacina valvatina (Reuss, 1867)
Pl. 1, figs. 4-11; Pl. 2, figs. 1-11; Pl. 3, figs. 1-12

Selected synonyms (restricted to Paratethys occurrences):

*v 1867 *Spirialis valvatina* Rss., Reuss, p. 146, pl. 6, fig. 11a-b.

v. *1867 Spirialis ventricosa* Sowby — Reuss, p. 61 (partim, non Sowerby, only part of the sample from Ronaszék, see also *Limacina gramensis*).

v. 1886 *Spirialis stenogyra* (Philippi) — Kittl, p. 67, pl. 2, figs. 35-36 (partim, non Philippi).

v. 1886 *Spirialis valvatina* Reuss — Kittl, p. 69, pl. 2, fig. 38.

v? 1886 *Spirialis koeneni* n.f., Kittl, p. 68, pl. 2, fig. 37 (mala) (nomen dubium).

v. *1886 Spirialis stenogyra* (Philippi) — Kittl, p. 67 (partim, non Philippi, 1844, only part of the sample from Ronaszék, see also *Limacina gramensis*).

. 1934 *Spirialis nucleatus* nov. sp., Zhizhchenko, pp. 80, 89.

. 1936 *Spirialis nucleatus* Zhizhchenko — Zhizhchenko, pp. 271, 323, pl. 26, figs. 7-10 (not figs. 8-12 as mentioned on p. 323) (cited as *Sp. nucleatis* on pl. 26).

. 1958 *Spirialis* cf. *koeneni* Kittl — Venglinskij, p. 74, pl. 1, fig. 2 (partim, non Kittl, non pl. 1, fig. 1 = *Limacina gramensis*).

. 1958 *Spirialis valvatina* Reuss — Venglinskij, p. 74, pl. 1, fig. 3; pl. 2, figs. 4-5.

. 1959 *Spirialis nucleatus* Zhizhchenko — Zhizhchenko, p. 288, pl. 18, figs. 30-33.

. 1968 *Spiratella valvatina* (Reuss) — Čtyroký et al., p. 131, pl. 4, fig. 10a-b.

v. 1972 *Spiratella valvatina* (Reuss, 1867) — Janssen, p. 61, figs. 31-37.

v. 1981 *Spiratella valvatina* (Reuss) 1887 — Krach, p. 125, pl. 3, figs. 2-4, 7-8; pl. 5, figs. 1-2, ?9, 10-11; pl. 6, figs. 1-2.

v. 1981 *Spiratella koeneni* (Kittl) 1886 — Krach, p. 126, pl. 3, figs. 5, 6, 9 (partim, non Kittl, non pl. 6, fig. 4 = *Limacina gramensis*).
v. 1981 *Spiratella koeneni* (Kittl) - transition to *S. stenogyra* (Phil.) — Krach, p. 126, pl. 5, fig. 4 (non Kittl, nec Philippi, non pl. 5, figs. 3, 5-7 = *Limacina gramensis*).
v. *1981 Spiratella stenogyra* (Philippi) 1844 — Krach, p. 126 (partim, non Philippi, only specimens with H/W-ratio below 110)
v. 1981 *Spiratella tarchanensis* (Kittl) 1886 — Krach, p. 127, pl. 4, fig. 1; ? pl. 6, fig. 6a-b (not the erroneously numbered fig. 6c: see *Peracle lata*).
v. 1981 *Spiratella subtarchanensis* (Shizhchenko) 1936 — Krach, p. 127, pl. 6, fig. 5 (mala?) (non Zhizhchenko?).
v. 1981 *Spiratella variabilis* (Friedberg) in coll. 1938 — Krach, p. 128, pl. 3, fig. 1 (partim, non Krach, non pl. 6, fig. 7 = *Limacina gramensis*).
v. 1981 *Spiratella* cf. *variabilis* (Friedberg) in coll. 1938 — Krach, p. 128, pl. 5, fig. 13 (partim, non Krach, non pl. 5, fig. 12 = *Limacina gramensis*).
v. *1984 Spirialis valvatina* Reuss, 1867 — Janssen, p. 72.
v. 1991a *Limacina valvatina* (Reuss, 1867) — Zorn, p. 19, pl. 1, figs. 1-3.
v. 1991b *Limacina valvatina* (Reuss, 1867) — Zorn, p. 97, pl. 1, figs. 1-6; pl. 10, figs. 1-2; pl. 11, figs. 4-5.
v. in press *Limacina valvatina* (Reuss, 1867) — Bohn-Havas & Zorn, pl. 1, figs. 1-9.

Type material — Lectotype designated by Janssen (1984, p. 72), based on illustrations of the remaining syntypes in Janssen (1972, p. 62, figs. 31-37). Lectotype and 6 paralectotypes in NHMW (reg. 1867.VII.42).
Type locality — Wieliczka (Poland).
Stratum typicum — Rock salt deposits (Miocene, Badenian, Wielician).
Diagnosis — Regularly conical *Limacina*, with H/W-ratio varying between c. 75 and 110.
Material studied (for a detailed specification see Table 6) — Brzeszcze-1 borehole, depth 61-62 m: 3 ex.

Plate 1

Figs. 1-2. *Limacina miorostralis* (Kautsky, 1925)
Łapczyca-1 borehole.
1: -183 m (RGM 393 020); a: apical view; b: frontal view.
2: -184 m (INGK); a: apical view; b: oblique apical view; c: frontal view.
Fig. 3. *Limacina andrussowi* (Kittl, 1886)
3: Lectotype, Kop Kotschegen, Kertsch Peninsula, Crimea; a: apical view; b: frontal view (NHMW).
Figs. 4-11. *Limacina valvatina* (Reuss, 1867)
Krywałd borehole, frontal views.
4: 104-105 m (INGK).
5: 97-99 m (RGM 393 011).
6: 97-99 m (INGK).
7-9: 90-95 m (INGK).
10-11: 80.57-81 m (INGK).
Figs. 1-2: specimens identified by Krach (1981) as *Spiratella andrussovi* (Kittl); figs. 4-6: as *Spiratella valvatina* (Reuss); figs. 7-9: as *Spiratella koeneni* (Kittl) and Figs. 10-11: as *Spiratella subtarchanensis* (Zhizhchenko). Magnification of all figures X 25.

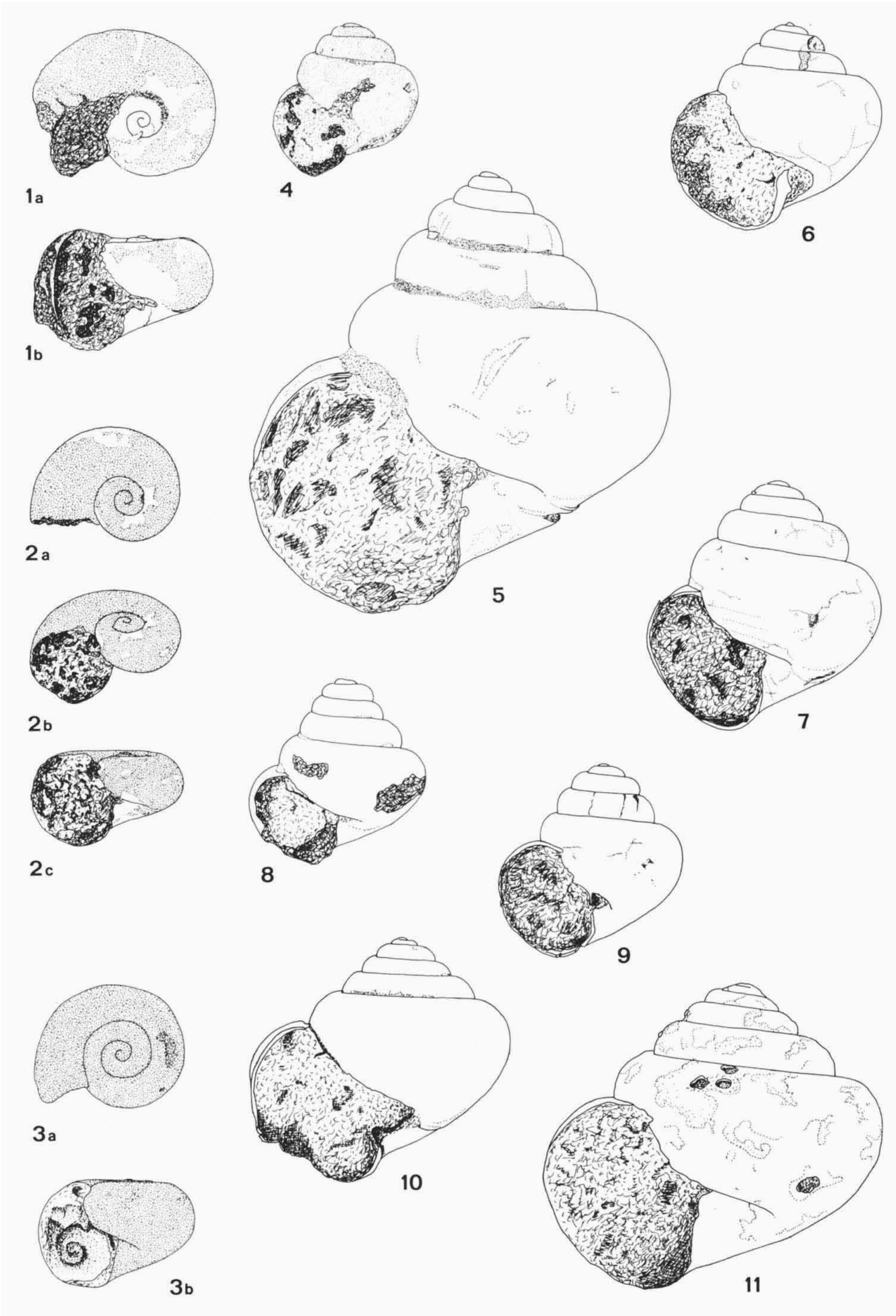


Plate 1

(*Limacina* cf. *valvatina*); depth 60 m: 2 ex.; depth 59-62 m: 9 ex. Czernica outcrop: 1 ex. Gliwice Stare outcrop: 7 ex. Kietrz-4 borehole, depth 35 m: 12 ex. Kietrz-5 borehole, depth 5.6-10 m: 18 ex. Kolanow-1 borehole, depth 1017-1021 m: 4 ex.; depth 1004.4-1011 m: 5 ex. Kop. Zofiówka borehole, depth 610 m: 1 ex. Korytnica outcrop: 1 ex. Koszyce Małe borehole, depth 155.1-159.6 m: 2 ex. Krywałd borehole, depth 111.3-113 m: 1 juvenile ex.; depth 104-105 m: 1 ex., 4 juvenile ex.; depth 102-104 m: 11 juvenile ex.; depth 99-101 m: 34 ex.; depth 97-99 m: 53 ex.; depth 95-101 m: 28 ex.; depth 95-97 m: 16 ex.; depth 94-95 m: 1 ex.; depth 90-101 m: 1 ex.; depth 90-95 m: 75 ex.; depth 81-82 m: 18 ex.; depth 80.57-81 m: 7 ex.; depth 80.52-81 m: 3 ex., 2 juvenile ex.; depth 80-88 m: 42 ex.; depth 80-82 m: 38 ex.; depth 78-80 m: 46 ex.; depth 78-79 m: 1 ex.; depth 74-76 m: 31 ex.; depth 72-73 m: 30 ex.; depth 70-72 m: 29 ex.; depth 68-79 m: 12 ex.; depth 68-70 m: 4 ex. Łabędy outcrop, 22 juvenile ex. Łapczyca-1 borehole, depth 267 m: 2 ex.; depth 234 m: 1 juvenile ex.; depth 231-232 m: 2 ex.; depth 187 m: 16 ex.; depth 181-184 m: 9 ex.; depth 180 m: 10 ex.; depth 178 m: 1 ex.; depth 171-178 m: 38 ex., 6 fragments; depth 177 m: 1 ex.; depth 167 m: 42 ex.; depth 154-159 m: 32 ex., 3 fragments; depth 97 m: 2 ex.: depth 51-60 m: 4 ex.; depth 25 m: 4 ex.; depth 25 m: 1 ex.; no depth indicated: 10 more or less distorted ex. Mielec-5 borehole, depth 680.50 m: 1 adult and 1065 juvenile to very juvenile ex. Mszana-1 borehole, depth 162-163 m: 5 ex.; depth 149-153 m: 1 ex.; depth 113-117 m: 1 ex. Niepaszyce outcrop: 33 juvenile ex. Niepaszyce-1 borehole (no depth indicated): 3 juvenile ex.; Niepaszyce-2 borehole (no depth indicated): sieving residue with thousands of juvenile ex. Roczyny-1 borehole, depth 160.2-162.4 m: c. 6 ex.; depth 156.2-158.2 m: c. 18 ex. Ujście borehole (Ukraine), depth 52.95-53.5 m: 1 deformed ex.

Discussion — Material identified *Spiratella tarchanensis* is available from all localities mentioned by Krach (1981), except from the Ukrainian locality Ujście. The specimens from the Łapczyca-1 borehole without exception can be recognised as either relatively depressed or otherwise distorted specimens of *L. valvatina*. The same is most probably true for the specimen from Ujście, illustrated by Krach (1981, pl. 6, fig. 6a-b). From Krywałd, Łabedy and Niepaszyce (various samples) exclusively juvenile specimens in shell preservation are present.

From the Niepaszyce-2 borehole there is a sieving residue, containing thousands of juvenile specimens. This sample was apparently washed on a 0.1 mm mesh. Apart from the monospecific holoplanktonic mollusc association this sample contains quite a few larval shells of planktotrophic benthic molluscan species (some bivalves, Rissoi-

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Plate 2

Figs. 1-11. *Limacina valvatina* (Reuss, 1967)

Krywałd borehole, frontal views.

1-3: 81-82 m (RGM 393 017-019).

4: 80.57-81 m (INGK).

5: 78-80 m (INGK).

6: 80-82 m (INGK).

7: 80-88 m (INGK).

8: 78-79 m (INGK).

9-11: Krywałd, 74-76 m (INGK).

Figs. 1-3, 7, 9-11: specimens identified by Krach (1981) as *Spiratella valvatina* (Reuss); fig. 5: as *Spiratella valvatina* var.; fig. 6: as *Spiratella valvatina* (Reuss) → *koeneni* (Kittl); figs. 4 and 8: as *Spiratella subtarchanensis*. Magnification of all figures X 25.

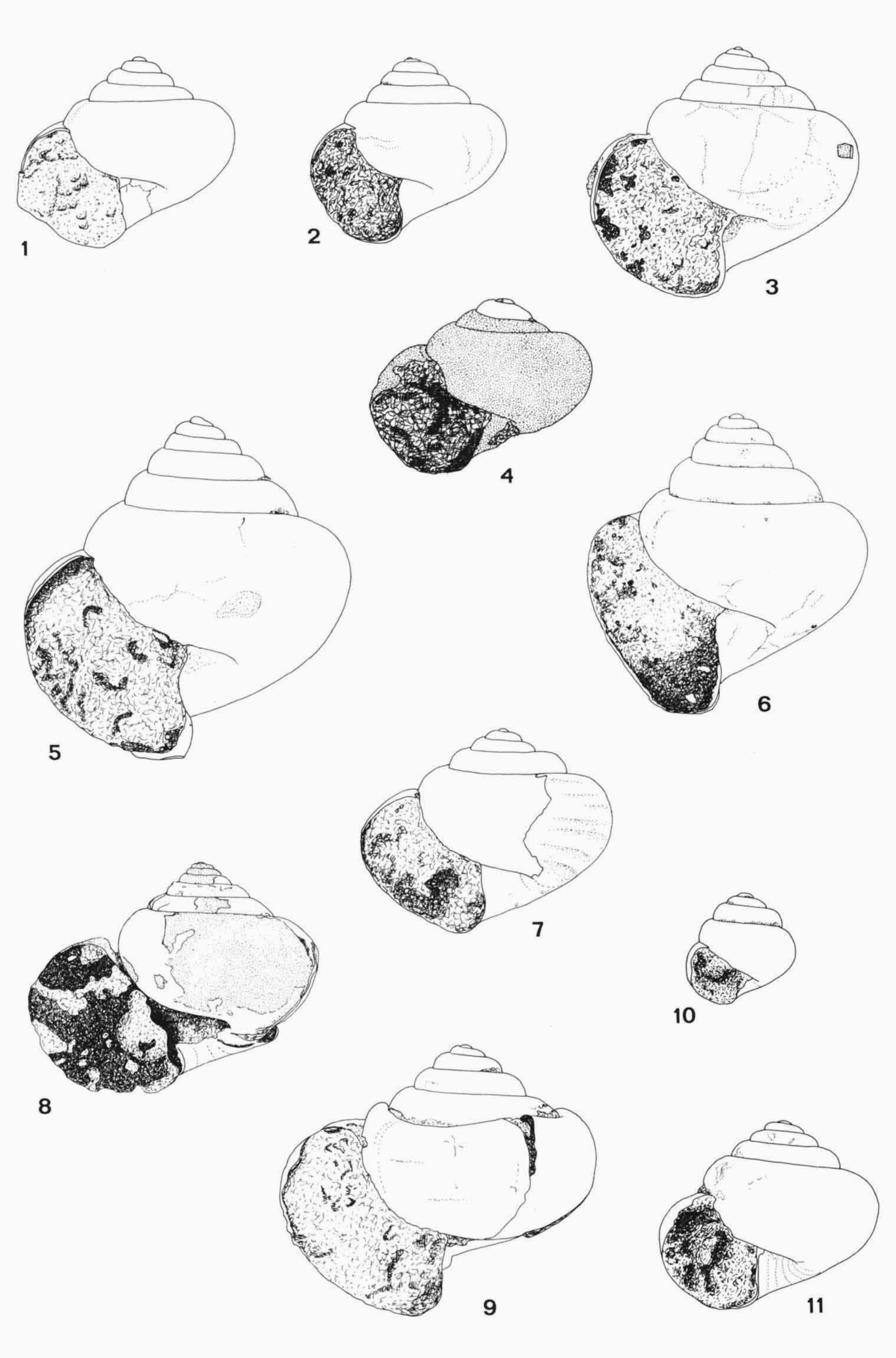

Plate 2

dae, Cerithiidae, Vermetidae, Pyramidellidae, Cephalaspidea), rare foraminifers (with strikingly few globigerinids), ostracodes, echinoderms, brachiopods (*Discina* sp.), and somewhat more common fish remains (skeleton parts, dermal scales and a few otoliths). As the larval shells of Gymnosomata (e.g. *Paedoclione*) in Recent bottom samples are predominantly found in the sieving fraction between 0.1 and 0.2 mm we thoroughly inspected this fraction in the present sample, but without success. It is rather curious, by the way, that exclusively the species *L. valvatina* is present in this sample. Among the many thousands of juvenile specimens not one shell of e.g. *L. miorostralis*, *Creseis spina*, or *Vaginella austriaca* could be found, so these have been either completely absent or extremely rare at the time of deposition of this sample.

Such very small specimens are difficult to identify and it is no surprise that Krach decided to name them *S. tarchanensis*, especially so as various rather flat specimens are represented in this material (e.g. Pl. 3, fig. 10), closely resembling juvenile *L. tarchanensis*.

After a careful comparison, however, we had to decide that all specimens fall within the range of variability of *L. valvatina*, because none of the specimens demonstrates the rapid increase in diameter of the whorls as is typical for *L. tarchanensis* (compare Janssen, 1984, pl. 1, figs. 10-13) and all intermediate forms are present. This means that *Limacina tarchanensis* does not occur in this part of the Paratethys.

Similar juvenile specimens from Krywałd (depths 104-105 m and 102-104 m), also in shell preservation, were identified *S. valvatina* or '*S. valvatina* → *S. koeneni*' by Krach. Among this material, which for the greater part we also include in *L. valvatina*, some relatively high specimens are present, which apparently are the first indications of *L. gramensis* (see Pl. 1, fig. 4).

In his 1981 paper Krach (p. 127, pl. 6, fig. 5) mentioned just one specimen of *S. subtarchanensis* (from the Krywałd borehole, depth not indicated, but in the collection available to us three samples are labelled with this name: 80.57-81 m, 7 ex.; this sample was mentioned already here in the introductory remarks to the Limacinidae,

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Plate 3

Figs. 1-12. *Limacina valvatina* (Reuss, 1867)

1: Krywałd, 74-76 m; frontal view.

2: Krywałd, 72-73 m; frontal view.

3: Krywałd, 70-72 m; frontal view.

4: Krywałd, 68-79 m; frontal view.

5-6: Łapczyca-1, -187 m; frontal views.

7-9: Niepaszyce-2, without depth indication; a: apical views; b: frontal views.

10: Krywałd, 111.3-113 m; frontal view.

11: Krywałd, 104-105 m; frontal view.

12: Łapczyca-1, -178 m (distorted specimen); a: apical view; b: frontal view.

Fig. 13. *Limacina gramensis* (Rasmussen, 1968)

Krywałd, 95-101 m, frontal view.

Figs. 1, 5-6: specimens identified by Krach (1981) as *Spiratella valvatina* (Reuss); figs. 2-3, 11: as *Spiratella valvatina* (Reuss) → *koeneni* (Kittl); figs. 4 and 13: as *Spiratella koeneni* (Kittl, 1886); figs. 7-10, 12: as *Spiratella tarchanensis* (Kittl). All specimens in coll. INGK. Magnification of all figures X 25.

