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A SYSTEMATIC ACCOUNT OF TERTIARY PTEROPODA (GASTROPODA, EUTHECOSOMATA) FROM AUSTRIA

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The taxonomy and stratigraphical distribution of euthecosomatous gastropods (Pteropoda) from Tertiary sediments in Austria are discussed. Most of the material studied originates from the so-called Molasse Zone and from the Vienna Basin. Eighteen species are recognised within the genera *Limacina*, *Creseis*, *Clio*, *Vaginella* and *Cuvierina*, of which twelve are recorded from Austria for the first time. Stratigraphically, the pteropod species discussed herein range from the Late Eocene (Priabonian) to the Middle Miocene (Early Sarmatian).

Key words — Mollusca, Gastropoda, Pteropoda, Tertiary (Priabonian-Sarmatian), Austria, taxonomy.

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Contents

Introduction

Pteropods are marine, holoplanktonic gastropods of small size (mm to cm), which are distributed worldwide, fossil as well as modern. The pteropod group discussed herein is assigned to the suborder Euthecosomata of the order Thecosomata. Austrian pteropods have been known from the middle of the nineteenth century, the smaller Limacinidae, however, have only been noted during recent decades. Formerly, pteropods escaped the attention of palaeontologists on account of their minute size, and the method of sampling, and they were also often interpreted as juvenile shells of other gastropods (*i.e.* as embryonic shells of Pyramidellidae). On the whole, the material available remained comparatively scanty, as the aragonitic shells fossilise poorly.

The only systematic papers in which also Austrian material was described, are those by Hörnes (1856), Kittl (1886), which encompasses the former Austro-Hungarian monarchy, and that by Čtyroký *et al.* (1968), which focusses on the Miocene of the Paratethys. A stratigraphical range from the Late Oligocene to Late Badenian was known.

Newly collected material, evidence of occurrences of older age in boreholes and progressive studies in other European countries during the last twenty years prompted a revision, or rather, a first systematic account of Austrian material. For the present study the entire pteropod collections of the Naturhistorisches Museum Wien, the Geologische Bundesanstalt Wien, the Institut für Paläontologie der Universität Wien and many boreholes of the Rohöl-Aufsuchungs GmbH and the Österreichische Mineralöl-Verwaltung were available. The material of the three last named institutions is now for the greater part included in the pteropod collection of the Geologisch-Paläontologische Abteilung of the Naturhistorisches Museum Wien, which also include the specimens studied by Kittl for his extensive work. This collection comprises the type material of four pteropod species which occur also in