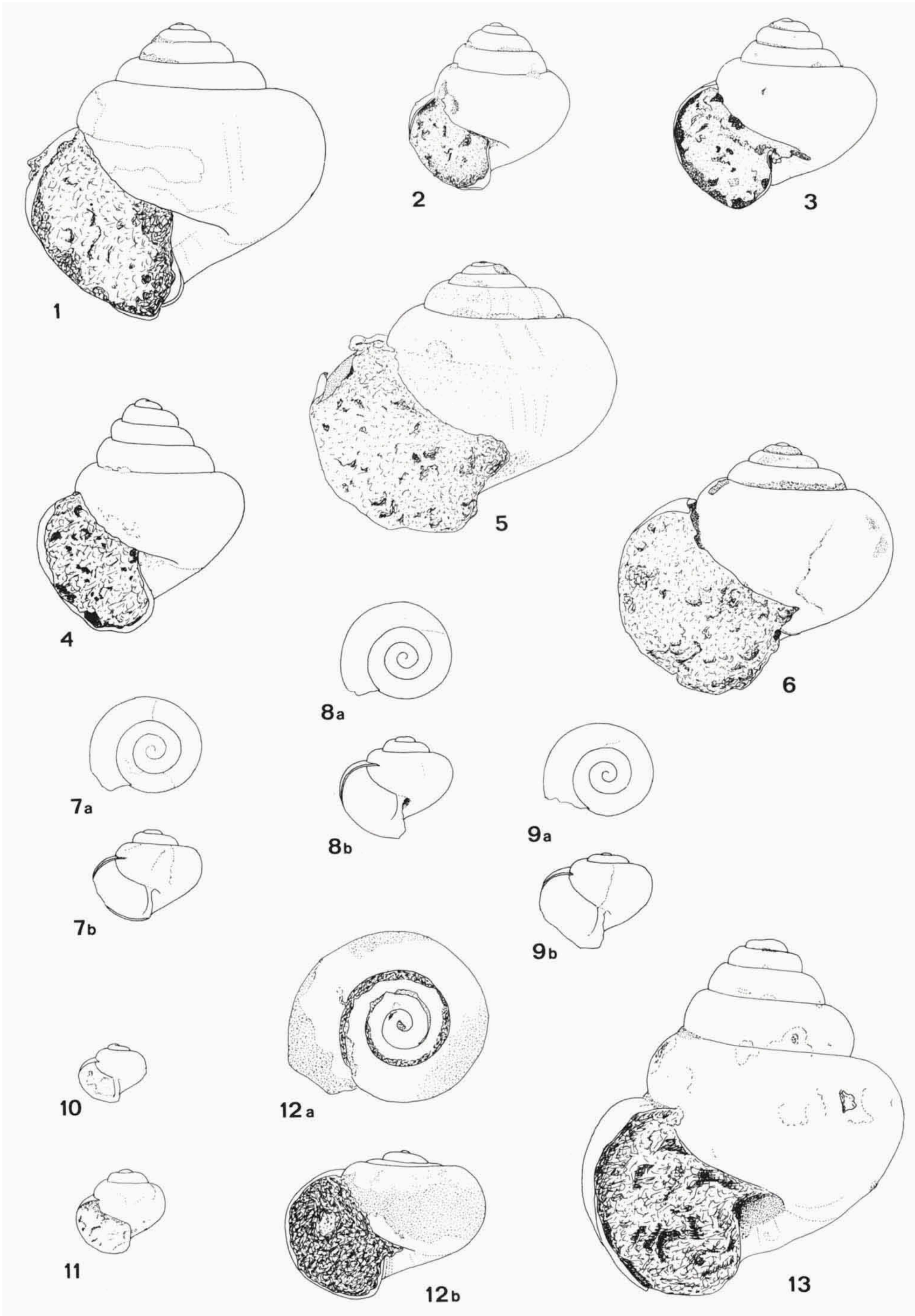

Plate 3

as an example of Krach's difficulties in identifying his material; 80.52-81 m, 3 ex.; 78-79 m, 1 ex.). Judging from the dimensions accompanying Krach's description (height 3.4 mm, width 3.5 mm) the ex. from 78-79 m depth (illustrated here on Pl. 2, fig. 8) must be the one referred to in the paper, although the illustration does not match the specimen at all. If the magnification of 20 X is correct, the illustrated shell has a width of c. 1.6 mm. In fact that specimen resembles much better the drawing of Krach's pl. 5, fig. 13 (width according to this illustration 3.1 mm), which, however, is indicated as '*S. variabilis*, young specimen'. The slide in which the specimen was kept quite unusually is written in ballpoint (most slides bear Krach's handwriting in pencil), so maybe he changed the identification afterwards and his illustration represents one of the other specimens (e.g. the one here illustrated on Pl. 2, fig. 4, width about 1.3 mm).

This last-mentioned shell, by the way, is one of the specimens most closely resembling *L. tarchanensis*, especially so by its H/W-ratio of 79.4, which is very low for the *L. valvatina* range of variability. A closer look at the specimen reveals, however, that its spire most probably is pressed slightly into the body whorl by deformation. We consider all specimens of these three samples to belong to the species *L. valvatina*. All three shells in the sample 80.52-81 m distinctly demonstrate the presence of an irregular spiral sculpture on the body whorl, as it is also found on some large specimens of *L. gramensis*.

The Krach collection comprised one sample, labelled 'Mielec-5, 680.50 m', consisting of a piece of clay of c. 20 g, in which the apical part of a rather large specimen of *L. valvatina* was visible. As several very small specimens were also present on the surface of this sample, it was decided to wash it on a 0.1 mesh. This yielded several interesting data. Not only the number of specimens preserved in this sample was considerably higher than expected, but also some observations on the preservation could be made. The total number of pteropod specimens found was 1067! But for one juvenile specimen of *Styliola subula* all specimens belong to *Limacina valvatina*. Some specimens occur in empty shell preservation, but the greater part is preserved either as pyritic or as calcitic casts, with especially in the smaller specimens the shell wall preserved. Of both types distorted and undistorted specimens are present (see Table

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Plate 4

Fig. 1. *Limacina ? gramensis* (Rasmussen, 1968)

Krywałd, 104-105 m (INGK); frontal view.

Figs. 2-9. *Limacina gramensis* (Rasmussen, 1968)

Krywałd, fig. 4b: lateral view, other figs.: frontal views.

2: 97-99 m (RGM 393 008).

3-4: 94-95 m (RGM 393 013-014).

5-6: 93-94 m (INGK).

7-8: 90-95 m (INGK).

9: 90-101 m (INGK).

Fig. 1: specimen identified by Krach (1981) as *Spiratella valvatina* (Reuss) → *koeneni* (Kittl); fig. 2: as *Spiratella valvatina* (Reuss); figs. 3-4, 9: as *Spiratella stenogyra* (Philippi); figs. 5-6: as *Spiratella variabilis* 'Friedberg' (syntypes); figs. 7-8: as *Spiratella koeneni* (Kittl). Magnification of all figures X 25.

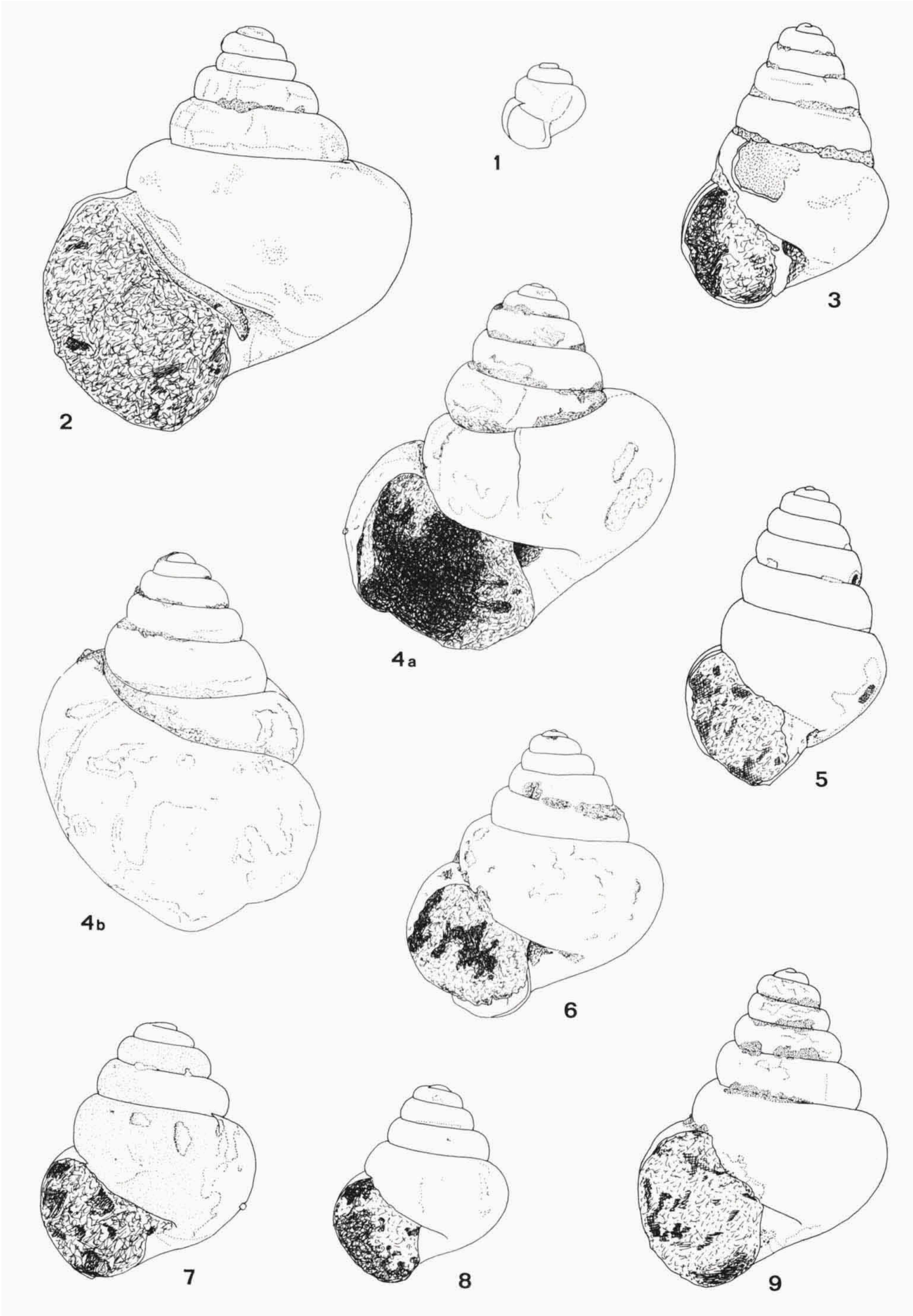

Plate 4

Table 5. *Limacina valvatina*, washed from 20 g of clay from the sample Mielec-5, depth 680.50 m.

sieving fraction	empty shells	pyritic casts		calcitic casts		total
		normal	squeezed	normal	squeezed	
> 1.0 mm	0	1	2	0	0	3
> 0.5 mm	0	1	58	0	0	59
> 0.3 mm	2	14	104	1	5	126
> 0.2 mm	7	32	115	3	22	179
> 0.1 mm	8	118	160	174	239	699

5 for quantitative information). From these data it can be deduced that all larger specimens occur exclusively in pyritic cast preservation. In the finest sieving fraction (> 0.1 < 0.2 mm), however, calcitic casts are more common than pyritic casts. Squeezing of the shells occurred in far more than half the number of specimens (63.7%), sometimes leaving nothing but completely flat, hardly recognisable remnants, but curiously enough a large number of specimens was not at all effected by rock pressure. The original sample comprised no more than 2 cm of sediment thickness at the most and it is difficult to understand how the observed differences are possible in such a restricted sedimentation interval. Apart from the mentioned pteropods the sample yielded abundant planktonic larvae of benthic gastropods and bivalves, some skeleton parts of bony fishes (no otoliths!) and just two benthic foraminifera. Very curious, considering the large number of planktonic molluscs, is the complete absence of planktonic foraminifera.

Spirialis nucleatus Zhizhchenko, 1934 was differentiated from *L. valvatina* by its 'more convex whorls and their gentler increase' (Zhizhchenko, 1934, p. 89), but Zhizhchenko (1936, p. 311) formulated the differences as 'its larger dimensions and its higher shell'. The illustrations given in this latter paper (copied from Andrussov, 1904) are those of shells remaining distinctly below a H/W-ratio of 110 and therefore we see no reason to maintain *S. nucleatus* as a separate taxon.

Plate 5

Figs. 1-3. *Limacina gramensis* (Rasmussen, 1968)

1-2: Krywałd, 99-101 m (INGK); frontal views.

3: Ujście (Ukraine), 52.95-53.3 m (INGK); a: frontal view, b: rear view.

Fig. 4. *Peracle lata* (Krach, 1979), lectotype

Brzeszcze-1, 59 m (INGK); a: apical view; b: frontal view.

Fig. 5. *Peracle* sp. nov.

Mszana-1, 145-149 m (INGK); a: apical view; b: frontal view; c: oblique frontal view to demonstrate columellar fold.

Figs. 1-3: specimens identified by Krach (1981) as *Spiratella variabilis* 'Friedberg' (1-2: syntypes, 3: lectotype); fig. 4 as *Spiratella lata* n. sp. (lectotype); fig. 5 as *Spiratella andrussovi* (Kittl). Magnifications: Figs. 3a-b: X 12.5, other figures: X 25.

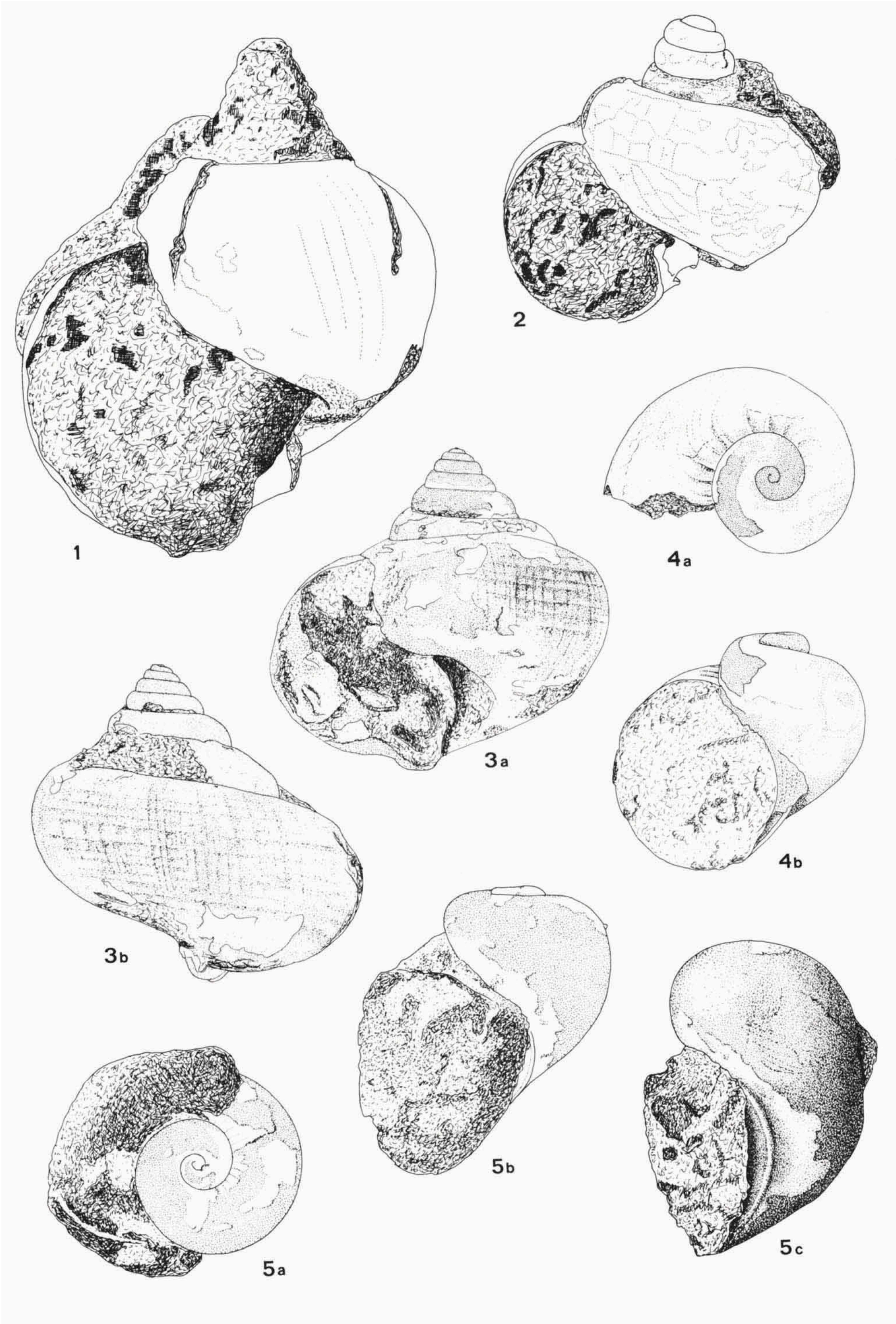

Plate 5

Familia CAVOLINIIDAE Fischer, 1883
Subfamilia CRESEIINAE Rampal, 1973 (emended)

Note — A subfamily name Creseinae (sic!) was introduced by Janssen (1990, p. 26). Rampal (1973, p. 1347) already introduced a family name Creseiidae, which is considered to be of subfamily level in the present paper.

Genus *Creseis* Rang, 1828
Creseis spina (Reuss, 1867)
Pl. 6, figs. 2-4; Pl. 7, figs. 2-4.

*v 1867 *Cleodora (Creseis) spina* Rss., Reuss, p. 145, pl. 6, fig. 9.
1883 Cleodora spina Rss — Niedzwiedzki, p. 392.
v. 1886 *Creseis* (?) *spina* (Reuss) — Kittl, p. 51.
? 1921 *Creseis spina* Reuss — Checchia-Rispoli, pp. 8-9, figs. 2, 2a.
1955 Cleodora spina Rss — Łuczkowska, p. 83.
. *1979a Vaginella lapugyensis* — Krach, p. 655, tables 1, 2 (non *V. lapugyensis* Kittl, 1886).
1980 Cleodora spina Reuss — Moisescu & Popescu, p. 217, pl. 2.
v. 1981 *Vaginella lapugyensis* Kittl, 1886 — Krach, p. 123, pl. 1, fig. 14; pl. 6, figs. 9, 10 (non Kittl).
v. 1984 *Cleodora (Creseis) spina* Reuss, 1867 — Janssen, pp. 66-67, pl. 1, figs. 1a, b, 2a, b.
v. 1991a *Creseis spina* (Reuss, 1867) — Zorn, p. 23, pl. 3, figs. 1-3, 5-11.
v. 1991b *Creseis spina* (Reuss, 1867) — Zorn, p. 110, pl. 5, figs. 1-6, 13-14; pl. 12, fig. 2.

Plate 6

Fig. 1. *Peracle lata* (Krach, 1979)
Brzeszcze-1, 62 m (INGK); a: apical view; b: slightly oblique apertural view to demonstrate columellar fold.
Figs. 2-4. *Styliola subula* (Quoy & Gaimard, 1827)
2: Brzeszcze-1, 59 m (INGK); a: apertural view; b: dorsal view (same specimen as Pl. 7, fig. 1).
3: Brzeszcze-1, 60 m (INGK); dorsal view.
4: Mielec-5, 680.50 m (RGM 303 022); apical fragment with protoconch.
Figs. 5-7. *Creseis spina* (Reuss, 1867)
Koszyce Małe, 155.1-159.6 m (INGK); protoconchs.
Figs. 8-15. *Vaginella austriaca* Kittl, 1886
All specimens from Korytnica (Figs. 8, 9, 11, 12, 14: INGK, Figs. 10, 13, 15: RGM 393 003-005 respectively).
8a: ventral view; 8b: right lateral view.
9: dorsal view.
10: apertural fragment showing longitudinal sculpture and shell repair.
11: apical fragment with irregular shell growth.
12a-b: ventral and dorsal views of specimen showing shell repair.
13-15: apical fragments showing protoconch; a: dorsal or ventral views; b: left lateral views.
Fig. 2-3: specimens identified by Krach (1981) as *Styliola lamberti* Checchia-Rispoli; figs. 5-7: as *Vaginella lapugyensis* Kittl; figs. 8-15: as *Vaginella austriaca* Kittl; figs. 1 and 4: not identified by Krach. Magnifications: Fig. 1 X 15; figs. 2-3 X 12.5; figs. 4-7, 13-15 X 25; figs. 8-12 X 6.

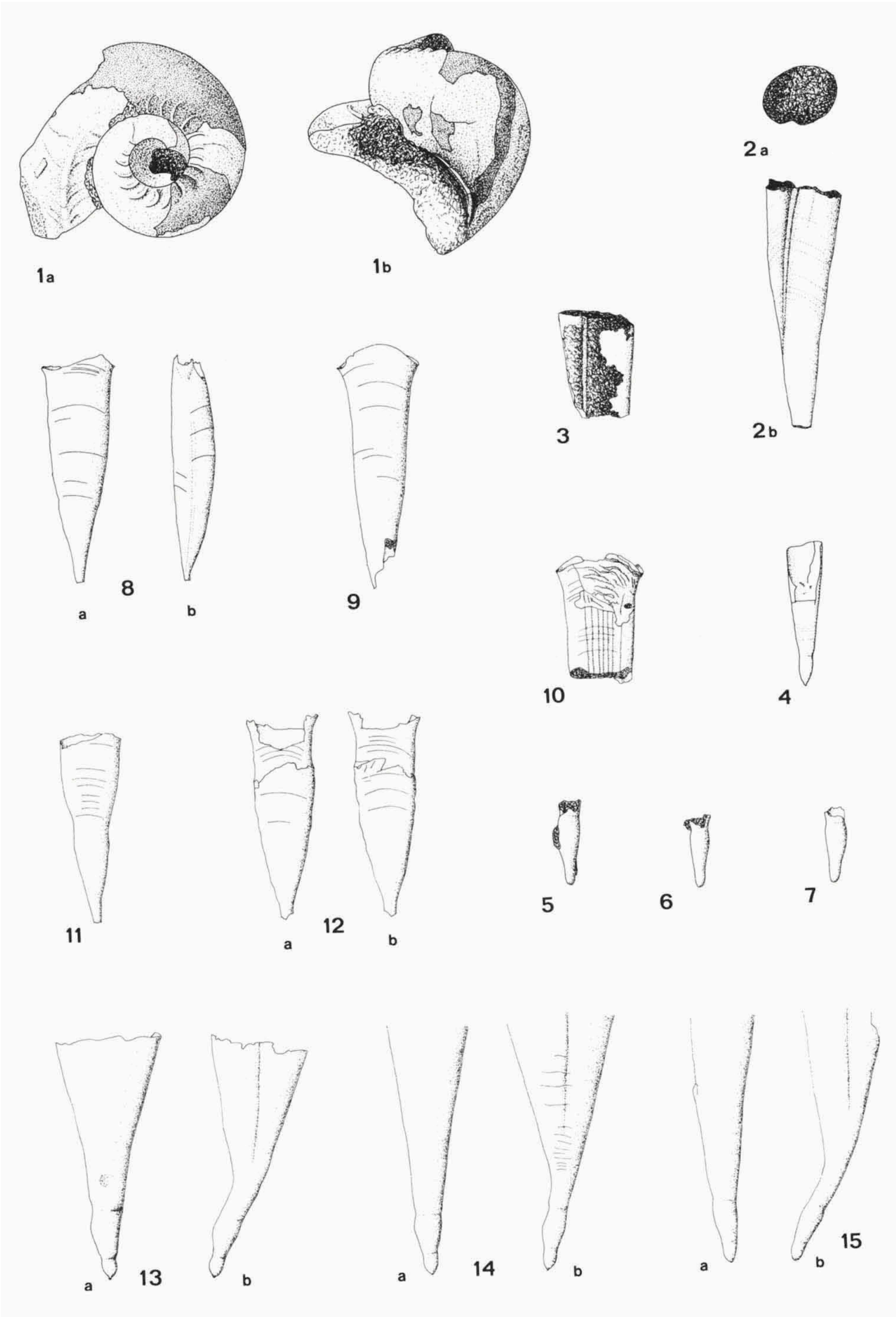

Plate 6

v. in press *Creseis spina* (Reuss, 1867) — Bohn-Havas & Zorn, pl. 2, fig. 9.
non:1968 *Creseis spina* Reuss, 1867 — Sirna, p. 420, fig. 5 (= *Vaginella lapugyensis*).
1979 *Creseis spina* Reuss, 1867 — d'Alessandro et al., p. 84, pl. 16, figs. 1-4 (= *Vaginella lapugyensis*).