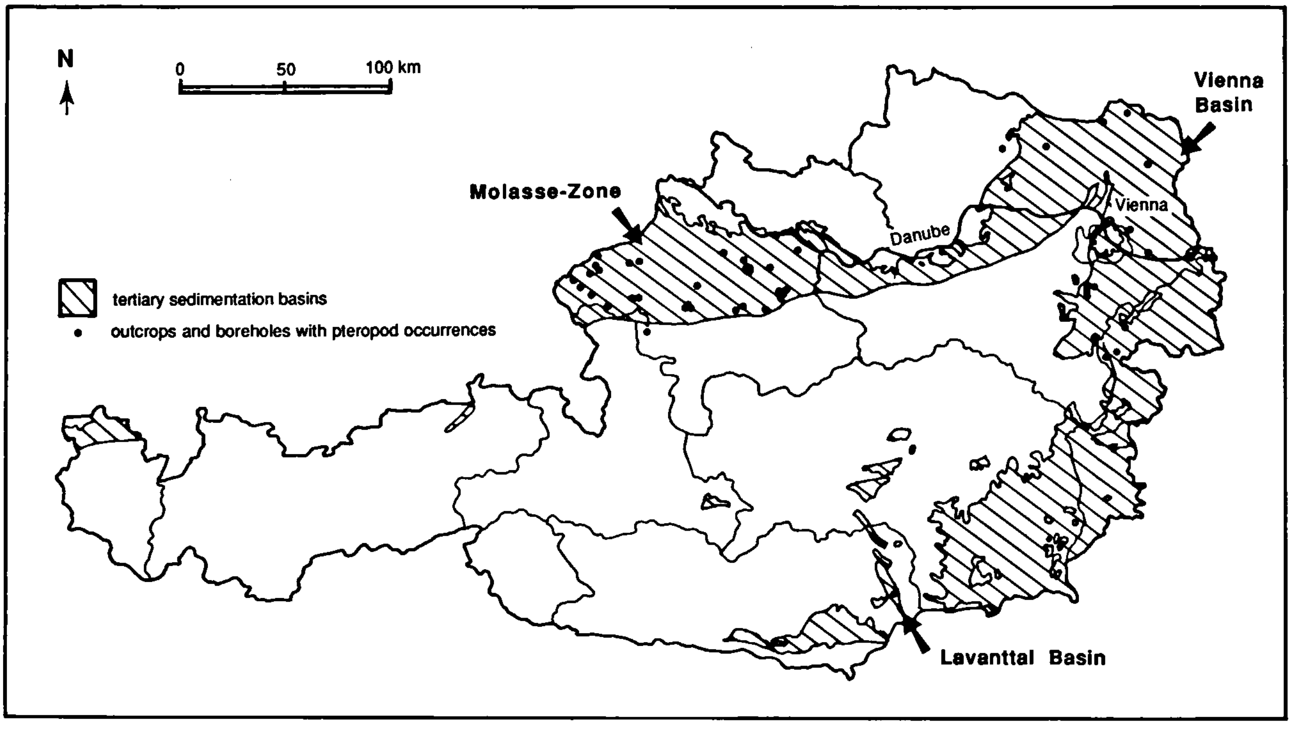


Fig. 1. Map of Austria showing localities that have yielded Tertiary pteropods.

Austria (*Limacina valvatina*, *L. hospes*, *Creseis spina* and *Vaginella austriaca*) and generally proved to be a valuable source for comparisons. In addition to the samples from the Aderklaa and Mannsdorf 1 boreholes (courtesy of the Österreichische Mineralöl-Verwaltung) all others come from boreholes sunk by the Rohöl-Aufsuchungs GmbH.

In another paper (Zorn, in press) the history of the pteropod studies in Austria, the stratigraphy and the localities are discussed. A schematic map (Fig. 1) showing the various localities will suffice here.

Abbreviations

GBA – Geologische Bundesanstalt, Vienna
NHMW-GP – Naturhistorisches Museum Wien, Geologisch-Paläontologische Abteilung
NHMW-Z – Naturhistorisches Museum Wien, Zoologische Abteilung (molluscan collections)
ÖMV – Österreichische Mineralöl-Verwaltung, Vienna and Aderklaa
RAG – Rohöl-Aufsuchungs GmbH, Vienna and Pettenbach
PI – Institut für Paläontologie der Universität Wien

c – circa
max. – maximum
min. – minimum
R – range of variation
s – standard deviation
V – coefficient of variation
$\bar{x}$ – mean
registr. no. – registration number

BBZ – Bulimina-Bolivina-Zone
BRZ – Bulimina-Rotalia-Zone
LLZ – Lower Lagenidae Zone
LPG – Lower Puchkirchen Group
SZ – Spiroplectammina Zone
TMF – Tonmergel Formation
ULZ – Upper Lagenidae Zone
UPG – Upper Puchkirchen Group

Concerning the symbols of the synonymy lists the reader is referred to Richter (1943).

Systematic descriptions

Phylum Mollusca
Classis Gastropoda
Ordo Thecosomata
Subordo Euthecosomata
Familia Limacinidae Gray, 1847
Genus *Limacina* Bosc, 1817

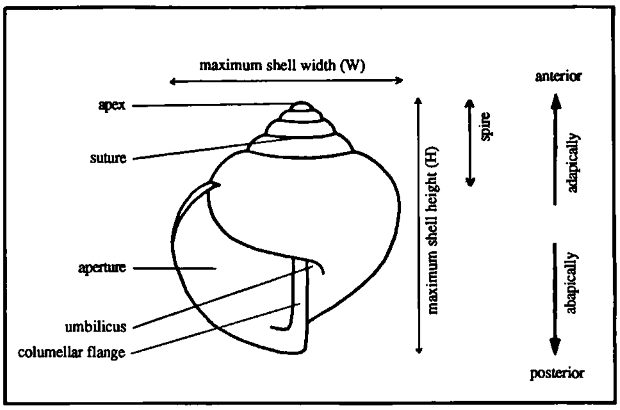


Fig. 2. Characters of the genus *Limacina*.

Diagnosis — Shell sinistral, planispiral to high trochospiral, occasionally with sunken, concave apex, umbilicus narrow to extremely wide or missing, shell surface mostly without ornamentation, aperture occasionally with special structures (projections, thickenings, extensions).
Type species — *Limacina helicina* (Phipps, 1774).
Stratigraphical range — Latest Paleocene-Recent.

Limacina valvatina (Reuss, 1867)
Pl. 1, Figs 1-6; Pl. 10, Figs 1, 2; Pl. 11, Figs 4, 5

*v 1867 *Sp. valvatina* Reuss, p. 146, pl. 6, fig. 11.
v. 1886 *Spirialis valvatina* Reuss. — Kittl, p. 69, pl. 2, fig. 38.
v. 1968 *Spiratella valvatina* (Reuss) — Čtyroký *et al.*, p. 131, pl. 4, fig. 10a-b.
. 1968 *Spiratella valvatina* (Reuss 1867) — Rasmussen, p. 243, pl. 27, figs 1-3, 11.
. 1969 *Limacina* A — Boekschoten, pl. 3, fig. 3a-b.
. 1972 *Spiratella valvatina* (Reuss, 1867) — A.W. Janssen, p. 61, figs 31-40, pl. 11, fig. 10.
v. 1981 *Spiratella valvatina* (Reuss) 1887 — Krach, p. 125, pl. 3, figs 2-4, 7, 8; pl. 5, figs 1, 2, 9-11; pl. 6, figs 1, 2a-b.
v. 1984a *Limacina valvatina* (Reuss, 1867) — A.W. Janssen, p. 381, pl. 20, figs 1a-b, 2a-b.
v. 1984b *Spirialis valvatina* Reuss, 1867 — A.W. Janssen, p. 72.
. 1990a *Limacina valvatina* (Reuss, 1867) — A.W. Janssen, p. 85, figs 7-9.