Type material — Lectotype and one paralectotype (Janssen, 1984) stored in the Naturhistorisches Museum in Vienna (reg. no. 1867.VII.40).
Locus typicus — Wieliczka (Poland).
Stratum typicum — Rock salt deposits (Miocene, Badenian, Wielician).
Diagnosis — *Creseis* with slender conical shell, straight to slightly curved. Transverse section circular to slightly elliptical. Surface smooth. Protoconch elongated, forming a rounded bulb in its younger part.
Material studied (for a detailed specification see Table 6) — Brzeszcze-1 borehole, depth 61 m: 2 ex.; depth 60 m: 1 ex. Koszyce Małe borehole, depth 155,1-159,6 m: c. 60 ex.; depth 155 m: c. 20 ex. Międzyrzecze-1 borehole, depth 101.5 m: 2 ex. (= *Creseis* cf. *spina*). Sierakowice-1 borehole, depth 414 m: 2 ex.

Discussion — The specimens from the Koszyce Małe and Sierakowice-1 boreholes are preserved quite well on slabs of clay. In several cases the protoconch could be made visible by preparation (Pl. 7, figs. 3-4). The specimens from Brzeszcze-1 are isolated pyritic casts with shell remnants without protoconchs.

In comparison with *Creseis spina* from Walbersdorf in Austria and the type material of this species from Wieliczka (Zorn, 1991b) the protoconch dimensions of the present material are very similar. The apical angle of the teleoconch ranges from 7 to 10°. This also fits the measurements of the individuals from Walbersdorf, whereas the type material has a slightly wider angle. The length of the teleoconch reaches 5.4 mm and the width 0.9 mm, which results in a length/width-ratio of 6. These data are taken from the largest specimen, which is illustrated on Pl. 7, fig. 4. The main part of the teleoconchs could not be measured because of incompleteness.

Irregular transverse folds, described for this species by Krach, are only visible in large specimens near the aperture.

But for one sample the available specimens of *Creseis spina* were originally described and labelled by Krach (1981) as *Vaginella lapugyensis* Kittl, 1886, which is the most slender species of *Vaginella*. Only the specimen illustrated in Krach's fig. 14 on pl. 1 has an additional pencil mark on its label stating '*C. spina*'. Maybe it was added after Krach's manuscript was finished. In a sample from Międzyrzecze-1 (101.5 m) labelled '*Vaginella* sp.' two specimens of *Creseis* were found. Because of their unfavourable

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Plate 7

Fig. 1. *Styliola subula* (Quoy & Gaimard, 1827)

Brzeszcze-1, 59 m; a: dorsal view; b: ventral view (same specimen as Pl. 6, fig. 2).

Figs. 2-4. *Creseis spina* (Reuss, 1867)

2: Koszyce Małe, 155 m; a: lateral view; b: frontal view.

3-4: Koszyce Małe, 155.1-159.6 m; specimens with protoconch.

Fig. 1: specimen identified by Krach (1981) as *Styliola lamberti* Checchia-Rispoli; figs. 2-4: as *Vaginella lapugyensis* Kittl. Magnifications: all specimens X 15. All specimens in coll. INGK.

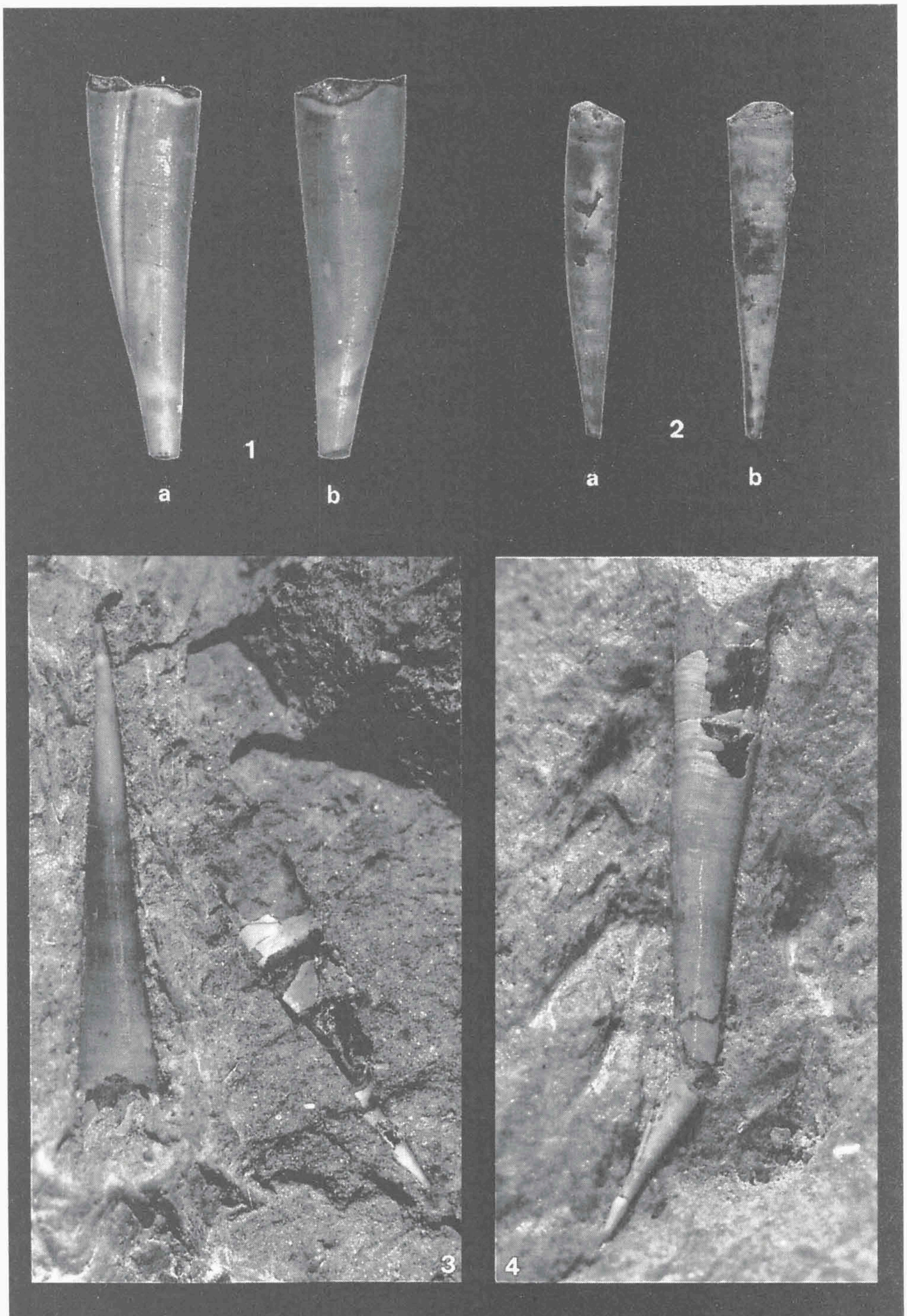

Plate 7

preservation they can only be identified *Creseis* cf. *spina*.

None of the available specimens demonstrates lateral carinae, the presence of which is a characteristic of the genus *Vaginella*, although Krach mentioned in his description that he found marked lateral lines near the aperture. Furthermore, as stated above, the protoconch (Pl. 6, figs. 5-7) is typically creseid. Therefore it must be concluded that not a single specimen of *V. lapugyensis* is present in the Krach collection. Still, the material available to us seems to be complete, compared to that mentioned by Krach in his systematic part (Sierakowice-1, Koszyce Małe, Brzeszcze-1), i.e. there are quite a lot more specimens available (Krach mentioned only seven specimens). The specimen illustrated by Krach (1981, pl. 6, fig. 10) could not been recognised.

On which material Krach's (1981, table 1) records of *V. lapugyensis* from the localities Gdów and Krywałd are based is unknown, it has not been available to us. The record of *V. lapugyensis* from Wieliczka is based on Krach's opinion that Reuss's specimens of *Creseis spina* (which he never saw personally!) could belong to *V. lapugyensis*.

Genus *Styliola* Gray, 1850
Styliola subula (Quoy & Gaimard, 1827)
Pl. 6, figs. 2-4; Pl. 7, fig. 1.

Selected synonyms (for further references the reader is referred to Janssen, 1990):
* 1827 *Cleodora subula* Quoy & Gaimard, p. 233, pl. 8, figs. D1-D3.
. 1921 *Clio (Styliola) Lamberti* Checchia-Rispoli — Checchia-Rispoli, p. 10, fig. 3.
. 1968 *Styliola lamberti* Checchia-Rispoli — Sirna, p. 420, fig. 6.
v. 1971 *Styliola sulcifera* Gabb — Jung, p. 216, pl. 19, figs. 14, 15.
. 1979 *Styliola lamberti* Checchia-Rispoli, 1921 — d'Alessandro et al., p. 84, pl. 16, figs. 43-45.
1979a Styliola lamberti — Krach, pp. 659, 660.
1980 *Styliola subula* (Quoy & Gaimard) — Shibata, p. 62.
v. 1981 *Styliola lamberti* Checchia-Rispoli 1921 — Krach, p. 122, pl. 1, fig. 10.
v. 1990 *Styliola subula* (Quoy & Gaimard, 1827) — Janssen, p. 32, pl. 5, figs. 13-19; pl. 6, figs. 1-9.

Type material — The type specimens could not be traced in the collection of the Laboratoire de Malacologie, Museum d'Histoire Naturelle in Paris (van der Spoel, 1976). Their whereabouts are unknown.
Locus typicus — 'Côte de Ténériffe', Atlantic Ocean.
Stratum typicum — Recent.
Diagnosis — *Styliola* with straight, slender and irregularly conical shell. Cross-section circular in the apical part, becoming slightly elliptical in apertural direction. A dorsal oblique groove is running from the posterior left margin in the direction of the anterior right margin. When reaching the aperture it ends in a protrusion.
Material studied (for a detailed specification see Table 6) — Brzeszcze-1 borehole, depth 60 m: 1 fragment; depth 59 m: 1 ex. Mielec-5 borehole, depth 680.5 m: 1 protoconch.

Discussion — The specimen from the Brzeszcze-1 borehole (59 m), originally described by Krach (1981) as *Styliola lamberti* Checchia-Rispoli, is an isolated individual shell filled with pyrite, but lacking its protoconch and apertural part (Pl. 6, fig. 2;

Pl. 7, fig. 1). Its length equals 3.65 mm and its maximal width 1.07 mm. No differences could be found when compared with the Recent species *Styliola subula*. The apical angle (13°) and the angle of the typical dorsal oblique groove with the posterior left margin of the shell (12°) are the same as in the living species (compared with data in Janssen, 1990 and measured in the same way). Also the transverse cross section, which is not altered by rock pressure, shows the same features.

The second specimen from the Brzeszcze-1 borehole (60 m) is only a fragment of the younger part of the teleoconch (Pl. 6, fig. 3). It was present in an unidentified sample, together with one specimen of *Creseis spina*, two specimens of *Limacina valvatina*, some foraminifers, otoliths and benthic gastropods.

The protoconch (Pl. 6, fig. 4), which was recovered from a washed sample from the Mielec-5 borehole, is elongated drop-shaped and sharply pointed. Its maximal width (0.107 mm) occurs in the upper half. It is slightly separated from the teleoconch by a weak constriction. Its maximal length equals 0.214 mm.

Janssen (1990) included in his synonymy list of *Styliola subula* from Australia all known finds of *Styliola lamberti* and two other fossil species, *Styliola rangiana* Tate, 1887 and *Styliola sulcifera* Gabb, 1873. A fourth fossil species which was initially considered to be a *Styliola* species, viz. *Styliola bicarinata* Tate, 1887, turned out to belong to the genus *Vaginella* (see Janssen, 1990). Summarising, *Styliola* appears to be a monospecific genus, only including *S. subula*, its type species.

The specimens of *S. subula* studied here represent the only known records of the genus *Styliola* in the entire Paratethys. Krach (1981) furthermore mentioned *S. lamberti* from Simoradz in his table 1, but abandoned this record in the systematic part. We had no material from that locality available.

Subfamilia CLIOINAE Janssen, 1990

Genus *Clio* Linné, 1767

Notes — Krach (1981) mentioned two species of *Clio* occurring in the Polish Middle Miocene, viz. *Clio fallauxi* and *C. pedemontana*. In his collection, however, one sample with four specimens labelled *Clio bittneri* (Kittl, 1886) is present from the Międzyrzecze-1 borehole. Obviously Krach changed his opinion on this identification, as he ignored this species in his 1981 paper and he added to the label: '? *Vaginella rzehaki*'. In our opinion this material represents very depressed and therefore not recognisable specimens of *Vaginella*.

Clio fallauxi (Kittl, 1886)

Pl. 8, figs. 1-9; Pl. 9, figs. 1-3.

*v 1886 *Balantium Fallauxi* Kittl, p. 62, pl. 2, figs. 23-26.

. *1887 Balantium Fallauxi* Kittl — Kittl, pp. 222, 223, 227, 228.

1904 *Balantium Fallauxi* Kittl — Sangiorgi, p. 80.

1922 *Balantium Fallauxi* Kittl — Protescu, p. 352, pl. 4, fig. 11.

. *1956a Balantium fallauxi* — Krach, p. 106, tables 3-4.

v. 1957 *Balantium fallauxi* Kittl — Krach & Nowak, p. 28, 31, 38, pl. 1, figs. 15, 19 [partim, non fig. 20 = *Clio* cf. *pedemontana* (non vidimus)].

1971 Clio fallauxi — Krach et al., p. 235.
. *1973 Clio fallauxi* Kittl — Krach, p. 526, table 1.
? 1974 *Clio fallauxi* (Kittl, 1886) — Stancu, p. 186, pl. 1, figs. 8-10.
. *1979a Clio fallauxi* — Krach, p. 659.
. *1980 Clio fallauxi* (Kittl) — Moisescu & Popescu, pp. 215, 219, pls 1-2.
v. 1981 *Clio fallauxi* (Kittl) 1886 — Krach, p. 123, pl. 1, figs. 2-8, 11-12 (partim, includes also *Clio pedemontana* and *Clio* sp. indet.).
v. 1984 *Balantium fallauxi* Kittl, 1886 — Janssen, p. 65, pl. 5, figs. 1-3.
v. in press *Clio fallauxi* (Kittl, 1886) — Bohn-Havas & Zorn, pl. 3, fig. 7.

Type material — Kittl based the species *Clio fallauxi* on material from the following localities: Peterswald, Dombrau, Polnisch-Ostrau and Pratzer Berg near Brno, nowadays located in the Czech Republic. He characterised the specimens from Peterswald and Dombrau as the typical form of this species. Janssen (1984), studying the pteropods in the collection of the Naturhistorisches Museum at Vienna, stated that only specimens from Polnisch-Ostrau (reg. no. 1888.I.5: 2 specimens; reg. no. 1888.I.70: 2 specimens) are available and no syntypes of the typical form. Therefore he designated Kittl's fig. 23, which shows a specimen from Peterswald and which was indicated by Kittl as the 'Typus', as the lectotype. The specimens from Polnisch-Ostrau were considered to belong to an undescribed species (see below).

In the meantime Kittl's sample from Dombrau, Eleonoren-Schacht (nowadays Dombrová near Ostrava, Moravia, Czech Republic: pers. comm. Dr P. Čtyroký; acquired 1884, reg. no. 1993/15/1-3) was rediscovered in the Vienna collection of samples arranged according to locality. It has now been transferred into the regular pteropod collection. It contains three specimens, preserved on slabs of sediment. The largest specimen (Pl. 9, fig. 1), which is not compressed, shows its convex dorsal side (shell is inclined ventrally) with a coarse sculpture of transverse ribs and a secondary and rather regular sculpture of finer transverse riblets. The regularity of these riblets demonstrates that they are not to be considered as growth lines. The latter are partly visible in higher magnification. Both sculptures are flexuous, in the middle part convex in abapical direction and concave near the margins. The coarse ribs are becoming very weak and almost absent in the posterior part of the shell. In its lateral parts the swollen shell is very flattened. The right margin is only partly preserved, the left one is slightly flexuous, convex in the anterior part and concave in the posterior part, just as in the specimen in Kittl's fig. 23. The apical angle measures 45° after reconstruction of the missing right area.

Plate 8

Figs. 1-5. *Clio fallauxi* (Kittl, 1886)
1: Dębowiec-45, 474-475 m (INGK); ventral view, X 3.5.
2: Dębowiec-45, 404.1-405.1 m (INGK); ventral view, X 3.5.
3: Simoradz-27, 354 m (RGM 393 026); dorsal view from interior, X 5.
4: Roczyny-1, 124-127 m (INGK); dorsal view from interior, X 5.5.
5: Roczyny-1, 156.2-158.2 m (INGK); dorsal view, X 5.
Figs. 6-9. *Clio* cf. *fallauxi* (Kittl, 1886)
6-7: Dębowiec-45, 508.2-509.2 m (INGK); dorsal view, X 3.5 (cast and mould of same specimen).
8-9: Roczyny-1, 158.2-160.2 m (INGK); dorsal view, X 3.5 (cast and mould of same specimen).
Figs. 1-2: specimens identified by Krach (1981) as *Clio fallauxi* (Kittl) subsp. indet.; figs. 3-5: as *Clio fallauxi* (Kittl).

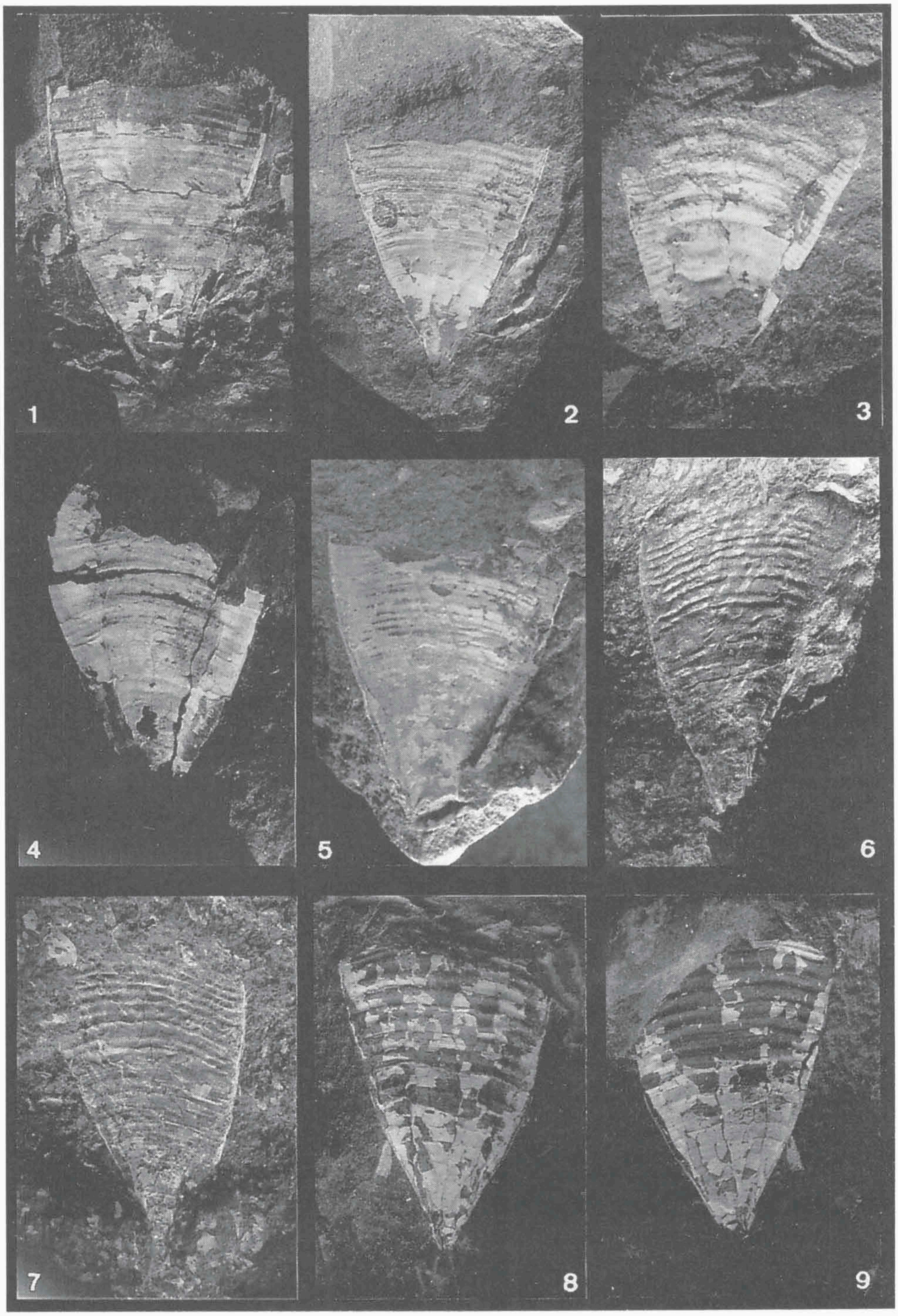

Plate 8

Of the second specimen (Pl. 9, fig. 2) one side is partly preserved which is less convex than in the first specimen. The riblets, which are almost straight and not flexuous, are distinctly visible, but the ribs are very weak and can only be seen in low angle light. The shell margin is almost straight. The third individual (Pl. 9, fig. 3) is poorly preserved and very fragmentary, but both sides are partly visible. Contrary to the riblets the presence of coarser ribs could not be established on the dorsal or on the ventral side because of the damaged condition. The more swollen dorsal side shows arched riblets and the flatter ventral side more straight ones. This demonstrates that the second described specimen shows its ventral side.