Material — Late Oligocene to Middle Miocene:
— Egerian - LPG: Eggelsberg 1, 2050-2052m (1 specimen), coll. NHMW-GP (registr. no. 1990/1319/5); Friedburg 1, 2142-2144m (1 specimen), coll. NHMW-GP (registr. no. 1990/1320/5); Weizberg 1, 1800m (1 specimen), coll. NHMW-GP (registr. no. 1990/1330/2). UPG: Diethaming 1, 890m (2 specimens), coll. NHMW-GP (registr. no. 1990/1317/7).
— Karpatian [Laaer Formation]: Laa an der Thaya, coll. NHMW-GP (leg. Rögl, 1967, registr. no. 1990/1316/18-33), 1/I/0-0,25m (2 specimens), 3/I/0,5-0,75m (2 specimens), 4/I/0,75-1m (5 specimens), 5/I/1-1,25m (6 specimens), 6/I/1,25-1,5m (1 specimen), 7/I/1,5-1,75m (1 specimen), 8/I/1,75-2m (3 specimens), 9/I/2,0-2,25m (4 specimens), 10/I/2,25-2,5m (1 specimen), 11/I/2,5-2,75m (1 specimen), 18/II/0-0,5m (1 specimen), III/0-0,1m (1 specimen), III/0,8-0,9m (6 specimens), III/1-1,1m (1 specimen), III/1,1-1,2m (2 specimens), 28/P/2 (1 specimen); coll. NHMW-GP (leg. Rögl, 1966, registr. no. 1990/1316/34, 7 specimens).
— Badenian - ULZ: Bad Vöslau, coll. NHMW-Z, (coll. Edlauer, registr. no. 36904, 1 specimen); Baden-Sooß, coll. NHMW-GP (registr. no. 1990/1310/2, a few juvenile specimens; Aderklaa 88, coll. NHMW-GP (registr. no. 1990/1295/5-7), 1690m (1 specimen), 1760m (1 specimen), 1860m (1 specimen); Aderklaa 92, coll. NHMW-GP (registr. no. 1990/1296/22-27), 1860m (1 specimen), 1880m (1 specimen), 1900m (4 specimens), 1910m (1 specimen), 1920m (2 specimens), 1930m (3 specimens).
SZ: Mannsdorf 1, coll. NHMW-GP (registr. no. 1990/1307/1), K/2055-2057m (2 specimens); Aderklaa 82, coll. NHMW-GP (registr. no. 1990/1290/8-17), 1480m (2 specimens), 1510m (1 specimen), 1520m (2 specimens), 1540m (1 specimen), 1600m (2 specimens), 1630m (1 specimen), 1660m (1 specimen), 1670m (1 specimen), 1680m (1 specimen), 1690m (1 specimen); Aderklaa 83, coll. NHMW-GP (registr. no. 1990/1291/4, 5), 1500m (1 specimen), 1600m (1 specimen); Aderklaa 85, coll. NHMW-GP (registr. no. 1990/1293/6-9), 1550m (8 specimens), 1560m (2 specimens), 1570m (1 specimen), 1590m (2 specimens); Aderklaa 87, coll. NHMW-GP (registr. no. 1990/1294/2-13), 1410m (5 specimens), 1420m (5 specimens), 1430m (1 specimen), 1450m (2 specimens), 1470m (1 specimen), 1480m (1 specimen), 1490m (4 specimens), 1520m (1 specimen), 1540m (1 specimen), 1550m (2 specimens), 1560m (1 specimen), 1580m (1 specimen); Aderklaa 88, coll. NHMW-GP (registr. no. 1990/1295/1-4), 1490m (1 specimen), 1500m (1 specimen), 1510m (3 specimens), 1590m (1 specimen); Aderklaa 92, coll. NHMW-GP (registr. no. 1990/1296/14-21) 1460m (1 specimen), 1470m (6 specimens), 1480m (5 specimens), 1490m (1 specimen), 1500m (10 specimens), 1510m (1 specimen), 1630m (1 specimen), 1670m (1 specimen).
BBZ: Aderklaa 83, coll. NHMW-GP (registr. no. 1990/1291/1-3), 1380m (1 specimen), 1400m (1 specimen), 1440m (3 specimens); Aderklaa 84, coll. NHMW-GP (registr. no. 1990/1292/1-4), 1470m (2 specimens), 1480m (1 specimen), 1490m (3 specimens), 1500m (2 specimens); Aderklaa 85, coll. NHMW-GP (registr. no. 1990/1293/1-5), 1420m (1 specimen), 1430m (6 specimens), 1500m (1 specimen), 1510m (2 specimens), 1540m (1 specimen); Aderklaa 87, coll. NHMW-GP (registr. no. 1990/1294/1), 1350m (1 specimen); Aderklaa 92, coll. NHMW-GP (registr. no. 1990/1296/5-13), 1350m (5 specimens), 1360m (1 specimen), 1380m (3 specimens), 1390m (1 specimen), 1410m (10 specimens), 1420m (12 specimens), 1430m (6 specimens), 1440m (6 specimens), 1450m (3 specimens); Walbersdorf, Wienerberger claypit, coll. NHMW-GP (leg. Steininger & Rögl, sample no. 430/Z, registr. no. 1990/1312/3, many juvenile specimens); Hainburg (borehole for the Donau-KW), coll. PI (registr. no. 2709, sample no. 20/14, 20/16, 20/18-20, many juvenile specimens).
BRZ: Aderklaa 82, coll. NHMW-GP (registr. no. 1990/1290/2-7), 1360m (1 specimen), 1370m (1 specimen), 1420m (1 specimen), 1440m (5 specimens), 1460m (19 specimens), 1470m (30 specimens).
Downhole contamination in the Karpatian from Badenian deposits: Aderklaa 87, coll. NHMW-GP (registr. no. 1990/1294/14), 2480m (1 specimen); Aderklaa 92, coll. NHMW-GP (registr. no. 1990/1296/28-40), 1950m (1 specimen), 1970m (1 specimen), 2180m (2 specimens), 2190m (1 specimen), 2220m (2 specimens),

n = 50	min.	max.	R	x̄	s	V	specimen from Vöslau
H	0,259	0,732	0,473	0,454	0,094	20,674	0,786
W	0,330	0,884	0,554	0,551	0,109	19,811	0,732
H/W	0,725	0,966	0,241	0,824	0,049	5,969	0,931

Table 1. Dimensions of *Limacina valvatina.*

n = 6	min.	max.	R	x̄
H	0,643	0,795	0,152	0,725
W	0,732	0,982	0,250	0,863
H/W	0,848	0,878	0,030	0,864

Table 2. Dimensions of the type material of *Limacina valvatina.*

2270m (2 specimens), 2300m (4 specimens), 2340m (1 specimen), 2350m (1 specimen), 2380m (2 specimens), 2450m (1 specimen), 2470m (1 specimen), 2480m (3 specimens).
Reworked specimens in Sarmatian strata from Badenian deposits: Marzer Kogel, Wienerberger claypit, coll. NHMW-GP (leg. Rögl, 1976, registr. no. 1990/1313/1, 11 specimens).

Description — The smooth shell, which shows clear growth lines only, has a moderately strongly elevated spire forming a slightly obtuse angle and projects *c* 1/6 of the entire shell height above the last whorl. The whorls are convex and high, increase regularly and very slowly in width and show relatively deep sutures. Height and width of the shell are nearly equal. When completely preserved, shell height slightly exceeds width, as shown by a specimen from Bad Vöslau (Pl. 1, Fig. 1), in which the narrow umbilicus and the aperture can be seen. The latter is oval and posteriorly slightly extended though damaged, attached to the periphery of the preceding whorl. This specimen also shows shortly before the aperture over the entire height of the whorl an anomaly in the shell growth, which is probably due to an injury. The columellar side of the aperture is slightly deflected outwards (columellar flange) and shows at the inner side a small, atypical bulge. As to the number of whorls, in the literature a maximum of four or five whorls is recorded (Reuss, 1867; von Koenen, 1883; Rasmussen, 1968). The Austrian specimens, however, reach at most 3¹/₄ whorls, just as the lectotype from Wieliczka does (Pl. 1, fig. 5).

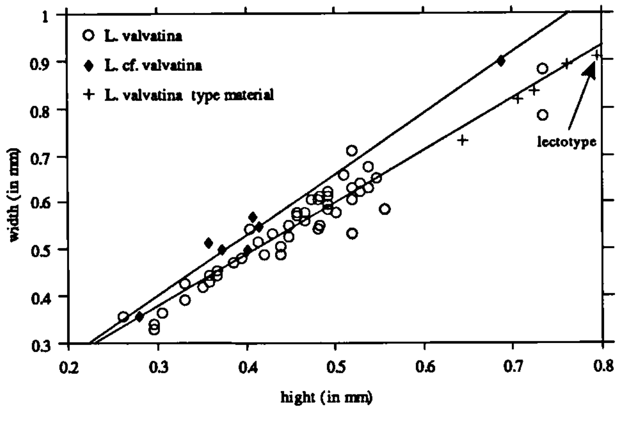


Fig. 3. Height/width (H/W) ratios of *Limacina valvatina* and *L.* cf. *valvatina.*

The embryonic shell (Pl. 11, Fig. 5) is cap-shaped with bulbous tip. No ornamentation is visible. The growth lines start behind the protoconch.