The differences between ventral and dorsal sides were not mentioned in Kittl's description. In his figs. 23-25 a specimen is illustrated in ventral (fig. 23) and lateral (fig. 24) view, the latter showing the coarse sculpture on both sides. This specimen originates from Peterswald, but in Kittl's text it is stated that the two Peterswald specimens show an almost complete ventral side, a dorsal side is not mentioned. Additionally the explanation of fig. 24 says that this view is supplemented. Summarising, it is not sure if there was a dorsal side preserved.

The dorsal side was especially mentioned by Kittl in the context of specimens from Polnisch-Ostrau (nowadays Polská Ostrava, Moravia, Czech Republic, pers. comm. Dr. P. Čtyroký), which he considered to be a variety of *Clio fallauxi*. They are very depressed, but two of them (reg. no. 1888.I.5) show the fine ribbing and in the younger part an indication of the coarse ribs. The latter can be made better visible by means of an artificial cast. One of these specimens is illustrated in Kittl's fig. 26 and in Janssen (1984, pl. 5, fig. 3). It is a ventral side seen from the insight and the sculpture is flexuous. The length is 11.9 mm, the width is 9 mm and the apical angle is 44°. From the other specimens from Polnisch-Ostrau it cannot be decided which side is preserved. They are very damaged and only the outline is visible. The lateral margins of all four specimens are almost straight. Janssen stated that it is probable that these specimens belong to an undescribed species because of the weak sculpture and the more straight lateral margins. Already Kittl tended to consider them as a variety because of these differences, most of which, however, he explained by the strong depression which this material has undergone. The additional material from Dombrau supports the point of view that both sides of *Clio fallauxi* are sculptured with ribs and riblets which can be very weak or absent by differences in preservation. The shape of the lateral margins is considered to be variable.

The three specimens from Dombrau and the four specimens from Polnisch-Ostrau of course are syntypes of *C. fallauxi*. The *Clio* specimen from Pratzer Berg near Brno (nowadays Pratecky kopec, Moravia, Czech Republic, pers. comm. Dr. P. Čtyroký) (reg. no. 1933/16) which was identified by Kittl (1886, pl. 2, fig. 28) as *Clio pedemontana* and by Janssen (1984, pl. 1, fig. 6) as *Clio* sp. ? nov. also belongs to *Clio fallauxi*.

Locus typicus — Peterswald (nowadays Petřvald; pers. comm. Dr P. Čtyroký), Moravia, Czech Republic.

Stratum typicum — Miocene, Early Badenian, Lagenidae Zone.

Diagnosis — *Clio* with triangular, dorso-ventrally flattened shell with dorsal side more convex. Shell axis curved ventrally. Shell surface with coarse transversal ribs and secondary fine riblets, flexuous on the dorsal side and straight on the ventral side. Lateral margins flexuous to almost straight.

Material studied (for a detailed specification see Table 6) — Dębowiec-45 borehole, depth 508.2-509.2 m: 1 ex. (*Clio* cf. *fallauxi*); depth 474-475 m: 1 ex.; depth 404.1-405.1 m: 1 ex. Grudna Dolna-5 borehole, depth 19-21 m: 1 ex. Międzyrzecze-1 borehole, depth 101.5 m: 1 ex. Roczyny-1 borehole, depth 160.2-162.4 m: 1 ex.; depth 158.2-160.2 m: 1 ex. (*Clio* cf. *fallauxi*); depth 156.2-158.2 m: 1 ex.; depth 124-127 m: 1 ex. Simoradz-26 borehole, depth 483-484 m: 1 ex. Simoradz-27 borehole, depth 354 m: 2 ex.; depth 352 m: 1 ex. Swierczyniec borehole, depth 224 m: 1 ex.

Discussion — Material from all boreholes which were mentioned by Krach (1981) is still extant and by comparison with the type material we could demonstrate that most of the specimens indeed belong to *C. fallauxi*. One specimen originating from the Świerczyniec borehole (224 m) identified as *Clio* sp. indet. also belongs to *Clio fallauxi*. The external mould of the dorsal side demonstrates the fine transverse sculpture together with a fair indication of the coarser ribbing.

One specimen from Siedlec-2 (337-343.7 m), supposed to represent this species by Krach, turned out to be a bivalve (*Thyasira* sp.). One specimen from Roczyny-1 (170-176 m) could only be identified as *Clio* sp. indet. and one specimen from Grudna Dolna-2 (78 m) is not recognisable. Both were labelled *Clio fallauxi*. From Grudna Dolna-5 (50-51 m) a specimen initially labelled *Clio pedemontana*?, afterwards changed to *Clio fallauxi*? belongs to *Clio pedemontana*. Two unfavourably preserved specimens from the Gdów-1 borehole (875.5-878 m) first labelled *Clio fallauxi*, later reidentified by Krach as *Clio bittneri*, had to be identified *Clio* sp. indet.

Concerning the material from Roczyny, Krach & Nowak (1957) gave *C. fallauxi* for the depth 0-182 m and 230-340 m. As is obvious from the above list of studied material no specimens from 230-240 m were present in the Krach collection. Records of *C. fallauxi* from Simoradz-26 and Brzezówka as given in Krach (1973) were not repeated in Krach (1981) and no material has been available to us. As could be reconstructed from Krach's (1981) illustrations the specimen of his plate 1, fig. 3 is also missing, as well as the specimen illustrated in fig. 20 of plate 1 in Krach & Nowak (1957).

The Polish material agrees with the species concept of *Clio fallauxi*. Two specimens from Dębowiec-45 (474-475 m and 404.1-405.1 m) show the ventral side with distinct straight transverse ribs and riblets. The largest specimen has a length of 13.4 mm and a width of 9.1 mm. The apical angles range from 39 to 49°. The lateral margins are either flexuous or straight.

The specimen from Roczyny-1, depth 158.2-160.2 m, by us identified as *Clio* cf. *fallauxi* (Pl. 8, figs. 8-9), has the same sculpture as typical *C. fallauxi*, but its apical angle is less wide. The same is true for the specimen illustrated on Pl. 8, figs. 6-7, from the Dębowiec-45 borehole, depth 508.2-509.2 m.

For differentiating characteristics with regard to *Clio pedemontana* (Mayer, 1868), a quite similar species occurring at the same stratigraphic level, the reader is referred to the description of that species.

Clio pedemontana (Mayer, 1868)
Pl. 9, figs. 4-6.

Selected synonyms:

*v 1868 *Cleodora pedemontana*, Mayer, Mayer, pp. 104-105, pl. 2, fig. 2.

. 1872 *Balantium pedemontanum* (May.) — Bellardi, pp. 31-32, pl. 3, fig. 10a-c.

v. 1886 *Balantium pedemontanum* (C. Mayer) — Kittl, pp. 64-65, pl. 2, fig. 33 (partim, non fig. 28 = *Clio fallauxi*).

. 1896 *Clio pedemontana* Mayer sp. — Audenino, p. 102, pl. 5, fig. 6.

1904 *Balantium pedemontanum* (May.) — Sacco, p. 13, pl. 4, fig. 7.

. 1922 *Balantium pedemontanum* Bellardi — Protescu, p. 352, pl. 4, fig. 10.

. 1958 *Euclio pedemontanum* (Mayer-Eymar) — Erünal-Erentöz, p. 129-130, pl. 21, figs. 11-12.

. 1971 *Clio pedemontana* (Mayer, 1868) — Robba, pp. 84-85, pl. 3, figs. 7-9.

v. 1971 *Clio* cf. *pedemontana* (Mayer) — Jung, pp. 219-220, pl. 20, figs. 5-7.
. 1974 *Clio pedemontana* (Mayer), 1869 — Stancu, pp. 185-186, pl. 1, figs. 2-7.
. 1978 *Clio pedemontana* (Mayer, 1868) — Robba & Spano, pp. 774-775, pl. 78, fig. 4.
. *1979a Clio pedemontana* — Krach, p. 659.
1980 Clio pedemontana (Mayer) — Moisescu & Protescu, p. 215, pl. 2.
1980 *Clio pedemontana* (Mayer, 1868) — d'Alessandro & Robba, p. 641, pl. 66, fig. 7a-d.
v. 1981 *Clio pedemontana* (Mayer 1868) — Krach, p. 123, pl. 1, figs. 1, 9.
v. 1981 *Clio fallauxi* (Kittl) 1886 — Krach, p. 123 (partim, includes also *Clio fallauxi* and *Clio* sp. indet.).
v. 1984 *Balantium pedemontanum* (Mayer, 1868) — Janssen, p. 66, pl. 6, figs. 1-4.
v. in press *Clio pedemontana* (Mayer, 1868) — Bohn-Havas & Zorn.
non:1979 *Clio* cf. *pedemontana* (Mayer, 1868) — d'Alessandro et al., p. 85, pl. 16, figs. 65-68 (= ? *Vaginella* sp.).
1983 *Clio pedemontana* (Mayer) — Anfossi et al., p. 93, pl. 1, fig. 12 [= ? *Clio braidense* (Bellardi)].

Type material — Twelve syntypes, belonging to the Eidgen. Technische Hochschule, at Zürich, temporarily stored in the Naturhistorisches Museum in Basel, four further syntypes in the Naturhistorisches Museum in Vienna (reg. no. 1993/10/1-4). Lectotype designation will take place in a forthcoming paper.
Locus typicus — Serravalle di Scrivia, Acqui, Turin (Piemonte, Italy).
Stratum typicum — 'Marne a pteropodi' (Miocene, Langhian).
Diagnosis — *Clio* with elongately triangular shell. Sculpture of transverse ribs, either regularly arched or flexuous, sometimes flattened out. The lateral margins are straight or slightly curved.
Material studied (for a detailed specification see Table 6) — Biadoliny-1 borehole, depth 52-54.2 m: 1 ex. Grudna Dolna-2 borehole, depth 66 m: 1 ex.; depth 50 m: 1 ex. (*Clio* cf. *pedemontana*). Grudna Dolna-5 borehole, depth 50-51 m: 1 ex.

Discussion — Krach (1981) mentioned four specimens from the boreholes Grudna Dolna-2, Biadoliny-1 and Simoradz-27. From Simoradz-27 no specimen is available to us. One specimen from Grudna Dolna-5, first labelled by Krach '*Clio pedemontana*?', but changed afterwards to '*Clio fallauxi*?', is here also included in *Clio pedemontana*.

Plate 9

Figs. 1-3. *Clio fallauxi* (Kittl, 1886)
Rediscovered syntypes from Dombrau, Czech Republic (NHMW, reg. no. 1993/15/1-3); X 5.5.
1: dorsal view.
2: ventral view.
3a: ventral view; 3b: dorsal view of same specimen.
Figs. 4, 6. *Clio pedemontana* (Mayer, 1868)
4: Biadoliny, 52-54,2 m (INGK); dorsal view.
6: Grudna Dolna-2, 66 m (INGK); dorsal view.
Fig. 5. *Clio* cf. *pedemontana* (Mayer, 1886)
Grudna Dolna-2, 50 m (INGK); ventral view.
Figs. 4-6: specimens identified by Krach (1981) as *Clio pedemontana* (Mayer).
Magnifications: all specimens X 3.5.

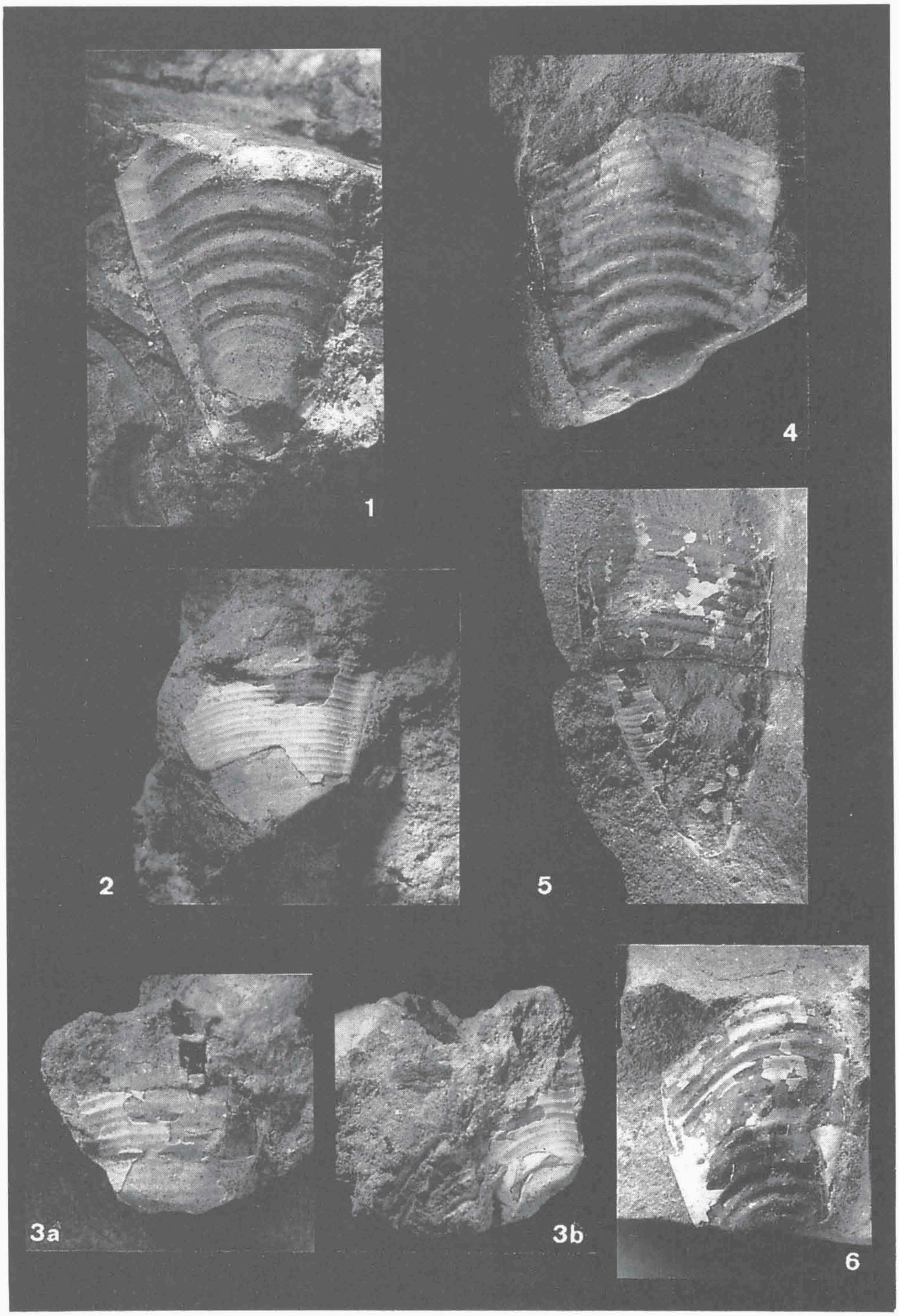

Plate 9

Among the specimens available in the Polish material two types of transverse sculpture can be distinguished. In some shells the curvature of the ribs is regularly convex in apertural direction, whereas in others the ribs are flexuous, concave near the margins and convex in their middle part (specimens from Biadoliny-1 and Grudna Dolna-2, 66 m). Whether or not these differences should be given taxonomical value cannot be decided on the basis of the restricted number of available specimens. Robba (1971, p. 84, pl. 3, figs. 7-8 and fig. 9) included both types of sculpture in *C. pedemontana*. In the original publication of Mayer (1868, p. 104, pl. 2, fig. 2) a specimen is illustrated with slightly flexuous ribs, but among syntypical specimens donated by Mayer to the Naturhistorisches Museum in Vienna only the form with gradually curved sculpture is present. So, apparently already Mayer included both types in his new species.

Clio fallauxi (Kittl, 1886) differs from the present species by a wider apical angle and in the presence of secondary transverse riblets, which are absent in *C. pedemontana*. In some cases it may be difficult to distinguish between *C. fallauxi* and *C. pedemontana*, as strongly and regularly developed growth lines resemble closely a weak transversal riblet sculpture. Similar problems occur if specimens are deformed by rock pressure, or if parts of the sculpture are not preserved. In such cases the apical angle can help. For instance, a specimen (Pl. 9, fig. 5) from the Grudna Dolna-2 borehole (50 m), identified by Krach (1981) as *C. pedemontana* shows the coarse transverse ribs only in the younger part of its shell and has a fine and regular sculpture of transverse riblets, reminding strongly of *C. fallauxi*. The apical angle of this specimen, however, is narrower (31°) than in *C. fallauxi* and agrees with *C. pedemontana*. As the apical angle in our experience is a more constant shell characteristic than the surface sculpture, we identified this specimen as *Clio* cf. *pedemontana*.

Subfamilia CAVOLINIINAE van der Spoel, 1967
Genus *Vaginella* Daudin, 1800

Monotype — *Vaginella depressa* Daudin, 1800.

Notes — The variability of *Vaginella* species is considerable. In the large material of both *V. depressa* and *V. austriaca* available to us from the Aquitaine and the North Sea basins, respectively, there is a wide range in size, apical angle, convexity, degree of constriction, and length/width-ratios, even within populations from one and the same locality. The extremes of such populations could easily be considered to represent separate species, if only a restricted number of individuals is available.

Measurements of vaginellid shells, and ratios calculated from these measurements, have frequently be used, and especially so by a number of Italian authors (e.g. Robba, 1971), to clarify the interrelationships of the various taxa within the genus *Vaginella*. However, in our opinion such measurements can exclusively be taken from excellently preserved specimens, which in most cases are either absent or extremely rare. Specimens with a completely developed aperture, still possessing their larval shell, are really exceptional and exclusively known in a very restricted number of species. Length measured on internal casts will always give too low a value, because as a rule neither the protoconch, nor the extreme apertural margin will be present. The degree of damage to these parts of the casts will not be identical among the measured individuals, so the results will suggest a non existing variability. Measurements of the apical angle likewise will be defective, either as a result of incomplete shells, or because the convexity of the sidelines hampers a good definition of such measurements. Values published for this parameter with an accuracy in minutes and even seconds (Robba, 1971, 1977; d'Alessandro & Robba, 1980) are confusing and should be strongly distrusted. In our experience repeated measurements of the apical angle on one and the same population results in deviations of 1-5 degrees! It is for these reasons that we did not apply such parameters for the discrimination of taxa and looked for well-defined morphological characteristics instead.

Krach (1981) mentioned *Vaginella austriaca* Kittl, 1886, *V. austriaca brevior* Krach, 1981 and *V. rzehaki* Kittl, 1886 for the Middle Miocene of Poland. Generally speaking, the Polish material of the genus *Vaginella* is in poor condition. Only the specimens from Korytnica are available in good shell preservation, whereas practically all other material is preserved on slabs of clay, or as more or less distorted and/or decalcified specimens. The Korytnica samples without exception belong to *V. austriaca*, almost exactly identical in shell form to those known from the 'Badener Tegel' of the Vienna Basin. The poor preservation of most other samples inevitably leads to problems in their identification. This was for instance clearly demonstrated by Krach himself: at a given moment he revised his material until then considered to belong to *V. depressa* Daudin, 1800, and named them *brevior*, considering them to be a subspecies of *V. austriaca*. Many of the labels on *Vaginella* samples in the Krach collection contain identifications that are changed once or twice.

Looking through Krach's material it soon becomes clear, that it is practically impossible to make a 100% separation between taxa like *V. austriaca*, *V. austriaca brevior*, *V. depressa*, and *V. rzehaki*. Compression of a *Vaginella* shell, as it takes place in non-consolidated sediments by rock pressure, leads to a depressed specimen in which the shell width is exaggerated. Thus, a *V. austriaca* specimen becomes wider, and will resemble *V. rzehaki* or even *V. depressa*. Also, such a compression will obscure the presence of apertural folds as often present in *Vaginella* species, e.g. *V. depressa*. The actual presence of such folds could not be established in any of the Polish *Vaginella* specimens.

In our opinion *V. austriaca brevior* Krach belongs entirely to *V. austriaca*. The type material of *V. rzehaki* also falls within the range of variability of *V. austriaca* (i.e. the lectotype) and of *V. depressa* (all paralectotypes). For these reasons we synonymise the three taxa *V. austriaca* Kittl, 1886, *V. austriaca brevior* Krach, 1981 and *V. rzehaki* Kittl, 1886 (see more extensive discussion below). In future we will use the name *V. austriaca* for this complex, as this taxon is very well characterised by its type material.

Vaginella austriaca Kittl, 1886
Pl. 6, figs. 8-15; Pl. 10, figs. 1-5; Pl. 11, figs. 1-6.

Selected synonyms:

v. 1856 *Vaginella depressa* Daud. — Hörnes, pp. 663-664, pl. 50, fig. 42a (non Daudin).

*v 1886 *Vaginella austriaca* n.f., Kittl, pp. 54-56, pl. 2, figs. 8-12.

v. 1886 *Vaginella rzehaki* n.f., Kittl, p. 56, pl. 2, figs. 13-16.

v. 1904 *Vaginella austriaca* Kittl — Sacco, p. 15, pl. 4, fig. 11.