Dimensions — See Tables 1, 2.

Remarks — The borehole specimens are preserved as pyritic casts, rarely with thin shell layers remaining. Because of this state of preservation the width appears to exceed the height in these specimens. This explains the dimensions given in Table 1. Most specimens from Laa are juveniles, as are all of the Hainburg, Sooß and Walbersdorf individuals.

Limacina valvatina resembles *L. tarchanensis* (Kittl, 1886), *L. hospes* Rolle, 1861 and the modern species *L. lesueurii* (d'Orbigny, 1836). *Limacina hospes* has on average a lesser H/W ratio, the apical angle is smaller and the whorls increase markedly more rapidly in width. The first whorl is narrower and the subsequent ones are wider than those of *L. valvatina.* The aperture is more regularly oval-rounded and larger in comparison with the entire shell. The most conspicuous feature, however, is the deflected apertural margin opposite the columellar side, but this is not yet developed in non-adult specimens and generally not preserved in pyritic casts.

Limacina tarchanensis also differs by a lesser H/W ratio (lectotype: H=1.179 mm, W=1.446 mm, H/W=0.815; see Pl. 4, fig. 6); the form of the aperture, however, is very similar. The increase in whorl width is between *L. hospes* and *L. valvatina.*

The H/W ratio of *Limacina lesueurii* is similar to that of *L. valvatina*, it has a similarly narrow umbilicus and the whorl increase is also comparable, but the aperture is shaped differently. It is comparatively smaller, adapically not extended and the outer margin attaches below the periphery of the preceding whorl. In addition, *L. lesueurii* shows a distinct spiral sculpture on its base.

In the Laaer Formation *L. valvatina* and *L. miorostralis* (Kautsky, 1925) co-occur. As these are unfortunately generally very juvenile and the protoconchs are devoid of any ornamentation, these species are hard to tell apart. From 1¹/₄ whorls onwards they may be distinguished on account of the more rapid increase in whorl width in *L. miorostralis.* The growth lines are also often stronger in *L. miorostralis.*

Up to now, *L. valvatina* from Austria was known only from the Bulimina-Bolivina Zone (Late Badenian) in the Aderklaa 1 borehole (Čtyorký *et al.*, 1968, p. 131). It is now also recorded from the Middle Badenian, Karpatian and Egerian. The main range of *L. valvatina* is Middle Miocene, but it is common in the Bulimina-Bolivina Zone. In the Early Miocene the species is known, apart from Austria, only from the North Sea Basin. An occurrence in the Lower Puchkirchen Group (Kiscellian) has become more convincing with the record of a form from the German Chattian originally identified as *L. ? valvatina* (see A.W. Janssen & King, 1988, p. 363). A.W. Janssen (1990a) referred all Late Oligocene individuals from the North Sea Basin to *L. valvatina*, on the basis of additional material (see also *L.* cf. *valvatina* below).

Limacina nucleatus (Zhizhchenko, 1934) from the Early Badenian of the Taman peninsula, *L. praerangi praerangi* (Tembrock, 1989) from the Mecklenburg Early and Middle Miocene and the Hungarian Miocene *Limacina* sp. (Strausz, 1966) might in part be conspecific with *L. valvatina*. The first-named species shows a somewhat more elevated spire.

Extra-Austrian distribution — Paratethys: Czechoslovakia [Miocene, Badenian, Kosovian, ?Early Tertiary], Poland [Miocene, Badenian], Romania [Miocene, Badenian, Sarmatian (Volhynian)], Soviet Union [Miocene, Badenian, Kosovian]. North Sea Basin: Belgium [Miocene, Hemmoorian], Germany [Late Oligocene, Vierlandian-Langenfeldian], Denmark [Oligocene, Chattian, Miocene, Vierlandian-Langenfeldian], The Netherlands [Miocene, Hemmoorian-Reinbekian].

Limacina cf. **valvatina** (Reuss, 1867)
Pl. 1, Figs 7, 8

Material — Late Oligocene-Early Miocene:
— Kiscellian - TMF: Diethaming 1, coll. NHMW-GP (registr. no. 1990/1317/3, 4), 860m (2 specimens), 870m (1 specimen).
— Egerian - LPG: Diethaming 1, coll. NHMW-GP (registr. no. 1990/1317/13), 970m (1 specimen), UPG: Diethaming 1, coll. NHMW-GP (registr. no. 1990/1317/8, 10, 12); Friedburg 1, coll. NHMW-GP (registr. no. 1990/1320/1), 1740-1742m (1 specimen).

n = 7	min.	max.	R	x̄
H	0,278	0,686	0,408	0,416
W	0,357	0,900	0,543	0,556
H/W	0,695	0,800	0,105	0,749

Table 3. Dimensions of *Limacina* cf. *valvatina*.