1921 *Vaginella austriaca* Kittl — Checchia-Rispoli, pp. 13-15, fig. 5, a.
v. 1934 *Vaginella floridana* n. sp., Collins, p. 216, pl. 13, figs. 22, 23.
. 1949 *Clio vrázi*, n. sp., Vasicek, pp. 35-36, fig. 1, pl. 1, figs. 2a, b, 3.
. 1957 *Vaginella austriaca* Kittl — Krach & Nowak, pl. 1, fig. 4.
. 1958 *Vaginella austriaca* Kittl — Erünal-Erentöz, p. 131, pl. 21, fig. 17.
. 1961 *Vaginella austriaca* Kittl — Dieci, p. 40, pl. 15, fig. 4a-b, pl. 16, fig. 6.
. 1966 *Vaginella austriaca* Kittl, 1886 — Strausz, p. 490, fig. 219.
v. 1968 *Vaginella austriaca* Kittl — Čtyroký et al., p. 133, pl. 4, figs. 3-8 (partim, non fig. 9 = *Clio* sp.).
. 1968 *Vaginella austriaca* Kittl, 1886 — Sirna, p. 423, fig. 10.
v. 1971 *Vaginella austriaca* Kittl, 1886 — Robba, pp. 86-87, pl. 3, figs. 12-17.
. 1974 *Vaginella austriaca* Kittl, 1886 — Stancu, p. 188, pl. 2, figs. 1a, b, 2, 5, 6, pl. 3, figs. 1a-b, 2-9.
v. 1975 *Vaginella depressa* Daudin, 1800 — van den Bosch et al., pl. 14, fig. 14 (non Daudin).
v. 1977 *Vaginella austriaca* Kittl, 1886 — Robba, pp. 587-588, pl. 17, figs. 1-4, pl. 18, fig. 4.
v. 1978 *Vaginella austriaca* Kittl, 1886 — Robba & Spano, pp. 762-764, pl. 76, fig. 4.
. 1979a *Vaginella austriaca brevior* ssp. n., Krach, pp. 655-656, fig. 1.
v. 1979 *Vaginella austriaca* Kittl, 1866 — d'Alessandro et al., pp. 85-86, pl. 15, fig. 25, pl. 16, figs. 21-35.
v. 1980 *Vaginella austriaca* Kittl, 1886 — d'Alessandro & Robba, pp. 620-623, pl. 61, figs. 6a-d, 7a-d; pl. 62, figs. 1-6; pl. 63, figs. 1-3.
. 1981 *Vaginella austriaca* Kittl, 1886 — Martinell & de Porta, pp. 5-6, figs. 11-14.
v. 1981 *Vaginella rzehaki* Kittl — Krach, p. 124, pl. 2, figs. 15-19.
v. 1981 *Vaginella austriaca* Kittl 1886 — Krach, p. 124, pl. 1, figs. 15-18, 20; pl. 2, figs. 1-3, 21-24; pl. 4, fig. 2.
v. 1981 *Vaginella austriaca brevior* ssp. n. — Krach, p. 125, pl. 2, figs. 4-14, 20.
v. 1983 *Vaginella austriaca* Kittl, 1886 — Spano, pp. 255-257, pl. 16, figs. 1-8.
v. 1984 *Vaginella austriaca* Kittl, 1886 — Janssen, pp. 73-75, pl. 4, figs. 1-8.
v. 1985 *Vaginella austriaca* Kittl, 1886 — Janssen, pp. 199-201, figs. 8-9.
v. 1991a *Vaginella austriaca* Kittl, 1886 — Zorn, p. 25, pl. 3, fig. 4; pl. 4, fig. 1-3.
v. 1991b *Vaginella austriaca* Kittl, 1886 — Zorn, p. 120, pl. 6, figs. 1-6; pl. 7 fig. 1-9; pl. 12, figs. 4, 5; pl. 14, figs. 1-8; pl. 16, figs. 1-4.
v. in press *Vaginella austriaca* Kittl, 1886 — Bohn-Havas & Zorn, pl. 2, figs. 2-8; pl. 3, figs. 3-5.

Type material — Lecto- and paralectotypes stored in the Naturhistorisches Museum, Vienna; see Janssen (1984, p. 73) and Zorn (1991a, p. 25) for a specification.
Locus typicus — Baden, Lower Austria.

Plate 10

Figs. 1-5. *Vaginella austriaca* Kittl, 1886
Magnification of all specimens X 8 (INGK).
1: Brzeszcze-1, 57 m.
2: Międzyrzecze-1, 101.5 m.
3: Łapczyca-1, 1088-1092.6 m.
4: Brzeszcze-1, 96 m.
5: Brzeszcze-1, 56 m.
Fig. 1 lectotype, and figs. 3-4:syntypes of *Vaginella austriaca brevior* Krach, 1979; fig. 2: specimen identified by Krach (1981) as *Vaginella* sp.; fig. 5: as *Vaginella austriaca* Kittl.

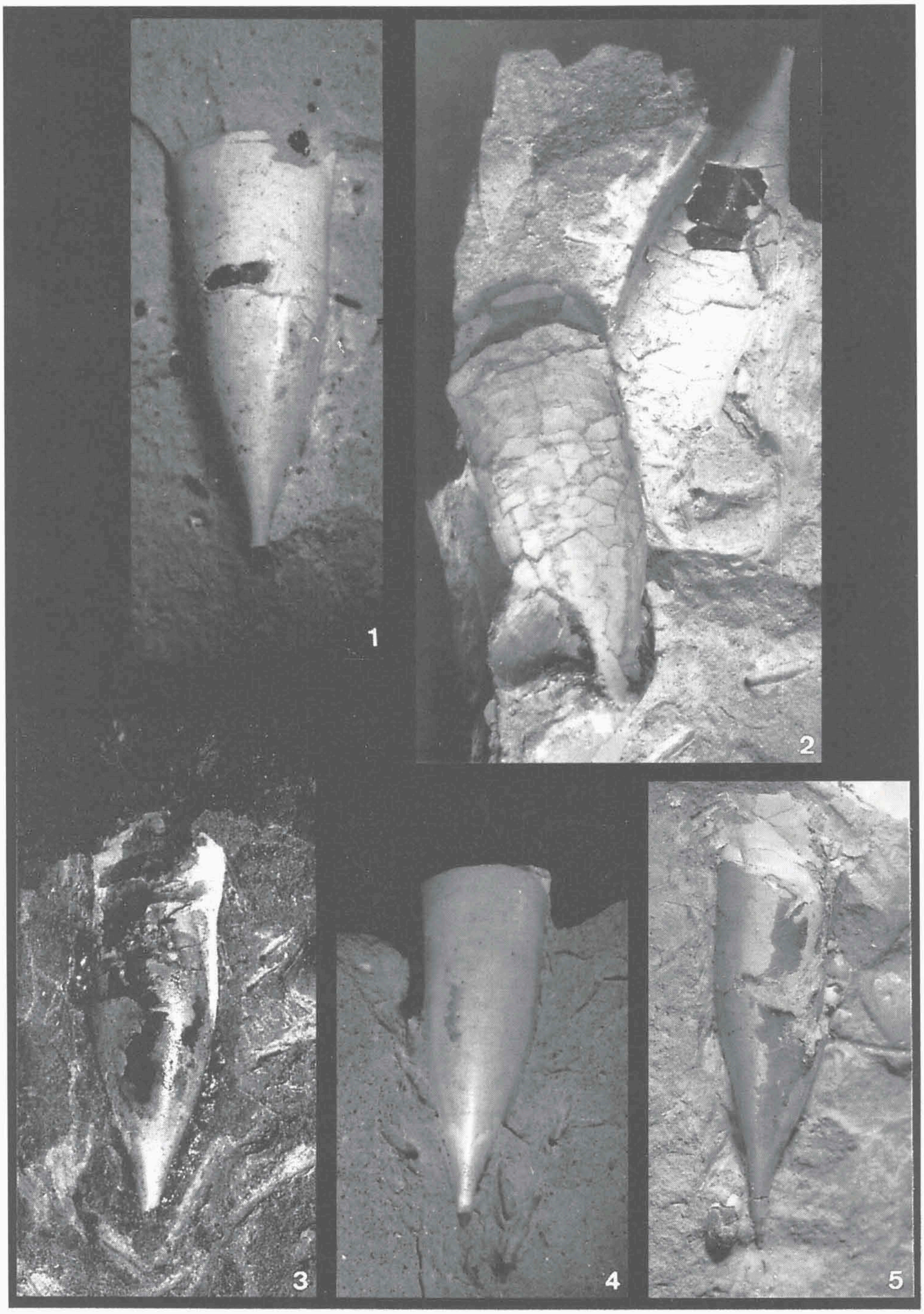

Plate 10

Stratum typicum — 'Badener Tegel', Upper Lagenidae Zone (Miocene, Badenian).

Diagnosis — *Vaginella* with straight shell, having its greatest width at the aperture (preapertural constriction very weak or absent). Aperture terminal, dorso-ventrally compressed. Dorsal apertural margin more strongly curved in abapical direction than ventral one. Lateral carinae present in basal two thirds of teleoconch. Larval shell dorso-ventrally slightly flattened, with two constrictions, deviating ventrally from the teleoconch-axis.

Notes on (type material of) *Vaginella austriaca brevior* — Krach (1979a) illustrated this taxon in his fig. 1. The specimen, originating from the Brzeszcze-1 borehole (depth not indicated), could not be recognised among the specimens available to us. Therefore we herewith designate a syntypical specimen from this locality (depth 57 m) as the lectotype, illustrated here in Pl. 10, fig. 1.

A sample of *Vaginella austriaca* from Lapugy (Transylvania, Rumania), stored in the Naturhistorisches Museum at Vienna (reg. no. 1890.I.385) contains specimens that strongly differ in size. The shell length of the largest individuals (3 specimens) is about 2 1/2 times that of the smallest ones. Still, the two extremes in our opinion represent *V. austriaca*. Also among the specimens in the Krach collection there is a specimen (Pl. 11, fig. 6), identified *V. austriaca brevior*, that agrees with the larger shells from Lapugy. All these larger forms demonstrate a slight dorso-ventral curvature of the shell axis, which in fact is exceptional for the genus *Vaginella*. This fact alone, however, is insufficient for a taxonomical separation from *V. austriaca*, as they agree in all other characteristics with the typical form and furthermore demonstrate all possible intermediate forms. A comparison with the *V. austriaca* population from the North Sea Basin demonstrates that also in this area the variability is very wide and includes specimens resembling the form indicated as *V. austriaca brevior* by Krach.

Notes on (type material of) *Vaginella rzehaki* — When Kittl (1886) described *Vaginella austriaca* and *V. rzehaki*, he separated the two species mainly because of the differing shell widths, *V. rzehaki* being wider than *V. austriaca*. Additionally he described the outline of *V. rzehaki as* being conical in its older part, the lateral margins then becoming parallel and widening again towards the aperture, which represents the largest diameter. In *V. austriaca* the shell diameter increases gradually towards the aperture and sometimes a preapertural constriction, although weak, is present. Furthermore the apertural widening in *V. austriaca* seems to be less accentuated. The difference between *V. rzehaki* and *V. depressa* is the less swollen shell of the former.

For one of his syntypes from Seelowitz (nowadays Židlochovice, Moravia, Czech Republic) (Kittl's fig. 16), which is a very large specimen, Kittl mentioned the presence of longitudinal sculptural elements, but he also realised that the outline of this specimen resembles *V. austriaca*. Kittl was not sure of the taxonomical status of this specimen. This very specimen (reg. no. 1993/12/1) was designated as the lectotype of *V. rzehaki* by Janssen (1984). The radial sculpture is also present in another individual (Janssen, 1984, pl. 3, fig. 4). This sculpture, however, seems to be of no diagnostic value, as a similar sculpture was found to occur in otherwise typical specimens of *V. austriaca* from Korytnica. Similar radial sculpture is also occasionally present in the Italian Miocene species *V. gibbosa* Audenino, 1896. As there are no real morphological differences between the lectotype of *V. rzehaki* and *V. austriaca* we consider the former to be synonymous with the latter. Since Kittl (1886) the name *V. rzehaki* has repeatedly been used in literature to indicate relatively wide *Vaginella* forms. Such wide specimens are also present in the Polish material, as indicated by Krach (1981). The preservation of all these specimens, however, is such that the relative width of these shells can be explained by deformation as a result of rock pressure. D'Alessandro & Robba (1980) considered various literature records of *V. gibbosa* Audenino, 1896, from the southern Italian Miocene (Checchia-Rispoli, 1921; Sirna, 1968; d'Alessandro et al., 1979) to be synonyms of *Vaginella rzehaki*. As they did not include the original description of Audenino, based on material from the Langhian of the Monte Capuccino near Turin, in their synonymy they obviously maintain the *V. gibbosa* taxon. We have excellently preserved material (in phosphatic cast preservation, RGM collection) available from southern Italy, as described by d'Alessandro & Robba (1980). A closer study of these samples (and their stratigraphical origin) will be necessary to decide whether or not such samples should be considered to fall within the range of variability of *Vaginella austriaca*.

The following type material was also mentioned by Janssen (1984): one paralectotype (original of Kittl's fig. 13) and six syntypes (reg. no. 1888.I.60) from Polnisch Ostrau. Janssen (1984) furthermore stated that syntypical material from the Poremba II borehole was missing in the Vienna collection. This sample was rediscovered afterwards and transferred into the regular pteropod collection (reg. no. 1888.I.2), with a label referring to its being the original of Kittl's fig. 14. Although just one specimen was mentioned by Kittl the two clay slabs of this sample (which are each others counterparts) contain several specimens. One of these could be partly isolated from the sediment and appeared to be a typical *V. depressa*. Its protoconch is missing, but it can be observed that this shell part does not deviate from the adult shell axis as is typical in *V. austriaca*. Another, very defective specimen could be prepared and its protoconch also appeared to be a typical *V. depressa*.. Five syntypes from Dombrau (reg. no. 1993/13) and two further specimens (reg. no. 1888.I.3, Kittl's fig. 15) and five syntypes from Poremba (borehole II, 1 specimen, and borehole III, 4 specimens; reg. no. 1993/14/1-3) have also been found in the meantime.

Material studied (for a detailed specification see Table 6) — Brzeszcze-1 borehole, depth 96 m: 14 ex.; depth 84 m: 1 ex.; depth 72 m: 3 ex.; depth 62 m: 14 ex.; depth 61-62 m: 40 ex.; depth 61 m: 28 ex.; depth 60 m: 41 ex.; depth 59 m: 19 ex.; depth 57 m: 21 ex.; depth 56 m: 26 ex. Dębowiec-45 borehole, depth 508.2-509.2 m: 2 ex.; depth 423.8-425 m: 1 ex.; depth 401.6-403 m: 1 ex. Grudna Dolna-2 borehole, depth 92 m: 6 ex. (*Vaginella* cf. *austriaca*); depth 89 m: 1 ex.; depth 80 m: 1 ex.; depth 79 m: 3 ex.; depth 69 m: 1 ex.; depth 60 m: 4 ex.; depth 57 m: 1 ex.; depth 50 m: 1 ex.; depth 46 m: 1 ex.; depth 41 m: 2 ex.; depth 17 m: 1 ex. Grudna Dolna-4 borehole, depth 110 m: 8 ex.; depth 105 m: 1 ex.; depth 98.5-99 m: 1 ex.; depth 94.5-95.5 m: 1 ex.; depth 52-52.5 m: 1 ex.; depth 30.5-31 m: 1 ex.; depth 29.5-30.5 m: 6 ex.; depth 26.5-27 m: 3 ex.; depth 10-11 m: 1 ex. Grudna Dolna-5 borehole, depth 86-87 m: 2 ex.; depth 75-78 m: 2 ex.; depth 73-75 m: 5 ex.; depth 71-73 m: 4 ex.; depth 69-71 m: 2 ex.; depth 67-69 m: 3 ex.; depth 66-67 m: 6 ex.; depth 65-66 m: 5 ex.; depth 64-65 m: 5 ex.; depth 63-64 m: 5 ex.; depth 61-62 m: 9 ex.; depth 59-61 m: 2 ex.; depth 57-59 m: 12 ex.; depth 55-57 m: 12 ex.; depth 53-55 m: 8 ex.; depth 51-53 m: 6 ex.; depth 50-51 m: 6 ex.; depth 49-50 m: 5 ex.; depth 44-45 m: 10 ex.; depth 35-37 m: 5 ex.; depth 25-27 m: 2 ex.; depth 19-21 m: 1 ex. Kop. Zofiówka borehole, depth 610 m: 1 ex.; depth 30 m: 4 ex. Korytnica outcrop: c. 100 ex. Łapczyca-1 borehole, depth 273 m: 2 ex.; depth 267 m: 2 ex.; depth 266 m: 1 ex.; depth 264 m: 1 ex.; depth 241-243 m: 5 ex.; depth 231-239 m: 9 ex.; depth 211-230 m: 8 ex.; depth 226 m: 1 ex.; depth 206 m: 2 ex.; depth 182 m: 3 ex.; depth 144-158 m: 4 ex. Łapczyca-2 borehole, depth 1088-1092.6 m: 5 ex.; depth 1075-1079.1 m: 5 ex. Łęki Dolne, depth 115-123 m: 3 ex.; depth 112-115 m: 7 ex.; depth 110-112 m: 3 ex.; depth 107-110 m: 5 ex.; depth 105-107 m: 2 ex.; depth 100-105 m: 4 ex.; depth 95-100 m: 14 ex.; depth 85-90 m: 4 ex.; depth 72-77 m: 1 ex.; depth not indicated: 7 ex. Międzyrzecze-1 borehole, depth 101-102 m: 32 ex.; depth 101.5 m: c. 28 ex. Mszana-1 borehole, depth 157-162 m: 5 ex.; depth 133.15-137 m: 6 ex.; depth 113.15-117 m: 6 ex. Roczyny-1 borehole, depth 352-353 m: 1 ex., depth 170-176 m: 8 ex.; depth 163.4-168.4 m: 8 ex.; depth 163-168 m: many ex.; depth 163-164 m: 1 ex.; depth 160.2-162.4 m: c. 17 ex.; depth 158.2-160.2 m: 6 ex.; depth 156.2-158.2 m: many ex.; depth 156-158 m: 7 ex.; depth 153-156 m: many ex.; depth 147-151 m: 6 ex.; depth 136-139 m: 5 ex.; depth 130-139 m: 4 ex.; depth 128.5-130 m: 1 ex.; depth 127-128 m: 4 ex.; depth 86.7-90.5 m: 1 ex.; depth 60-62 m: 5 ex.; depth 56.4-60.4 m: 2 ex.; depth 53.4-56.2 m: 2 ex.; depth 50.4-53.4 m: 2 ex.; depth not indicated: 2 ex. Roczyny-2 borehole, depth 69.5-71.5 m: 3 ex.; depth not indicated: 6 ex. Świerczyniec

borehole, depth 248 m: 3 ex.; depth 218 m: 6 ex.; depth 160-200 m: 21 ex.
Furthermore, a number of less favourably preserved specimens had to be identified in open nomenclature (*Vaginella* sp.). These are also specified in Table 6.

Discussion — In a sample from Korytnica several specimens, as stated above, show a distinct longitudinal sculpture, comparable to that present in the lectotype of *V. rzehaki*. Also several examples of pathological shells are present. One specimen (Pl. 6, fig. 12) shows an irregular rupture in shell growth present all around the shell, probably caused by some kind of mechanical influence, but the shell growth continued regularly after this incident. In another specimen (Pl. 6, fig. 10) shell repair occurred very irregularly after damage to the apertural shell part. The shape of the shell is restored, but its surface is uneven and furrowed, and real growth lines are only present next to the aperture, but they are curved rather abnormally. This specimen also demonstrates the presence of longitudinal sculpture. Two other individuals have developed a non-typical lateral constriction in the older half of the teleoconch. One of these is illustrated in Pl. 6, fig. 11.

Notes on the stratigraphy — From the Paratethys area e.g. Krach (1979a-b, 1981) and Zorn (1991a) published range charts for *Vaginella* species, the same was done for northern Italy by Robba (1972) and for Sardinia by Spano (1983). In each of these cases the vertical ranges of *V. depressa* and *V. austriaca* show a considerable overlap. In the North Sea Basin (most probably also in the Aquitaine Basin), on the contrary, the vertical ranges suggest (Janssen & King, 1988) that *V. depressa* is the ancestor species of *V. austriaca*. Should this be true, than both belong to one and the same evolutionary lineage. Accepting this hypothesis would mean that the transition from *V. depressa* to *V. austriaca* would have occurred almost simultaneously everywhere, making a co-occurrence of these two taxa very unlikely.

Looking at the Krach material and other samples, from the Paratethys as well as from the Mediterranean area, with this hypothesis in the back of one's mind, leads to another interpretation of the various species. It appears that parts of the vertical ranges are based either on single specimens, or on poorly preserved material, that can as easily be identified differently. Summarising we conclude that at least in the Central Paratethys the vertical ranges of both species can be interpreted as similar to those in the North Sea Basin, where *V. depressa* is restricted to the Vierlandian (= Aquitanian to Early Burdigalian) and *V. austriaca* to the Hemmoorian-Reinbekian (=

Plate 11

Figs. 1-6. *Vaginella austriaca* Kittl, 1886

1: Poremba II, Czech Republic (NHMW, reg. no. 1888.I.2), rediscovered syntype of *Vaginella rzehaki* Kittl.

2: Grudna Dolna-5, 73-75 m (INGK).

3: Grudna Dolna-2, 89 m (INGK).

4: Grudna Dolna-5, 55-57 m (INGK), juvenile specimen.

5: Grudna Dolna-5, 71-73 m; 6: Świerczyniec, 160-200 m (INGK).

Figs. 2-3, 5: specimens identified by Krach (1981) as *Vaginella rzehaki* Kittl; fig. 4: as *Vaginella ? rzehaki* Kittl; fig. 6: syntype of *Vaginella austriaca brevior* Krach, 1979. All specimens X 8.

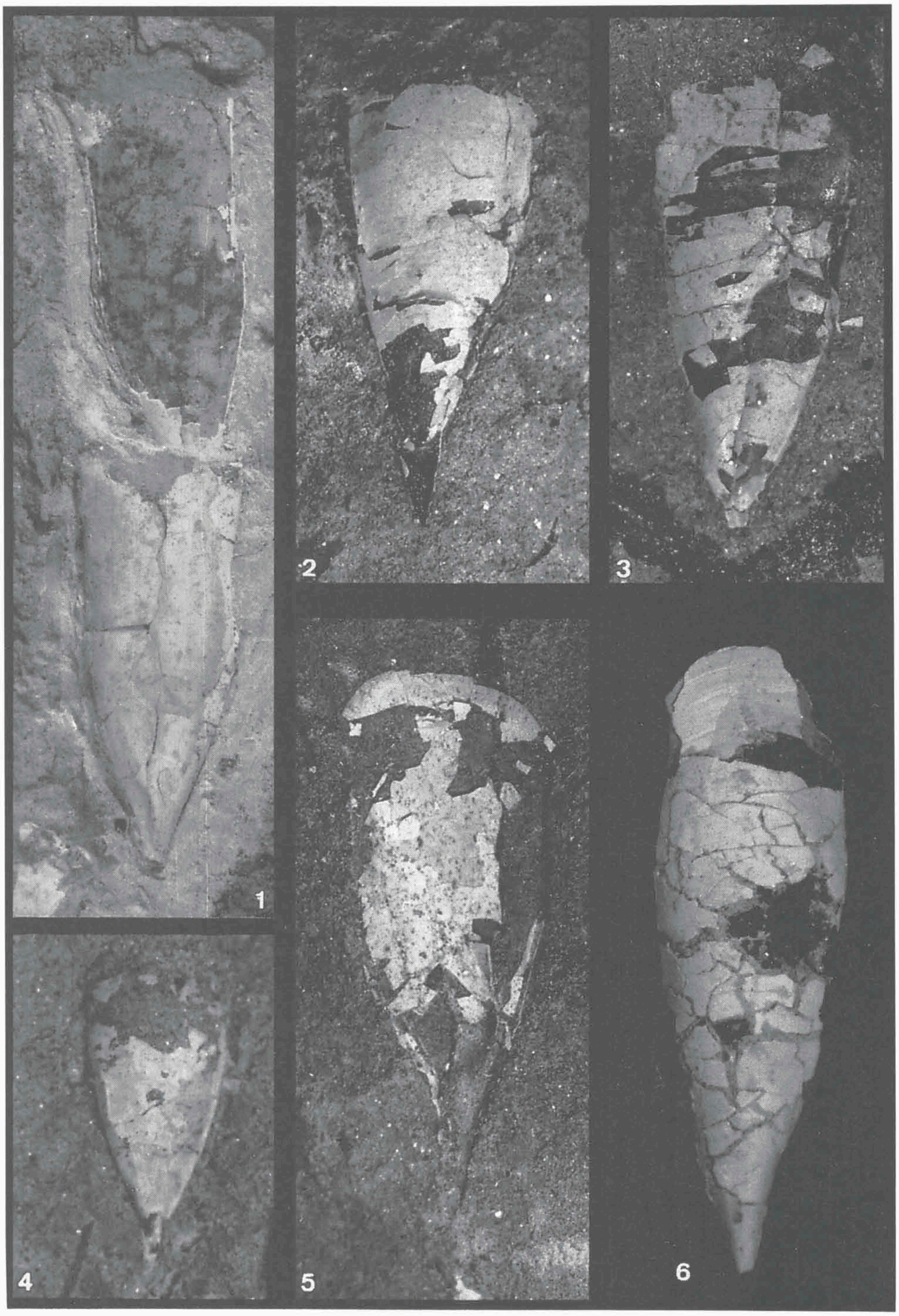

Plate 11

Late Burdigalian to Langhian), although exceptionally some contradictions remain (one specimen from the Badenian of Forchtenau in Austria, see Janssen, 1984, p. 75, pl. 4, fig. 13; Zorn, 1991a, p. 27, pl. 4, fig. 4; 1991b, p. 124, pl. 8, fig. 2).