Dimensions — See Table 3.

Remarks — These pyritic casts have slightly lesser H/W ratios and concomitantly a larger apical angle than typical *L. valvatina*. A.W. Janssen (1972, p. 63; 1990a) stressed the variation of this ratio in *L. valvatina* and specimens 'in a very depressed form' were recorded from the earliest Early Miocene (Vierlandian) (A.W. Janssen & King, 1988, p. 364). Specimens from the Late Oligocene of Jutland are also described by A.W. Janssen as very depressed. The H/W ratio indicated do not allow a direct comparison, as the Austrian specimens are preserved exclusively as pyritic casts and their shell height is therefore affected by the loss of apertural morphology. These special features demonstrate a resemblance with *L. tarchanensis*; it is impossible to distinguish between this species and a few small specimens at hand. As they co-occur with *L. valvatina* in the Egerian and *L. tarchanensis* has so far been recorded with certainty only from the Badenian, they are considered more closely related to *L. valvatina*. Specimens of *L. tarchanensis* recorded by Gheorghian *et al.* (1967) from the Early Miocene of Transsylvania cannot be verified. Should additional material from the Egerian and Kiscellian become available in future and the conspecificty with *L. valvatina* prove correct, the range will be extended to the Late Kiscellian.

Limacina sp. (MacNeil & Dockery, 1984, p. 244, pl. 65, figs 10-12, 14-18) from the Mississippi Early Oligocene shows a comparable habit.

Limacina hospes Rolle, 1861
Pl. 2, Fig. 1-7; Pl. 10, Fig. 5; Pl. 11, Fig. 1

*v 1861 *Limacina hospes* Rolle, p. 3, pl. 1, fig. 1, 1a-b.
v. 1886 *Spirialis hospes* (Rolle). — Kittl, p. 69, pl. 2, fig. 39.
1953 *Spiratella* cf. *hospes* (Rolle) — Sieber, p. 372.
? 1953 *Spirialis hospes* (Rolle) — Jorgulescu, p. 208, pl. 9, fig. 6.
1960 *Spirialis hospes* — Paghida, p. 323.
. 1967 *Spirialis hospes* (Rolle) — Gheorghian *et al.*, p. 8, pl. 1, fig. 1a-c.
1971 *Sp. hospes* Rolle — Rado & Tudor, p. 288.
1975 *S. hospes* (Rolle) — Gheorghian, p. 178.
1979 *Limacina (Limacina) hospes* (Rolle 1862) — R. Janssen, p. 350.
1979 *Spiratella hospes* (Rolle) — Stancu, p. 1390.
1980 *Spiratella hospes* (Rolle) — Moisescu & Popescu, p. 218, pl. 2.
v. 1984b *Limacina hospes* Rolle, 1861 — A.W. Janssen, p. 69, pl. 2, fig. 1a-d.
1988 *S. hospes* — Pana *et al.*, p. 60.
. 1989 *Limacina antoniae* Janssen & King, 1988 (*nomen nudum*) = *Limacina hospes* Rolle, 1861 — A.W. Janssen, p. 95.
. 1990a *Limacina hospes* Rolle, 1861 — A.W. Janssen, p. 84, figs 1-6.

Material — Oligocene:

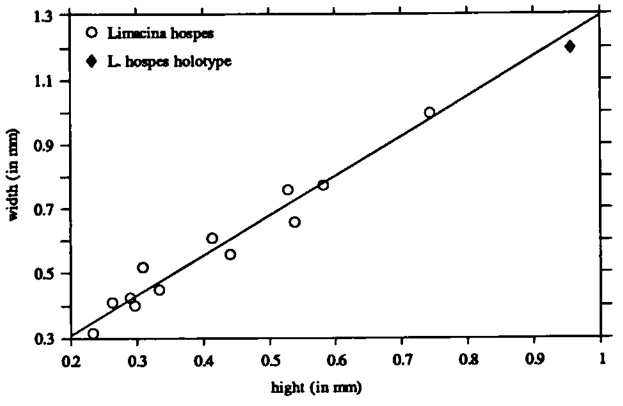


Fig. 4. Height/width (H/W) ratio of *Limacina hospes.*

n = 12	min.	max.	R	x̄	holotype
H	0,232	0,741	0,509	0,412	0,950
W	0,313	1,000	0,687	0,575	1,210
H/W	0,588	0,811	0,223	0,711	0,790

Table 4. Dimensions of *Limacina hospes.*

— Egerian, Lower Puchkirchen Group: Eggelsberg 1, coll. NHMW-GP (registr. no. 1990/1319/2, 3, 7, 9, 10, 12, 14), 2030-2032m (1 specimen), 2040-2042m (1 specimen), 2070-2072m (1 specimen), 2110-2112m (8 specimens), 2120-2122m (2 specimens), 2130-2132m (1 specimen), 2140-2142m (1 specimen); Friedburg 1, coll. NHMW-GP (registr. no. 1990/1320/4, 6, 9), 2120-2122m (1 specimen), 2160-2162m (2 specimens), 2320-2322m (1 specimen); Schallerbach 2, coll. NHMW-GP (registr. no. 1990/1328/2, 3, 5, 6), 360m (1 specimen), 370m (1 specimen), 380m (2 specimens), 390m (2 specimens).

Description — The spire is relatively low and the whorls increase in width slowly at first, then more rapidly. The shell height equals 3/4 of the width. The specimens, exclusively preserved as pyritic casts, show a maximum of 2¼ whorls, whereas the holotype has 3 ¼ whorls. The holotype (Pl. 2, fig. 7) preserves the typical deflected apertural margin, which cannot be seen in the Austrian specimens on account of state of preservation and ontogenetic stage (not yet full-grown). The aperture is large and oval. Just as in *L. valvatina* it attaches at the periphery of the penultimate whorl. The umbilicus is only visible in the holotype where it is narrow.

Dimensions — See Table 4.

Remarks — The differences between *L. hospes* and *L. valvatina* and *L. tarchanensis* have been discussed above. Especially similar is *L. dilatata* (von Koenen, 1892) from the Latdorfian of Germany, which resembles *L. hospes* in apertural morphology, but has a higher spire. A.W. Janssen (1989, p. 95) indicated that in *L. dilatata* height and width are nearly equal, whereas in *L. hospes* width exceeds height. The only record up to now of *L.* cf. *hospes* from the Late Oligocene of the Zehrmühle boreholes in Upper Austria is that of Sieber (1953).

The younger Rumanian records could perhaps refer to *L. tarchanensis*, as these are markedly younger than the typical Oligocene finds. There is no description of these shells and the illustration in Gheorghian *et al.* (1967, pl. 1, fig. 1a-c) does not allow a definite assignment.

Extra-Austrian distribution — Paratethys: Rumania [Miocene, Middle Egerian, Ottnangian, Badenian, Kosovian, Sarmatian (Volhynian), Late Miocene]. North Sea Basin: Belgium [Oligocene, Rupelian], Germany [Oligocene, Rupelian, Chattian], Denmark [Oligocene, Chattian].