Carefully looking at the various papers that appeared during the last decades on similar occurrences in northern Italy suggests that in that area too quite a lot of material is so poorly preserved that a taxonomical revision very well might lead to the same conclusions on the vertical ranges, and, therefore, to a better practical applicability of this fossil group in biostratigraphy. In Italy, however, the difficulties are still larger, as several other *Vaginella* taxa are distinguished there which should be taken into consideration. The problem can only be solved after a careful study of the available material. This goes beyond the framework of this paper, obviously.

The general confusion regarding the interpretation of Mediterranean vaginellids, however, is distinctly demonstrated, e.g. by Spano (1983, p. 257), who compared small and slender specimens of *V. austriaca* ('esemplari di piccole dimensioni') with a mean length/width-ratio of 2.88 (compared to 2.47 for 'normal' specimens) from the Early Miocene of Sardinia with *Vaginella austriaca brevior*, which — as already indicated by its name — is characterised by a relatively wider shell.

Subordo PSEUDOTHECOSOMATA
Familia PERACLIDIDAE

Genus *Peracle* Forbes, 1844 (= *Peraclis* Pelseneer, 1888: unjustified emendation, art. 33-b-iii ICZN)

Peracle lata (Krach, 1979)
Pl. 5, fig. 4; Pl. 6, fig. 1.

*v 1979a *Spiratella lata* n.sp., Krach, pp. 658-660, fig. 4.
v. *1979b Spiratella lata* n.sp. — Krach, p. 1391.
v. *1979c Spiratella lata* n.sp. — Krach, p. 1392.
v. 1981 *Spiratella lata* n.sp. (sic!) — Krach, p. 129, pl. 3, figs. 13, 14a-b; pl. 6, fig. 8a-c (fig. 8c is erroneously numbered 6c).
. *1982 Spiratella lata* Krach — Bernasconi & Robba, p. 217

Lectotype designation — The syntype sample of this taxon consists of three specimens. The specimen recognisable as the one illustrated by Krach (1979a, fig. 4, and 1981, pl. 3, figs. 13, 14) is herewith designated as the lectotype. The other two specimens are paralectotypes.
Type locality — Brzeszcze near Bielsko (Poland), borehole 1, depth 59 m below surface.
Stratum typicum — Unspecified sediments of Badenian (Early Opolian, Moravian) age (*Uvigerina costai* Zone, according to Krach, 1979a, table 1).
Diagnosis — *Peracle* with $2^1/_2$-3 convex whorls, rapidly increasing in diameter. Initial $1^1/_2$ whorls planospiral and therefore shell with a blunt apex. Shell hardly higher than wide (but basal part may be missing). Aperture oval to almost circular, a columellar seam is present but not very wide. Short radial folds with a distinct backwards curvature are present below the suture, fading out toward the aperture on the last half whorl of the largest available specimen. In adult specimens a subsutural

spine develops on the apertural margin.

Material studied (for a detailed specification see Table 6) — Brzeszcze-1 borehole, depth 62 m: 1 ex.; depth 59 m: 3 ex. (lectotype and paralectotypes).

Description — The available material consists of three syntype specimens, a fourth specimen was discovered in a sample of *Vaginella austriaca* from the same borehole, depth 62 m. All specimens are preserved as pyritic casts, with the thin-walled shell still partly preserved. The height of the shell is but slightly more than the shell width. The largest syntype has a height of 1.55 mm and consists of $2^1/_2$ whorls, the first $1^1/_2$ of which are planospiral, thus causing a rather blunt apex. The diameter of the nucleus is c. 0.06 mm. The whorls are very convex and increase rapidly in diameter, resulting in a large aperture with a height of c. 1.1 mm and a width of c. 1.0 mm. The whorls are separated by a deep suture. The last whorl descends quickly. Near the aperture its upper margin attaches below the periphery of the penultimate whorl. The abaxial margin of the aperture is regularly curved, with a gradual transition into the base. The columellar side is excavated; a rather narrow but distinct columellar seam is present, separated by a thickened ridge. This ridge is also thickened on the inner side of the shell, as it leaves an obvious furrow on the pyrite cast. The basal part of the shell is distinctly damaged in two of the three type specimens, but in the lectotype it is regularly rounded. There is no indication that the columella has been extended into a basal rostrum, as is usual in *Peracle*, but also in the holotype the shell may be damaged and incomplete.

Along the suture of the last half whorl of the lectotype about ten spaced radial folds (crests) are present. They are slightly curved in a backward direction, following the course of faintly visible growth lines. Just below the crests the growth lines change into a forward curve.

There is no further surface sculpture, as is usual in more or less weathered *Peracle* shells, but it must be considered probable that a reticulate cuticulum has been present on (parts of) the shell.

The specimen found in the -62 m sample (Pl. 6, fig. 1a-b) is relatively large, but its apex, basal part and apertural margin are severely damaged. Shell remnants on the cast demonstrate nicely the radial crests below the suture, but these are also quite well visible on the pyrite cast, at places where the shell wall has disappeared. On the last half whorl before the aperture the crests tend to fade away and the growth lines start from the upper suture in a forward curve. At the same time a distinct spiral develops at a short distance below the suture, exactly at the place where the growthlines change their forward curvature into a backward one.

Discussion — *P. lata* resembles the Recent species *Peracle apicifulva* Meisenheimer, 1906 (compare van der Spoel, 1976, fig. 11a-c) in its proportions, but in the latter species the apex is more pointed, the body whorl is comparatively wider, and the radial crests along the suture are distinctly more closely set.

The spiral present on the body whorl of the largest specimen no doubt indicates the presence of an apertural spine, as present in *Peracle bispinosa* Pelseneer, 1888 (van der Spoel, 1976, fig. 10b), which differs from the present species by its pointed apex.

In *P. moluccensis* Tesch, 1903 (compare van der Spoel. 1976, fig. 12c-d) the upper part of the shell is flattened with a hardly protruding apex.

Further Tertiary *Peracle* forms are known (unpublished data, RGM collection) from the Pliocene of southern France and Italy. Furthermore, a specimen illustrated sub nomine *Spiratella andrussovi* by d'Alessandro et al. (1979, p. 82, pl. 15, fig. 13a-b), from the Miocene of Puglia, southern Italy, belongs to the species group possessing a long spine on the basal part of the apertural margin, as is obvious from a distinct groove present on the base of the cast.

Peracle sp. nov.
Pl. 5, fig. 5.

v. *1981 Spiratella andrussovi* (Kittl) — Krach, p. 128 (partim, non Kittl).

Material studied — Mszana-1 borehole, depth 145-149 m, 1 ex. (INGK).

Description — Only one specimen is available, preserved as a pyrite cast, with some remnants of the shell-wall. The shell is higher than wide (H = 1.7 mm, W = 1.5 mm). It has almost three convex whorls, which are flattened below the suture, as a result of which the shell has an almost flat apical side. The whorls increase quickly in diameter, they have their greatest diameter above the midline. The suture separating the whorls increases in depth towards the aperture, but this is difficult to observe as the last half of the body whorl is covered with an irregular pyrite layer. The last whorl descends quickly, touching the penultimate whorl at its base only. The aperture is large (height 1.2 mm, width 1.0 mm) and somewhat triangular. Its columellar side is excavated; a distinct columellar seam is present, separated by a ridge. There is no indication that the columella has been extended into a rostrum, as commonly seen in *Peracle*, but this may be because of the preservation.

Along the suture of the body whorl, at those places where some remnants of the aragonitic shell wall are still present, traces of radial folds (crests) can be seen in low angle light. Growth lines could not be observed. There is no further surface sculpture, but also in this specimen a reticulate cuticulum might have been present on (parts of) the shell.

Discussion — This specimen demonstrates some resemblance with the Recent *Peracle moluccensis* Tesch, 1903 by its flattened apical side. Still, in apertural direction the whorls descend strongly, which is not the case in *P. moluccensis*. Also the transverse section of the whorls is different, and there is no trace of a subsutural carina or of an apertural spine. Presumably the specimen represents an undescribed *Peracle* species, but the fact that only one, not very favourably preserved specimen is available prevents us from introducing it as a new taxon.

Biostratigraphy based on holoplanktonic molluscs

Vertical distribution of the species in the Carpathian Foredeep

The distribution in the various boreholes and outcrops of the holoplanktonic gastropods, as recognised in this paper, is given in Fig. 12. Concerning the stratigraphic origin of the various pteropod samples in the Krach collection we usually have very incomplete information, as the samples bear only the name of the borehole and the

Table 6. Summary of samples from the W. Krach collection discussed in this paper. The available number of specimens is given in the column 'n' and may also refer to juvenile and/or defective specimens, or to fragments.

Locality	depth	this paper	n	in Krach collection	coll.	notes
Biadoliny-1	52-54.2	*Clio pedemontana*	1	*Clio pedemontana*	INGK	cast and mould present; Krach, 1981, pl. 1, fig. 1; this paper Pl. 9, fig. 4
Brzeszcze-1	96	*Vaginella austriaca*	13	*Vaginella austriaca brevior*	INGK	syntypes of *Vaginella austriaca brevior*
Brzeszcze-1	96	*Vaginella austriaca*	1	*Vaginella austriaca brevior*	INGK	syntypes of *Vaginella austriaca brevior*; Pl. 10, fig. 4
Brzeszcze-1	84	*Vaginella austriaca*	1	*Vaginella austriaca*	INGK	
Brzeszcze-1	72	*Vaginella austriaca*	3	*Vaginella austriaca*	INGK	
Brzeszcze-1	62	*Peracle lata*	1	-	INGK	not mentioned in Krach (1981); from sample identified *Vaginella austriaca*; no syntype !
Brzeszcze-1	62	*Vaginella austriaca*	5	*Vaginella austriaca*	INGK	
Brzeszcze-1	62	*Vaginella austriaca*	6	*Vaginella austriaca* subsp. n.	INGK	syntypes of *Vaginella austriaca brevior*
Brzeszcze-1	62	*Vaginella austriaca*	3	*Vaginella* sp.	INGK	
Brzeszcze-1	61- 62	*Limacina* cf. *valvatina*	3	-	INGK	from sample identified *Vaginella austriaca*
Brzeszcze-1	61- 62	*Vaginella austriaca*	40	*Vaginella austriaca*	INGK	
Brzeszcze-1	59- 62	*Limacina valvatina*	9	*Spiratella valvatina*	INGK	
Brzeszcze-1	61	*Limacina miorostralis*	1	*Spiratella andrussovi*	INGK	
Brzeszcze-1	61	*Creseis spina*	2	*Vaginella lapugyensis*	INGK	
Brzeszcze-1	61	*Vaginella austriaca*	15	*Vaginella austriaca brevior*	INGK	syntypes of *Vaginella austriaca brevior*
Brzeszcze-1	61	*Vaginella austriaca*	10	*Vaginella austriaca* subsp. n.	INGK	syntypes of *Vaginella austriaca brevior*
Brzeszcze-1	61	*Vaginella austriaca*	3	*Vaginella* sp.	INGK	

Table 6 (continued).

Locality	depth	this paper	n	in Krach collection	coll.	notes
Brzeszcze-1	60	*Limacina valvatina*	2	-	INGK	not mentioned in Krach (1981); from sample identified *Vaginella austriaca*
Brzeszcze-1	60	*Creseis spina*	1	-	INGK	Pl. 6, fig. 4
Brzeszcze-1	60	*Styliola subula*	1	-	INGK	Pl. 6, fig. 3
Brzesczce-1	60	*Vaginella austriaca*	16	*Vaginella austriaca brevior*	INGK	syntypes of *Vaginella austriaca brevior*
Brzesczce-1	60	*Vaginella austriaca*	3	*Vaginella austriaca* subsp. n.	INGK	syntypes of *Vaginella austriaca brevior*
Brzesczce-1	60	*Vaginella austriaca*	22	-	INGK	
Brzesczce-1	59	*Peracle lata*	1	*Spiratella lata*	INGK	lectotype; Pl. 5, fig. 4
Brzesczce-1	59	*Peracle lata*	1	*Spiratella lata*	INGK	paralectotype
Brzesczce-1	59	*Peracle lata*	1	*Spiratella lata*	RGM	paralectotype
Brzesczce-1	59	*Styliola subula*	1	*Styliola lamberti*	INGK	Pl. 6, fig. 2; Pl. 7, fig. 1
Brzesczce-1	59	*Vaginella austriaca*	12	*Vaginella austriaca* ?	INGK	
Brzesczce-1	59	*Vaginella austriaca*	6	*Vaginella austriaca* subsp. n.	INGK	syntypes of *Vaginella austriaca brevior*
Brzesczce-1	59	*Vaginella austriaca*	1	*Vaginella austriaca* subsp. n.	INGK	syntypes of *Vaginella austriaca brevior*
Brzeszcze-1	57	*Vaginella austriaca*	15	*Vaginella austriaca*	INGK	
Brzeszcze-1	57	*Vaginella austriaca*	1	*Vaginella austriaca* ?	INGK	
Brzeszcze-1	57	*Vaginella austriaca*	2	*Vaginella austriaca brevior*	INGK	syntypes of *Vaginella austriaca brevior*
Brzeszcze-1	57	*Vaginella austriaca*	1	*Vaginella austriaca brevior*	INGK	lectotype of *Vaginella austriaca brevior*; Pl. 10, fig. 1.
Brzeszcze-1	57	*Vaginella austriaca*	2	*Vaginella austriaca* subsp. n.	INGK	syntypes of *Vaginella austriaca brevior*
Brzeszcze-1	56	*Vaginella austriaca*	12	*Vaginella austriaca*	INGK	
Brzeszcze-1	56	*Vaginella austriaca*	2	*Vaginella austriaca*	INGK	Pl. 10, fig. 5

Table 6 (continued).

Locality	depth	this paper	n	in Krach collection	coll.	notes
Brzesczce-1	56	*Vaginella austriaca*	12	*Vaginella austriaca* subsp. n.	INGK	syntypes of *Vaginella austriaca brevior*
Czernica	-	*Limacina valvatina*	1	*Spiratella valvatina*	INGK	
Dębowiec-45	508.2-509.2	*Vaginella austriaca*	2	*Vaginella austriaca*	INGK	
Dębowiec-45	474-475	*Clio fallauxi*	1	*Clio fallauxi* subsp. indet.	INGK	Krach, 1981, pl. 1, fig. 6; this paper Pl. 8, fig. 1
Dębowiec-45	423.8-425	*Vaginella austriaca*	1	*Vaginella austriaca*	INGK	
Dębowiec-45	404.1-405.1	*Clio fallauxi*	1	*Clio fallauxi* subsp. indet.	INGK	Krach, 1981, pl. 1, fig. 5; this paper Pl. 8, fig. 2
Dębowiec-45	401.6-403	*Vaginella austriaca*	1	*Vaginella austriaca*	INGK	
Gdów-1	875.5-878	*Clio* sp. indet.	2	*Clio bittneri*	INGK	
Gliwice Stare	-	*Limacina valvatina*	3	*Spiratella valvatina*	INGK	
Gliwice Stare	-	*Limacina valvatina*	4	*Spiratella koeneni*	INGK	
Grudna Dolna-2	92	*Vaginella* cf. *austriaca*	6	*Vaginella rzehaki*	INGK	
Grudna Dolna-2	89	*Vaginella austriaca*	1	*Vaginella rzehaki*	INGK	Pl. 11, fig. 3
Grudna Dolna-2	80	*Vaginella austriaca*	1	*Vaginella rzehaki* ?	INGK	
Grudna Dolna-2	79	*Vaginella austriaca*	3	*Vaginella austriaca brevior*	INGK	syntypes of *Vaginella austriaca brevior*
Grudna Dolna-2	78	indet.	1	*Clio fallauxi*	INGK	
Grudna Dolna-2	69	*Vaginella austriaca*	1	*Vaginella rzehaki* ?	INGK	
Grudna Dolna-2	66	*Clio pedemontana*	1	*Clio pedemontana*	INGK	Pl. 9, fig. 6
Grudna Dolna-2	60	*Vaginella austriaca*	4	*Vaginella austriaca*	INGK	
Grudna Dolna-2	57	*Vaginella austriaca*	1	*Vaginella austriaca*	INGK	
Grudna Dolna-2	50	*Clio* cf. *pedemontana*	1	*Clio pedemontana*	INGK	Krach, 1981, pl. 1, fig. 9; this paper Pl. 9, fig. 5
Grudna Dolna-2	50	*Vaginella austriaca*	1	*Vaginella austriaca brevior*	INGK	syntype of *Vaginella austriaca brevior*
Grudna Dolna-2	46	*Vaginella austriaca*	1	*Vaginella austriaca*	INGK	
Grudna Dolna-2	42	*Vaginella* sp.	1	*Vaginella rzehaki* ?	INGK	
Grudna Dolna-2	41	*Vaginella austriaca*	2	*Vaginella rzehaki* ?	INGK	
Grudna Dolna-2	17	*Vaginella austriaca*	1	*Vaginella austriaca*	INGK	

Table 6 (continued).

Locality	depth	this paper	n	in Krach collection	coll.	notes
Grudna Dolna-4	110	*Vaginella austriaca*	8	*Vaginella austriaca*	INGK	
Grudna Dolna-4	105	*Vaginella austriaca*	1	*Vaginella rzehaki*	INGK	
Grudna Dolna-4	98.5-99	*Vaginella austriaca*	1	*Vaginella rzehaki*	INGK	
Grudna Dolna-4	94.5-95.5	*Vaginella austriaca*	1	*Vaginella rzehaki*	RGM	
Grudna Dolna-4	52-52.5	*Vaginella austriaca*	1	-	INGK	
Grudna Dolna-4	30.5-31	*Vaginella austriaca*	1	*Vaginella rzehaki*	INGK	
Grudna Dolna-4	29.5-30.5	*Vaginella austriaca*	1	*Vaginella rzehaki* ?	INGK	
Grudna Dolna-4	29.5-30.5	*Vaginella austriaca*	5	-	INGK	
Grudna Dolna-4	26.5-27	*Vaginella austriaca*	3	-	INGK	
Grudna Dolna-4	10-11	*Vaginella austriaca*	1	*Vaginella austriaca* ?	INGK	
Grudna Dolna-5	86-87	*Vaginella austriaca*	1	*Vaginella austriaca*	INGK	
Grudna Dolna-5	86-87	*Vaginella austriaca*	1	*Vaginella rzehaki*	INGK	
Grudna Dolna-5	75-78	*Vaginella austriaca*	2	*Vaginella rzehaki*	INGK	
Grudna Dolna-5	73-75	*Vaginella austriaca*	4	*Vaginella austriaca*	INGK	
Grudna Dolna-5	73-75	*Vaginella austriaca*	1	*Vaginella rzehaki*	INGK	Pl. 11, fig. 2
Grudna Dolna-5	71-73	*Vaginella austriaca*	3	*Vaginella austriaca*	INGK	
Grudna Dolna-5	71-73	*Vaginella austriaca*	1	*Vaginella rzehaki*	INGK	Pl. 11, fig. 5
Grudna Dolna-5	71-73	*Vaginella* sp.	4	*Vaginella rzehaki*	INGK	
Grudna Dolna-5	69-71	*Vaginella austriaca*	2	*Vaginella rzehaki*	INGK	
Grudna Dolna-5	67-69	*Vaginella austriaca*	3	*Vaginella rzehaki*	INGK	
Grudna Dolna-5	66-67	*Vaginella austriaca*	4	*Vaginella austriaca*	INGK	
Grudna Dolna-5	66-67	*Vaginella austriaca*	2	*Vaginella rzehaki*	INGK	
Grudna Dolna-5	65-66	*Vaginella austriaca*	5	*Vaginella austriaca*	INGK	
Grudna Dolna-5	64-65	*Vaginella austriaca*	5	*Vaginella rzehaki*	INGK	
Grudna Dolna-5	63-64	*Vaginella austriaca*	5	*Vaginella rzehaki*	INGK	
Grudna Dolna-5	61-63	*Vaginella* sp.	6	*Vaginella rzehaki* ?	INGK	
Grudna Dolna-5	61-62	*Vaginella austriaca*	4	*Vaginella austriaca* ?	INGK	
Grudna Dolna-5	61-62	*Vaginella austriaca*	5	*Vaginella rzehaki*	INGK	
Grudna Dolna-5	59-61	*Vaginella austriaca*	2	*Vaginella austriaca* ?	INGK	
Grudna Dolna-5	57-59	*Vaginella austriaca*	7	*Vaginella austriaca*	INGK	
Grudna Dolna-5	57-59	*Vaginella austriaca*	5	*Vaginella rzehaki* ?	INGK	

Table 6 (continued).

Locality	depth	this paper	n	in Krach collection	coll.	notes
Grudna Dolna-5	55-57	*Vaginella austriaca*	11	*Vaginella rzehaki* ?	INGK	
Grudna Dolna-5	55-57	*Vaginella austriaca*	1	*Vaginella rzehaki* ?	INGK	Pl. 11, fig. 4
Grudna Dolna-5	53-55	*Vaginella austriaca*	3	*Vaginella rzehaki*	INGK	
Grudna Dolna-5	53-55	*Vaginella austriaca*	5	*Vaginella rzehaki* var.	INGK	
Grudna Dolna-5	51-53	*Vaginella austriaca*	6	*Vaginella austriaca brevior*	INGK	syntypes of *Vaginella austriaca brevior*
Grudna Dolna-5	50-51	*Clio pedemontana*	1	*Clio fallauxi* ?	INGK	
Grudna Dolna-5	50-51	*Vaginella austriaca*	6	*Vaginella rzehaki*	INGK	
Grudna Dolna-5	49-50	*Vaginella austriaca*	5	*Vaginella rzehaki* ?	INGK	
Grudna Dolna-5	44-45	*Vaginella austriaca*	10	*Vaginella austriaca*	INGK	
Grudna Dolna-5	35-37	*Vaginella austriaca*	2	*Vaginella austriaca*	INGK	
Grudna Dolna-5	35-37	*Vaginella austriaca*	3	*Vaginella rzehaki*	INGK	
Grudna Dolna-5	25-27	*Vaginella austriaca*	2	*Vaginella austriaca*	INGK	
Grudna Dolna-5	19-21	*Clio fallauxi*	1	*Clio fallauxi*	RGM	
Grudna Dolna-5	19-21	*Vaginella austriaca*	1	*Vaginella austriaca* ?	INGK	
Grudna Dolna-5	15-17	*Vaginella* sp.	1	*Vaginella rzehaki* ?	INGK	
Kietrz-4	35	*Limacina valvatina*	12	*Spiratella valvatina*	INGK	
Kietrz-4	35	*Vaginella* sp.	1	*Vaginella* sp.	INGK	
Kietrz-5	5.6-10	*Limacina valvatina*	18	*Spiratella valvatina*	INGK	
Kolanów-1	1017-1021	*Limacina valvatina*	4	*Spiratella valvatina*	INGK	
Kolanów-1	1004.4-1011	*Limacina valvatina*	5	*Spiratella valvatina*	INGK	
Kop. Zofiówka	610	*Limacina valvatina*	1	-	INGK	not mentioned in Krach (1981); from sample identified *Vaginella austriaca*
Kop. Zofiówka	610	*Vaginella austriaca*	1	-	INGK	not mentioned in Krach (1981)
Kop. Zofiówka	30	*Vaginella austriaca*	4	-	INGK	not mentioned in Krach (1981)
Korytnica	outcrop	*Limacina valvatina*	1	*Spiratella valvatina*	INGK	leg. W. Bałuk
Korytnica	outcrop	*Vaginella austriaca*	c. 85	*Vaginella austriaca*	INGK	leg. W. Bałuk
Korytnica	outcrop	*Vaginella austriaca*	5	*Vaginella austriaca*	INGK	leg. W. Bałuk; Pl. 6, figs. 8-9, 11-12, 14

Table 6 (continued).

Locality	depth	this paper	n	in Krach collection	coll.	notes
Korytnica	outcrop	*Vaginella austriaca*	7	*Vaginella austriaca*	RGM	leg. W. Bałuk
Korytnica	outcrop	*Vaginella austriaca*	3	*Vaginella austriaca*	RGM	leg. W. Bałuk; Pl. 6, figs. 10, 13, 15
Koszyce Małe	155.1-159.6	*Limacina valvatina*	1	-	INGK	not mentioned in Krach (1981); from sample identified *Vaginella lapugyensis*
Koszyce Małe	155.1-159.6	*Creseis spina*	3	*Vaginella lapugyensis*	INGK	Pl. 6, Figs. 5-7
Koszyce Małe	155.1-159.6	*Creseis spina*	c. 60	*Vaginella lapugyensis*	INGK	
Koszyce Małe	155.1-159.6	*Creseis spina*	1	*Vaginella lapugyensis*	INGK	Pl. 7, fig. 4
Koszyce Małe	155.1-159.6	*Creseis spina*	2	*Vaginella lapugyensis*	INGK	Krach, 1981, pl. 6, fig. 9 ?; this paper Pl. 7, fig. 3
Koszyce Małe	155.1-159.6	*Creseis spina*	1	*Vaginella lapugyensis*	RGM	
Koszyce Małe	155	*Creseis spina*	c. 20	*Vaginella lapugyensis*	INGK	
Koszyce Małe	155	*Creseis spina*	1	*Vaginella lapugyensis*	INGK	Krach, 1981, pl. 1, fig. 14; this paper Pl. 7, fig. 2
Koszyce Małe	155	*Creseis spina*	3	*Vaginella lapugyensis*	RGM	
Krywałd	111.3-113	*Limacina valvatina*	1	*Spiratella tarchanensis*	INGK	Pl. 3, fig. 10
Krywałd	108-109	*Limacina valvatina*	1	*Spiratella andrussovi*	INGK	
Krywałd	104-105	*Limacina gramensis*	1	*Spiratella stenogyra*	INGK	
Krywałd	104-105	*Limacina ? gramensis*	1	*Spiratella valvatina* → *koeneni*	INGK	Pl. 4, fig. 1
Krywałd	104-105	*Limacina valvatina*	1	*Spiratella valvatina* → *koeneni*	INGK	
Krywałd	104-105	*Limacina valvatina*	1	*Spiratella stenogyra*	INGK	
Krywałd	104-105	*Limacina valvatina*	1	*Spiratella valvatina*	INGK	Pl. 1, fig. 4
Krywałd	104-105	*Limacina valvatina*	1	*Spiratella valvatina* → *koeneni*	INGK	Pl. 3, fig. 11
Krywałd	104-105	*Limacina valvatina*	1	*Spiratella valvatina* → *koeneni*	INGK	
Krywałd	102-104	*Limacina ? gramensis*	3	*Spiratella valvatina* → *koeneni*	INGK	
Krywałd	102-104	*Limacina valvatina*	11	*Spiratella valvatina* → *koeneni*	INGK	
Krywałd	99-101	*Limacina gramensis*	2	*Spiratella variabilis*	INGK	syntypes of *Spiratella variabilis*
Krywałd	99-101	*Limacina gramensis*	1	*Spiratella variabilis*	INGK	syntype of *Spiratella variabilis*; Pl. 5, fig. 1

Table 6 (continued).

Locality	depth	this paper	n	in Krach collection	coll.	notes
Krywałd	99-101	*Limacina gramensis*	1	*Spiratella variabilis*	INGK	syntype of *Spiratella variabilis*; Pl. 5, fig. 2
Krywałd	99-101	*Limacina valvatina*	34	*Spiratella valvatina*	INGK	
Krywałd	95-101	*Limacina gramensis*	13	*Spiratella koeneni*	INGK	
Krywałd	95-101	*Limacina gramensis*	1	*Spiratella koeneni*	INGK	Pl. 3, fig. 13
Krywałd	95-101	*Limacina valvatina*	28	*Spiratella koeneni*	INGK	
Krywałd	90-101	*Limacina gramensis*	31	*Spiratella stenogyra*	INGK	
Krywałd	90-101	*Limacina gramensis*	1	*Spiratella stenogyra*	INGK	Pl. 4, fig. 9
Krywałd	90-101	*Limacina valvatina*	1	*Spiratella stenogyra*	INGK	
Krywałd	90-101	benthic gastropod	1	*Spiratella stenogyra*	INGK	
Krywałd	97-99	*Limacina gramensis*	1	*Spiratella valvatina*	INGK	
Krywałd	97-99	*Limacina gramensis*	1	*Spiratella valvatina*	RGM	Pl. 4, fig. 2
Krywałd	97-99	*Limacina gramensis*	5	*Spiratella koeneni*	RGM	
Krywałd	97-99	*Limacina gramensis*	2	*Spiratella variabilis*	INGK	syntypes of *Spiratella variabilis*
Krywałd	97-99	*Limacina valvatina*	1	*Spiratella variabilis*	INGK	syntype of *Spiratella variabilis*
Krywałd	97-99	*Limacina valvatina*	12	*Spiratella koeneni*	RGM	
Krywałd	97-99	*Limacina valvatina*	38	*Spiratella valvatina*	INGK	
Krywałd	97-99	*Limacina valvatina*	1	*Spiratella valvatina*	INGK	Pl. 1, fig. 6
Krywałd	97-99	*Limacina valvatina*	1	*Spiratella valvatina*	RGM	Pl. 1, fig. 5
Krywałd	95-97	*Limacina valvatina*	16	*Spiratella valvatina* → *koeneni*	INGK	
Krywałd	94-95	*Limacina gramensis*	21	*Spiratella stenogyra*	INGK	
Krywałd	94-95	*Limacina gramensis*	3	*Spiratella stenogyra*	RGM	
Krywałd	94-95	*Limacina gramensis*	1	*Spiratella stenogyra*	RGM	Pl. 4, fig. 5
Krywałd	94-95	*Limacina gramensis*	1	*Spiratella stenogyra*	RGM	Pl. 4, fig. 3
Krywałd	94-95	*Limacina gramensis*	1	*Spiratella stenogyra*	RGM	Fig. 4
Krywałd	94-95	*Limacina valvatina*	1	*Spiratella stenogyra*	INGK	
Krywałd	90-95	*Limacina gramensis*	29	*Spiratella koeneni*	INGK	
Krywałd	90-95	*Limacina gramensis*	1	*Spiratella koeneni*	INGK	Pl. 4, fig. 7
Krywałd	90-95	*Limacina gramensis*	1	*Spiratella koeneni*	INGK	Pl. 4, fig. 8

Table 6 (continued).

Locality	depth	this paper	n	in Krach collection	coll.	notes
Krywałd	90- 95	*Limacina valvatina*	51	*Spiratella koeneni*	INGK	
Krywałd	90- 95	*Limacina valvatina*	1	*Spiratella koeneni*	INGK	Pl. 1, fig. 7
Krywałd	90- 95	*Limacina valvatina*	1	*Spiratella koeneni*	INGK	Pl. 1, fig. 8
Krywałd	90- 95	*Limacina valvatina*	1	*Spiratella koeneni*	INGK	Pl. 1, fig. 9
Krywałd	90- 95	*Limacina valvatina*	21	*Spiratella valvatina*	INGK	
Krywałd	93- 94	*Limacina gramensis*	1	*Spiratella variabilis*	INGK	syntype of *Spiratella variabilis*; Pl. 4, fig. 4
Krywałd	93- 94	*Limacina gramensis*	1	*Spiratella variabilis*	INGK	syntype of *Spiratella variabilis*; Pl. 4, fig. 6
Krywałd	80- 88	*Limacina valvatina*	41	*Spiratella valvatina*	INGK	
Krywałd	80- 88	*Limacina valvatina*	1	*Spiratella valvatina*	INGK	Pl. 2, fig. 7
Krywałd	82- 84	benthic gastropod	1	*Spiratella andrussovi*	INGK	
Krywałd	81- 82	*Limacina valvatina*	15	*Spiratella valvatina*	RGM	
Krywałd	81- 82	*Limacina valvatina*	1	*Spiratella valvatina*	RGM	Pl. 2, fig. 1
Krywałd	81- 82	*Limacina valvatina*	1	*Spiratella valvatina*	RGM	Pl. 2, fig. 2
Krywałd	81- 82	*Limacina valvatina*	1	*Spiratella valvatina*	RGM	Pl. 2, fig. 3
Krywałd	80- 82	*Limacina valvatina*	37	*Spiratella valvatina* → *koeneni*	INGK	
Krywałd	80- 82	*Limacina valvatina*	1	*Spiratella valvatina* → *koeneni*	INGK	Pl. 2, fig. 6
Krywałd	80.57-81	*Limacina valvatina*	4	*Spiratella subtarchanensis*	INGK	
Krywałd	80.57-81	*Limacina valvatina*	1	*Spiratella subtarchanensis*	INGK	Pl. 1, fig. 10
Krywałd	80.57-81	*Limacina valvatina*	1	*Spiratella subtarchanensis*	INGK	Pl. 1, fig. 11
Krywałd	80.57-81	*Limacina valvatina*	1	*Spiratella subtarchanensis*	INGK	Pl. 2, fig. 4
Krywałd	80.52-81	*Limacina valvatina*	3	*Spiratella subtarchanensis*	INGK	spirals on body whorl
Krywałd	80.52-81	*Limacina valvatina*	2	*Spiratella valvatina* → *koeneni*	INGK	
Krywałd	78- 80	*Limacina valvatina*	45	*Spiratella valvatina* var.	INGK	
Krywałd	78- 80	*Limacina valvatina*	1	*Spiratella valvatina* var.	INGK	Pl. 2, fig. 5
Krywałd	78- 79	*Limacina valvatina*	1	*Spiratella subtarchanensis*	INGK	Pl. 2, fig. 8
Krywałd	68- 79	*Limacina gramensis*	1	*Spiratella koeneni*	INGK	
Krywałd	68- 79	*Limacina valvatina*	11	*Spiratella koeneni*	INGK	
Krywałd	68- 79	*Limacina valvatina*	1	*Spiratella koeneni*	INGK	Pl. 3, fig. 4
Krywałd	74- 76	*Limacina valvatina*	27	*Spiratella valvatina*	INGK	

Table 6 (continued).

Locality	depth	this paper	n	in Krach collection	coll.	notes
Krywałd	74- 76	*Limacina valvatina*	1	*Spiratella valvatina*	INGK	Pl. 2, fig. 9
Krywałd	74- 76	*Limacina valvatina*	1	*Spiratella valvatina*	INGK	Pl. 2, fig. 10
Krywałd	74- 76	*Limacina valvatina*	1	*Spiratella valvatina*	INGK	Pl. 2, fig. 11
Krywałd	74- 76	*Limacina valvatina*	1	*Spiratella valvatina*	INGK	Pl. 3, fig. 1
Krywałd	72- 73	*Limacina valvatina*	29	*Spiratella valvatina* → *koeneni*	INGK	
Krywałd	72- 73	*Limacina valvatina*	1	*Spiratella valvatina* → *koeneni*	INGK	Pl. 3, fig. 2
Krywałd	70- 72	*Limacina valvatina*	28	*Spiratella valvatina* → *koeneni*	INGK	
Krywałd	70- 72	*Limacina valvatina*	1	*Spiratella valvatina* → *koeneni*	INGK	Pl. 3, fig. 3
Krywałd	68- 70	*Limacina valvatina*	4	*Spiratella valvatina* → *koeneni*	INGK	
Łabędy	-	*Limacina valvatina*	22	*Spiratella tarchanensis*	INGK	
Łapczyca-1	312	*Limacina miorostralis*	2	*Spiratella andrussovi*	INGK	
Łapczyca-1	273	*Vaginella austriaca*	2	*Vaginella austriaca brevior* ?	INGK	
Łapczyca-1	267	*Limacina valvatina*	2	*Spiratella valvatina*	INGK	
Łapczyca-1	267	*Vaginella austriaca*	2	*Vaginella austriaca* subsp. nov.	INGK	syntype of *Vaginella austriaca brevior*
Łapczyca-1	266	*Vaginella austriaca*	1	*Vaginella austriaca* subsp. nov.	INGK	syntype of *Vaginella austriaca brevior*
Łapczyca-1	264	*Vaginella austriaca*	1	*Vaginella austriaca* ?	INGK	
Łapczyca-1	247	*Vaginella* sp.	1	*Vaginella rzehaki* ?	INGK	
Łapczyca-1	241-243	*Vaginella austriaca*	5	*Vaginella austriaca* ?	INGK	
Łapczyca-1	234	*Limacina valvatina*	1	*Spiratella tarchanensis*	INGK	
Łapczyca-1	231-239	*Vaginella austriaca*	9	*Vaginella austriaca* ?	INGK	
Łapczyca-1	231-232	*Limacina valvatina*	2	*Spiratella valvatina*	INGK	
Łapczyca-1	230	*Vaginella* sp.	1	*Vaginella rzehaki* ?	INGK	
Łapczyca-1	211-230	*Vaginella austriaca*	8	*Vaginella austriaca* ?	INGK	
Łapczyca-1	227	benthic gastropod	1	*Spiratella andrussovi*	INGK	
Łapczyca-1	226	*Vaginella austriaca*	1	*Vaginella austriaca* subsp. nov.	INGK	syntype of *Vaginella austriaca brevior*
Łapczyca-1	206	*Vaginella austriaca*	2	*Vaginella austriaca* ?	INGK	
Łapczyca-1	187	*Limacina valvatina*	14	*Spiratella valvatina*	INGK	
Łapczyca-1	187	*Limacina valvatina*	1	*Spiratella valvatina*	INGK	Pl. 3, fig. 5

Table 6 (continued).

Locality	depth	this paper	n	in Krach collection	coll.	notes
Łapczyca-1	187	*Limacina valvatina*	1	*Spiratella valvatina*	INGK	Pl. 3, fig. 6
Łapczyca-1	184	*Limacina miorostralis*	1	*Spiratella andrussovi*	INGK	Pl. 1, fig. 2
Łapczyca-1	181-184	*Limacina valvatina*	9	*Spiratella valvatina*	INGK	
Łapczyca-1	183	*Limacina miorostralis*	1	*Spiratella andrussovi*	RGM	Pl. 1, fig. 1
Łapczyca-1	182	*Vaginella austriaca*	3	*Vaginella austriaca* ?	INGK	
Łapczyca-1	180	*Limacina valvatina*	10	*Spiratella tarchanensis*	INGK	
Łapczyca-1	178	*Limacina valvatina*	1	*Spiratella tarchanensis*	INGK	Pl. 3, fig. 13
Łapczyca-1	171-178	*Limacina valvatina*	38	*Spiratella valvatina*	INGK	
Łapczyca-1	177	*Limacina valvatina*	1	*Spiratella tarchanensis*	INGK	deformed specimen
Łapczyca-1	167	*Limacina valvatina*	42	*Spiratella valvatina*	INGK	
Łapczyca-1	154-159	*Limacina valvatina*	32	*Spiratella valvatina*	INGK	
Łapczyca-1	144-158	*Vaginella austriaca*	4	*Vaginella austriaca*	INGK	
Łapczyca-1	97	*Limacina valvatina*	2	*Spiratella valvatina*	INGK	
Łapczyca-1	51- 60	*Limacina valvatina*	4	*Spiratella valvatina*	INGK	
Łapczyca-1	25	*Limacina valvatina*	4	*Spiratella valvatina*	INGK	
Łapczyca-1	25	*Limacina valvatina*	1	*Spiratella tarchanensis*	INGK	
Łapczyca-1	-	*Limacina valvatina*	10	*Spiratella* sp.	INGK	more or less distorted
Łapczyca-2	1088-1092.6	*Vaginella austriaca*	2	*Vaginella austriaca brevior*	INGK	syntypes of *Vaginella austriaca brevior*
Łapczyca-2	1088-1092.6	*Vaginella austriaca*	1	*Vaginella austriaca brevior*	INGK	syntype of *Vaginella austriaca brevior*; Pl. 10, fig. 3
Łapczyca-2	1088.4-1092.6	*Vaginella austriaca*	2	*Vaginella rzehaki*	INGK	
Łapczyca-2	1086.4-1092.6	*Vaginella* sp.	4	*Vaginella* sp.	INGK	
Łapczyca-2	1075-1079.1	*Vaginella austriaca*	3	*Vaginella austriaca brevior*	INGK	syntypes of *Vaginella austriaca brevior*
Łapczyca-2	1075-1079.1	*Vaginella austriaca*	2	*Vaginella austriaca brevior*	RGM	syntypes of *Vaginella austriaca brevior*
Łęki Dolne	115-123	*Vaginella austriaca*	3	*Vaginella austriaca*	INGK	
Łęki Dolne	112-115	*Vaginella austriaca*	7	*Vaginella*	INGK	
Łęki Dolne	110-112	*Vaginella austriaca*	3	*Vaginella austriaca*	INGK	

Table 6 (continued).

Locality	depth	this paper	n	in Krach collection	coll.	notes
Łęki Dolne	107-110	*Vaginella austriaca*	5	*Vaginella austriaca*	INGK	
Łęki Dolne	105-107	*Vaginella austriaca*	2	*Vaginella austriaca*	INGK	
Łęki Dolne	100-105	*Vaginella austriaca*	4	*Vaginella austriaca*	INGK	
Łęki Dolne	95-100	*Vaginella austriaca*	14	*Vaginella austriaca*	INGK	
Łęki Dolne	85- 90	*Vaginella austriaca*	1	*Vaginella austriaca*	INGK	
Łęki Dolne	85- 90	*Vaginella austriaca*	3	*Vaginella austriaca brevior*	INGK	syntypes of *Vaginella austriaca brevior*
Łęki Dolne	72- 77	*Vaginella austriaca*	1	*Vaginella austriaca*	INGK	
Łęki Dolne	-	*Vaginella austriaca*	7	*Vaginella austriaca*	INGK	
Międzyrzecze-1	101-102	*Vaginella austriaca*	15	*Vaginella austriaca brevior*	INGK	syntypes of *Vaginella austriaca brevior*
Międzyrzecze-1	101-102	*Vaginella austriaca*	6	*Vaginella rzehaki* ?	INGK	
Międzyrzecze-1	101-102	*Vaginella austriaca*	10	*Vaginella rzehaki*	INGK	
Międzyrzecze-1	101-102	*Vaginella austriaca*	1	*Vaginella rzehaki* ?	INGK	Krach, 1981, pl. 1, fig. 13
Międzyrzecze-1	101.5	*Creseis* cf. *spina*	2	*Vaginella* sp.	INGK	
Międzyrzecze-1	101.5	*Clio fallauxi*	1	*Clio fallauxi*	INGK	
Międzyrzecze-1	101.5	*Vaginella austriaca*	c. 25	*Vaginella* sp.	INGK	
Międzyrzecze-1	101.5	*Vaginella austriaca*	3	*Vaginella* sp.	INGK	Pl. 10, fig. 2
Mielec-5	680.50	*Limacina valvatina*	1	*Spiratella valvatina*	INGK	
Mielec-5	680.50	*Limacina valvatina*	1065	-	INGK	from 20 g. of clay
Mielec-5	680.50	*Styliola subula*	1	-	RGM	from 20 g. of clay, Pl. 6, fig. 4
Mszana-1	162-163	*Limacina valvatina*	5	*Spiratella valvatina*	INGK	
Mszana-1	162-163	*Vaginella* sp.	1	*Vaginella rzehaki* ?	INGK	
Mszana-1	157-163	*Vaginella* sp.	13	*Vaginella austriaca* ?	INGK	
Mszana-1	157-162	*Vaginella austriaca*	5	*Vaginella austriaca brevior*	INGK	syntypes of *Vaginella austriaca brevior*
Mszana-1	149.5-153.5	*Vaginella* sp.	4	*Vaginella austriaca* ?	INGK	
Mszana-1	149-153	*Limacina valvatina*	1	*Spiratella valvatina*	INGK	
Mszana-1	145-149	*Peracle* sp.	1	*Spiratella andrussovi*	INGK	Pl. 5, fig. 5
Mszana-1	145-149	*Limacina miorostralis*	2	*Spiratella andrussovi*	INGK	

Table 6 (continued).

Locality	depth	this paper	n	in Krach collection	coll.	notes
Mszana-1	141-149	*Vaginella* sp.	15	*Vaginella austriaca* ?	INGK	
Mszana-1	137-141	*Vaginella* sp.	12	*Vaginella austriaca*	INGK	
Mszana-1	133.5-137	*Vaginella* sp.	23	*Vaginella austriaca* ?	INGK	
Mszana-1	133.15-137	*Vaginella austriaca*	6	*Vaginella austriaca brevior*	INGK	syntypes of *Vaginella austriaca brevior*
Mszana-1	113.5-129.15	*Vaginella* sp.	7	*Vaginella austriaca* ?	INGK	
Mszana-1	113.15-117	*Vaginella austriaca*	6	*Vaginella austriaca brevior*	INGK	syntypes of *Vaginella austriaca brevior*
Mszana-1	113-117	*Limacina valvatina*	1	*Spiratella valvatina*	INGK	
Niepaszyce	-	*Limacina valvatina*	33	*Spiratella tarchanensis*	INGK	
Niepaszyce-1	-	*Limacina valvatina*	3	*Spiratella tarchanensis*	INGK	
Niepaszyce-2	-	*Limacina valvatina*	many	*Spiratella tarchanensis*	INGK	in sieving residue
Niepaszyce-2	-	*Limacina valvatina*	many	*Spiratella tarchanensis*	INGK	from sieving residue
Niepaszyce-2	-	*Limacina valvatina*	many	*Spiratella tarchanensis*	RGM	in sieving residue
Niepaszyce-2	-	*Limacina valvatina*	many	*Spiratella tarchanensis*	RGM	from sieving residue
Niepaszyce-2	-	*Limacina valvatina*	1	*Spiratella tarchanensis*	INGK	Pl. 3, fig. 7
Niepaszyce-2	-	*Limacina valvatina*	1	*Spiratella tarchanensis*	INGK	Pl. 3, fig. 8
Niepaszyce-2	-	*Limacina valvatina*	1	*Spiratella tarchanensis*	INGK	Pl. 3, fig. 9
Roczyny-1	352-353	*Vaginella austriaca*	1	*Vaginella austriaca*	INGK	
Roczyny-1	170-176	*Clio* sp. indet.	1	*Clio fallauxi*	INGK	
Roczyny-1	170-176	*Vaginella austriaca*	8	*Vaginella austriaca*	INGK	
Roczyny-1	163.4-168.4	*Vaginella austriaca*	8	*Vaginella austriaca*	INGK	
Roczyny-1	163-168	*Vaginella austriaca*	many	*Vaginella austriaca*	INGK	
Roczyny-1	163-164	*Vaginella austriaca*	1	*Vaginella austriaca*	INGK	
Roczyny-1	162-163	*Vaginella* sp.	3	*Vaginella rzehaki*	INGK	
Roczyny-1	160.2-162.4	*Limacina valvatina*	c. 6	-	INGK	in sample identified *Vaginella austriaca*
Roczyny-1	160.2-162.4	*Clio fallauxi*	1	*Clio fallauxi*	INGK	
Roczyny-1	160.2-162.4	*Vaginella austriaca*	2	*Vaginella austriaca* ?	INGK	
Roczyny-1	160.2-162.4	*Vaginella austriaca*	c. 15	*Vaginella austriaca*	INGK	

Table 6 (continued).

Locality	depth	this paper	n	in Krach collection	coll.	notes
Roczyny-1	158.2-160.2	*Clio* cf. *fallauxi*	1	*Clio fallauxi*	INGK	Krach & Nowak, 1957, pl. 1, figs. 15, 19; Krach, 1981, pl. 1, figs. 4, 7; this paper Pl. 8, figs. 8-9
Roczyny-1	158.2-160.2	*Vaginella austriaca*	3	*Vaginella austriaca*	INGK	
Roczyny-1	158.2-160.2	*Vaginella austriaca*	3	*Vaginella rzehaki*	INGK	
Roczyny-1	156.2-158.2	*Limacina valvatina*	c. 30	-	INGK	in sample identified *Vaginella austriaca*
Roczyny-1	156.2-158.2	*Clio fallauxi*	1	*Clio fallauxi*	INGK	Krach, 1981, pl. 1, fig. 2; this paper Pl. 8, fig. 5
Roczyny-1	156.2-158.2	*Vaginella austriaca*	many	*Vaginella austriaca*	INGK	
Roczyny-1	156-158	*Vaginella austriaca*	7	*Vaginella austriaca*	INGK	
Roczyny-1	156-158	*Vaginella* sp.	2	*Vaginella rzehaki* ?	INGK	
Roczyny-1	153-156	*Vaginella austriaca*	many	*Vaginella austriaca*	INGK	
Roczyny-1	153-156	*Vaginella austriaca*	many	*Vaginella austriaca*	RGM	
Roczyny-1	147-151	*Vaginella austriaca*	6	*Vaginella austriaca* ?	INGK	
Roczyny-1	136-139	*Vaginella austriaca*	5	*Vaginella austriaca*	INGK	
Roczyny-1	130-139	*Vaginella austriaca*	4	*Vaginella austriaca*	INGK	
Roczyny-1	128.5-130	*Vaginella austriaca*	1	*Vaginella austriaca*	INGK	
Roczyny-1	127-128	*Vaginella austriaca*	4	*Vaginella austriaca*	INGK	
Roczyny-1	124-127	*Clio fallauxi*	1	*Clio fallauxi*	INGK	Krach, 1981, pl. 1, fig. 12; this paper Pl. 8, fig. 4
Roczyny-1	86.7-90.5	*Vaginella austriaca*	1	*Vaginella austriaca*	INGK	
Roczyny-1	60-62	*Vaginella austriaca*	5	*Vaginella austriaca*	INGK	
Roczyny-1	56.4-60.4	*Vaginella austriaca*	2	*Vaginella austriaca*	INGK	
Roczyny-1	53.4-56.2	*Vaginella austriaca*	2	*Vaginella austriaca*	INGK	
Roczyny-1	50.4-53.4	*Vaginella austriaca*	2	*Vaginella austriaca*	INGK	
Roczyny-1	-	*Vaginella austriaca*	2	*Vaginella austriaca*	INGK	
Roczyny-2	69.5-71.5	*Vaginella austriaca*	3	*Vaginella austriaca*	INGK	
Roczyny-2	-	*Vaginella austriaca*	6	*Vaginella austriaca*	INGK	
Siedlec-2	337-343.7	*Thyasira* sp. (Bivalvia)	1	*Clio* aff. *fallauxi*	INGK	

Table 6 (continued).

Locality	depth	this paper	n	in Krach collection	coll.	notes
Sierakowice-1	414	*Creseis spina*	2	*Vaginella lapugyensis*	INGK	
Simoradz-26	483-484.1	*Clio fallauxi*	1	*Clio pedemontana*	INGK	
Simoradz-27	354	*Clio fallauxi*	1	*Clio fallauxi*	INGK	
Simoradz-27	354	*Clio fallauxi*	1	*Clio fallauxi*	RGM	Pl. 8, fig. 3
Simoradz-27	352	*Clio fallauxi*	1	*Clio fallauxi*	INGK	
Swierczyniec	248	*Vaginella austriaca*	3	*Vaginella austriaca brevior*	INGK	syntype of *Vaginella austriaca brevior*
Swierczyniec	224	*Clio fallauxi*	1	*Clio* sp. indet.	INGK	
Swierczyniec	218	*Vaginella austriaca*	6	*Vaginella austriaca*	INGK	
Swierczyniec	160-200	*Vaginella austriaca*	16	*Vaginella austriaca*	INGK	
Swierczyniec	160-200	*Vaginella austriaca*	4	*Vaginella austriaca brevior*	INGK	syntypes of *Vaginella austriaca brevior*
Świerczyniec	160-200	*Vaginella austriaca*	1	*Vaginella austriaca brevior*	INGK	syntype of *Vaginella austriaca brevior*; Pl. 11, fig. 6
Ujście (Ukraine)	52.95-53.3	*Limacina valvatina*	1	*Spiratella variabilis*	INGK	syntype of *Spiratella variabilis*; deformed specimen
Ujście (Ukraine)	52.95-53.3	*Limacina gramensis*	1	*Spiratella variabilis*	INGK	lectotype of *Spiratella variabilis*; Pl. 5, fig. 3
Ujście (Ukraine)	52.95-53.3	*Limacina gramensis*	1	*Spiratella variabilis*	RGM	syntype of *Spiratella variabilis*; deformed specimen

Localities and Boreholes	*Limacina gramensis*	*Limacina miorostralis*	*Limacina valvatina*	*Limacina* cf. *valvatina*	*Creseis spina*	*Creseis* cf. *spina*	*Styliola subula*	*Clio fallauxi*	*Clio* cf. *fallauxi*	*Clio pedemontana*	*Clio* cf. *pedemontana*	*Clio* sp. indet.	*Vaginella austriaca*	*Vaginella* sp.	*Peraclis lata*	*Peraclis* sp.
Biadoliny-1										X						
Brzeszcze-1		X	X	X		X	X						X			X
Czernica			X													
Dębowiec-45								X	X				X			
Gdów												X				
Gliwice Stare			X													
Grudna Dolna-2										X	X		X	X	X	
Grudna Dolna-4													X			
Grudna Dolna-5								X		X			X		X	
Kietrz-4			X												X	
Kietrz-5			X													
Kolanów-1			X													
Kop. Zotiówka			X										X			
Korytnica			X										X			
Koszyce Małe			X		X											
Krywałd	X		X													
Łabędy			X													
Łapczyca-1		X	X										X		X	
Łapczyca-2													X		X	
Łęki Dolne													X			
Międzyrzecze-1						X		X					X			
Mielec-5			X				X									
Mszana-1		X	X										X		X	X
Niepaszyce			X													
Niepaszyce-1			X													
Niepaszyce-2			X													
Roczyny-1			X	X				X	X			X	X		X	
Roczyny-2													X			
Sierakowice-1					X											
Simoradz-26								X								
Simoradz-27								X								
Świerczyniec								X					X			
Ujście	X		X													
Wieliczka			X		X											

Fig. 12. Presence of the holoplanktonic mollusc species recognised in this paper in the various boreholes and outcrops. Compare Fig. 3 for the position of most localities.

depth, without indication of the stratigraphic level. Detailed information is difficult to obtain. Reports with the borehole data have not been available to us and in his 1981 paper Krach only published one general table showing the vertical ranges of the species. For some of the boreholes we found stratigraphical data in other publications (Alexandrowicz, 1963; Krach, 1956a, b; 1973, 1979a; Krach & Nowak, 1957). Therefore our Fig. 13, summarising the stratigraphical distribution of the species

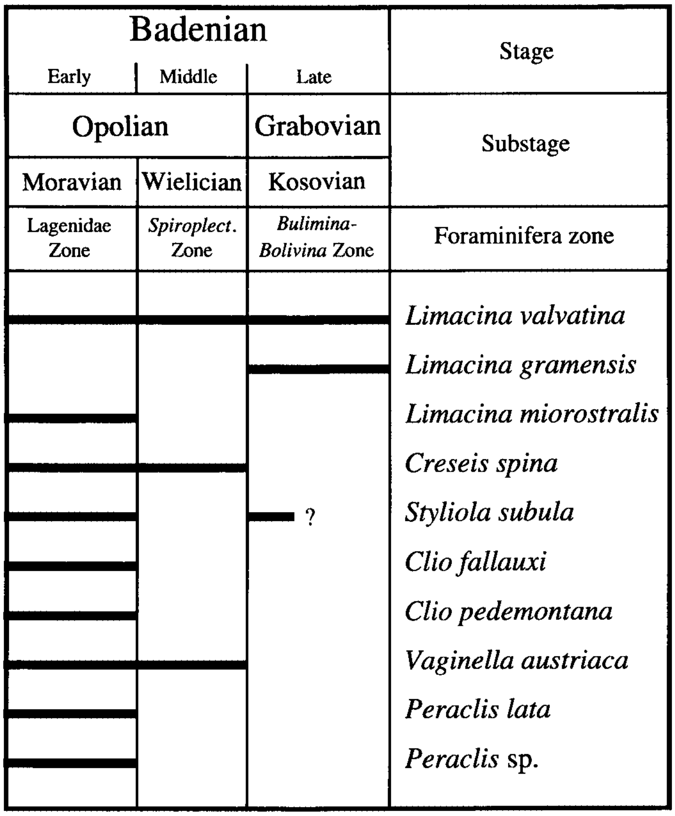

Fig. 13. Chronostratigraphical distribution in the Miocene of the Carpathian Foredeep of holoplanktonic mollusc species recognised in this paper.

revised herein, is but a synthesis of Krach's table 2 and some additional literature data. In spite of the fact that the taxonomical revision changed the naming of most of the samples we could generally adopt Krach's ranges. There remains one contradiction, viz. in the case of *Limacina miorostralis* (see below).

We have hardly any information on the lithostratigraphy of the various deposits. Concerning chronostratigraphy, the occurrence of Miocene Polish pteropods in the Carpathian Foredeep is restricted to the Badenian, which is subdivided into Early, Middle and Late Badenian. The name Opolian is used for Early and Middle Badenian together, and Grabovian for the Late Badenian. An older subdivision distinguished the Moravian (= Early Badenian, Early Opolian), the Wielician (Middle Badenian, Late Opolian) and the Kosovian (= Late Badenian, Grabovian). The three substages correlate with the Vienna Basin foraminifer zones (Lagenidae Zone, *Spiroplectammina* Zone and *Bulimina-Bolivina* Zone, respectively).

Limacina valvatina, a very common species in the Central Paratethys, is the only species which is present during the whole Badenian. It is found in higher numbers at the base of the upper Badenian deposits, which phenomenon is well known from elsewhere in the Paratethys and generally indicated as the '*Spiratella* Horizon'

Limacina gramensis is the only species restricted to the Grabovian. From the Krywałd borehole we have samples available from the depth interval 90-105 m. Krach (1956b) stated, that in this borehole the boundary between the Opolian and the Grabovian probably is situated between 95 and 102 m. Alexandrowicz (1963) put this boundary at 102 m. In 1979 Krach considered the species '*Spiratella variabilis*' (now revised to *Limacina gramensis*) to be of Kosovian age. Samples with this identification are present from the interval 93-101 m. Considering the facts that downhole contamination cannot be excluded, and that the distinction between the taxa *L. valvatina* and *L. gramensis* is an artificial one we restrict the range of *L. gramensis* to the Grabovian. The species is also known from the same stratigraphic level in Rumania and in the Ukraine (this paper).

Creseis spina and *Vaginella austriaca* are found in the Early Badenian (Opolian). The greater part of the available material of *Creseis spina* is of Late Opolian age (see Krach, 1981, table 2, as '*Vaginella lapugyensis*'), which is also true for its type lot. Specimens from the boreholes Brzeszcze-1 and Międzyrzecze-1, according to Alexandrowicz (1963) and Krach (1979a), are of Early Opolian age. Therefore we suppose that the samples from Sierakowice and especially the rich material from Koszyce Małe are of Late Opolian age. In Rumania this species was recorded from the Middle Badenian (Moisescu & Popescu, 1980), in Austria and Slovakia it is known from the Late Badenian of the Vienna Basin (Zorn, 1991a, b), and in Austria also from the Middle Badenian of the Eisenstadt Basin (Bohn-Havas & Zorn, in press).

Styliola subula is a long ranging species occurring world wide and known from the Late Oligocene or the Early Miocene (Shibata, 1980; Jung, 1971, as *Styliola sulcifera*) to the Recent. Quite recently *Styliola* specimens became available from Late Oligocene deposits in Denmark, southwestern France (Zorn & Janssen, 1993) and Germany (all RGM collection). These belong to the same or a very closely related species.

The individuals from Poland are of Early Opolian (Brzeszcze-1) and probably of Grabovian age (Mielec-5). The age of the latter material is supported by the fact that it was found in a sample with a mass occurrence of *Limacina valvatina*, which characterises the basal deposits of the Late Badenian. Additionally, the only other indication of pteropods in Mielec (Krach, 1956a) is also of Grabovian age.

The species *Limacina miorostralis*, *Clio fallauxi* and *C. pedemontana* are only known from the Early Opolian time interval, which makes this period to the most diverse part of the Badenian with respect to pteropod distribution. In the Paratethys *L. miorostralis* is a rare species. Apart from the Polish records given in the present paper the species is only known from the Karpatian of Austria (Zorn, 1991a, b). Krach (1981, table 2), who identified this species as '*Spiratella andrussovi*', apparently erroneously indicated the range of this species as Grabovian. The three sections in which *L. miorostralis* occurs (Łapczyca-1, Brzeszcze-1, Mszana-1) were considered, however, by Krach (1979a) as belonging to the Moravian, on the basis of the occurrence of *Vaginella austriaca brevior*. The sample depths of the *L. miorostralis* occurrences in the respective boreholes are within the range of *Vaginella austriaca* in each case.

Clio fallauxi and *C. pedemontana* are restricted to the Early Badenian in many parts of the Central Paratethys. Both species are also known from Rumania (Stancu, 1974; Moisescu & Popescu, 1980), Moravia (Kittl, 1886, 1887) and Hungary (Bohn-Havas &

Zorn, in press).

The pseudothecosomatous species *Peracle lata* and *Peracle* sp. nov. are only known from Poland. The stratigraphic range of *P. lata* was not indicated by Krach (1981), but he (1979a, p. 658) indicated the age as Moravian (as *Spiratella lata*). *Peracle* sp. nov. was found together with *Limacina miorostralis* (see above).

Summarising it must be concluded that in southern Poland pteropod distribution is almost completely restricted to the Badenian. One report on pteropods from the Late Eocene was published (Krach, 1985), but the materials underlying that paper have not been available to us in the INGK collection.

Comparison with the North Sea Basin

Of the ten pteropod species known from the Carpathian Foredeep only five are also known from the North Sea Basin, viz. the three *Limacina* species, *Styliola subula* and *Vaginella austriaca*. Among the limacinids *L. valvatina* has the longest range, reaching from the Late Oligocene (Chattian) to the Early Langenfeldian, at which point the species seems to evolve into *L. gramensis*. During the Hemmoorian and the Reinbekian *L. valvatina* is accompanied by *L. miorostralis* and *Vaginella austriaca*. Therefore it might be concluded that the Reinbekian-Langenfeldian boundary (= transition between pteropod zones 19 and 20, Janssen & King, 1988) rather accurately can be correlated with the Opolian-Grabovian boundary in Poland. The Opolian might correlate with (part of) the Hemmoorian/Reinbekian-complex (pteropod zones 18 and 19).

Pteropod zones 18 and 19 are distinguished in the North Sea Basin by the extinction of a number of species near the end of zone 18. Of these species only *Styliola subula* (= *Styliola* sp. in Janssen & King, 1988) is present in the Opolian, but considering its long range outside the North Sea Basin this occurrence is of no value for a more detailed interpretation.

The occurrence of *Limacina gramensis* in the Grabovian correlates nicely with the lower part of pteropod zone 20 of Janssen & King (1988), but unlike what happens in the North Sea Basin the species *L. valvatina* does not seem to become extinct after the appearance of *L. gramensis* (see notes on the occurrence in the Krywałd borehole above).

Palaeobiogeographical notes

Among the species encountered in the Polish part of the Carpathian Foredeep *Vaginella austriaca* is the most widespread one. Apart from a single observation in the U.S.A., it is known from the North Sea Basin, the Aquitaine Basin, the Mediterranean area, and the Central Paratethys.

The three limacinid species, *L. gramensis*, *L. miorostralis* and *L. valvatina*, are exclusively known from the Central Paratethys and from the North Sea Basin. Their absence from the Mediterranean area could be considered a good indication for a Neogene northern European connection between these two basins, albeit that such a connection is not supported by any other discipline. Therefore we must suppose that migration took place over the south and that the apparent absence, e.g. from the well-investigated Italian Miocene, is caused by preservational reasons.

The palaeogeography of these species, however, demonstrates a striking resemblance with the distribution patterns along climatic belts of various Recent Pteropoda (van der Spoel, 1967), with populations of the same or closely related species, separated by areas in which these species are absent.

The other pteropod species found in the Polish Miocene are either restricted to the Central Paratethys or recorded from the Central Paratethys and the Mediterranean area.

Conclusions

In the present paper the systematics of Krach's (1981) pteropod material from the Middle Miocene of South Poland are revised.

Of the eight *Spiratella* species recognised by Krach only two names remain, one of which is transferred to the genus *Limacina*, and the other is considered to belong in the genus *Peracle* of the Pseudothecosomata. Only three species of the genus *Limacina* are accepted, viz. *L. gramensis* (Rasmussen, 1968), *L. miorostralis* (Kautsky, 1925) and *L. valvatina* (Reuss, 1867). Two pseudothecosomatid species are recognised, *Peracle lata* (Krach, 1979) and *Peracle* sp. nov.

Among the Cavoliniidae two species of the genus *Clio* were found, viz. *C. fallauxi* (Kittl, 1886) and *C. pedemontana* (Mayer, 1868), agreeing with Krach's interpretation. The species referred to by Krach as *Styliola lamberti* Checchia-Rispoli is here considered to belong to the Recent species *Styliola subula* (Quoy & Gaimard, 1827). Of the four *Vaginella* species accepted by Krach, one (*V. lapugyensis* Krach, non Kittl, 1886) turned out to be *Creseis spina* (Reuss, 1867). The remaining three taxa, *V. austriaca* Kittl, 1886, *V. austriaca brevior* Krach, 1979, and *V. rzehaki* Kittl, 1886, are synonymised and treated in this paper as *V. austriaca*.

The occurrence of the Middle Miocene Polish holoplanktonic molluscs is restricted to the Badenian. *Limacina valvatina* is the only species present during the entire Badenian. *L. gramensis* is recorded from the Late Badenian (Grabovian). *Creseis spina* and *Vaginella austriaca* are found in the Early and Middle Badenian (Opolian). *Styliola subula* is present in the Early Badenian (Moravian) and probably in the Late Badenian (Grabovian). Typical for the Early Badenian are also *Limacina miorostralis*, *Clio fallauxi*, *C. pedemontana*, *Peracle lata* and *Peracle* sp. nov. Summarising, the Early Badenian (Early Opolian, Moravian) is the most diverse part of the Badenian with respect to holoplanktonic mollusc distribution.

A comparison with the biostratigraphical zonation based on holoplanktonic molluscs in the North Sea Basin (Janssen & King, 1988) demonstrates that the material studied in the present paper correlates with the upper part of pteropod zones 18/19 and the lower part of zone 20.

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