Limacina miorostralis (Kautsky, 1925)
Pl. 3, Figs 1-4; Pl. 11, Fig. 2

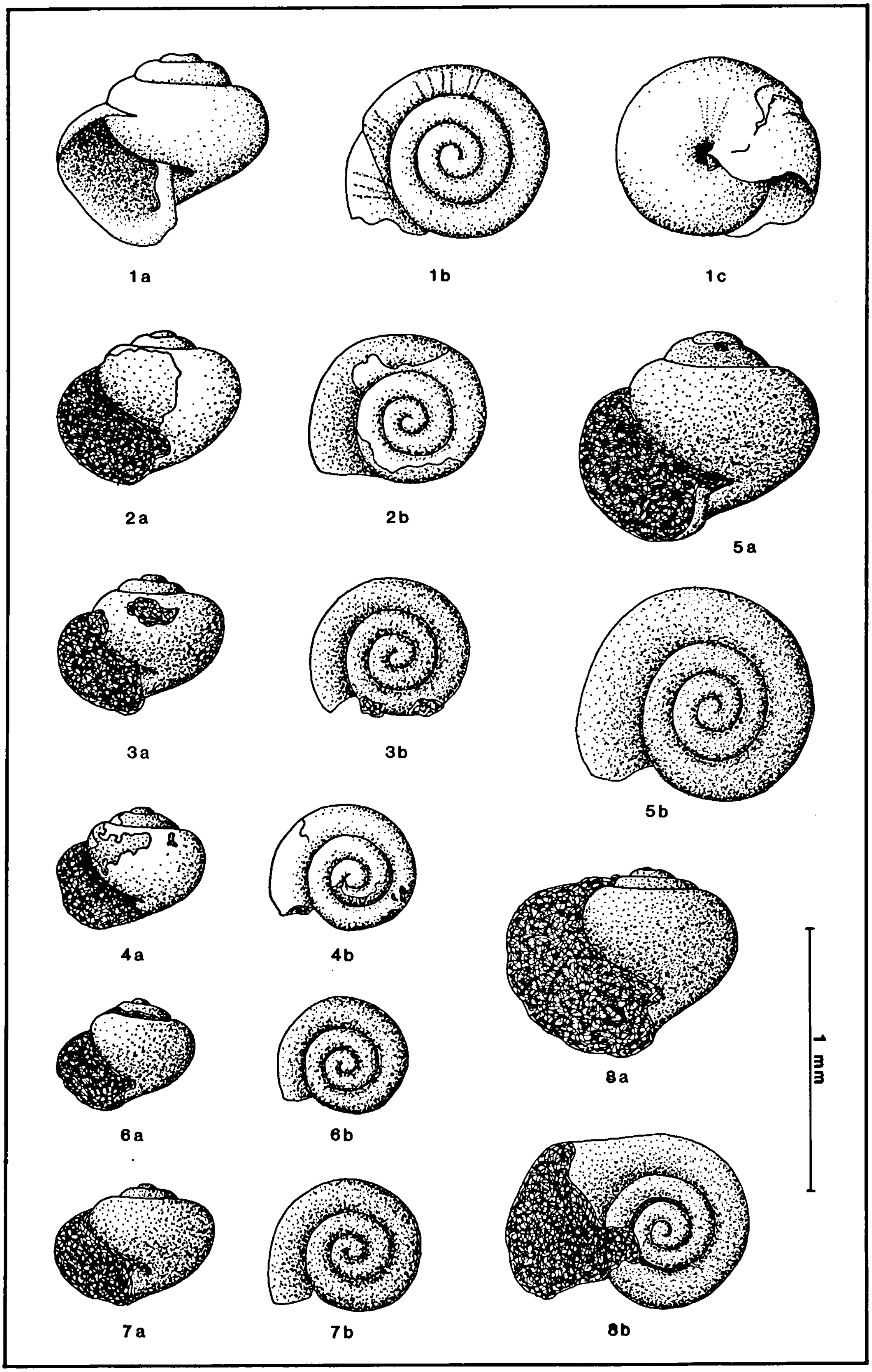
1883 *Spirialis rostralis* Eyd. et Soul. — von Koenen, p. 358.
1886 *Spirialis rostralis* Eyd. & Soul. — Koch, p. 134.
* 1925 *Spirialis miorostralis* Kautsky, pp. 202, 238.
1952 *Spiratella miorostralis* Kautsky, sp. 1925 — Glibert, pp. 147, 159, tab. 3, p. 170, tab. 4, p. 175, tab. 5.
v. *1967* *Spiratella andrusovi andrusovi* — Rögl, p. 36.
v. 1968 *Spiratella andrussowi andrussowi* (Kittl) — Čtyroký *et al.*, p. 131 [*partim*], pl. 4, fig. 12a-b.
1970 *Spiratella andrusovi* — Papp *et al.*, p. 31.

PLATE 1

Figs 1-6. *Limacina valvatina* (Reuss, 1867).
1a-c: Bad Vöslau, coll. NHMW-Z (Edlauer collection, registr. no. 36904), Badenian [Upper Lagenidae Zone], apertural, apical, and umbilical views. 2a-b: pyritic cast with shell fragments, Laa an der Thaya, NHMW-GP (registr. no. 1990/1316/20a), Karpatian [Laaer Formation], apertural and apical views. 3a-b: pyritic cast, Aderklaa 82 (1460 m), NHMW-GP (registr. no. 1990/1290/6a), Badenian [Bulimina-Rotalia Zone], apertural and apical views. 4a-b: pyritic cast with shell fragments, Aderklaa 82 (1600 m), NHMW-GP (registr. no. 1990/1290/12a), Badenian [Spiroplectammina Zone], apertural and apical views. 5a-b: lectotype, pyritic cast, Wieliczka, NHMW-GP (registr. no. 1867.VII.42), Badenian [Wielician], apertural and apical views. 6a-b: pyritic cast, Diethaming 1 (890 m), NHMW-GP (registr. no. 1990/1317/7), Egerian [Upper Puchkirchen Group], apertural and apical views.

Figs 7, 8. *Limacina* cf. *valvatina* (Reuss, 1867).
7a-b: pyritic cast, Diethaming 1 (890 m), NHMW-GP (registr. no. 1990/1317/8a), Egerian [Upper Puchkirchen Group], apertural and apical views. 8a-b: pyritic cast, Diethaming 1 (900 m), NHMW-GP (registr. no. 1990/1317/10a), Egerian [Upper Puchkirchen Group], apertural and apical views.

PLATE 1



v. 1972 *Spiratella kautskyi* Janssen, p. 63, figs 41a-b, pl. 11, fig. 11a-b.
. 1972 (?) *Spiratella miorostralis* (Kautzky, 1925) — Nordsieck, p. 125, pl. 32, fig. 220.
v. *1975* *Spiratella andrusovi andrusovi* (Kittl) — Steininger *et al.*, pp. 16, 61, tab. 1.
? 1981 *Spiratella andrussowi* (Kittl) — Krach, p. 128, pl. 3, fig. 15a-b; pl. 5, fig. 14a-b.
. 1984a *Limacina miorostralis* (Kautsky, 1925) — A.W. Janssen, p. 381, pl. 20, figs 3a-b, 4a-b.
. 1986 *Spiratella miorostralis* — A.W. Janssen, fig. 3.

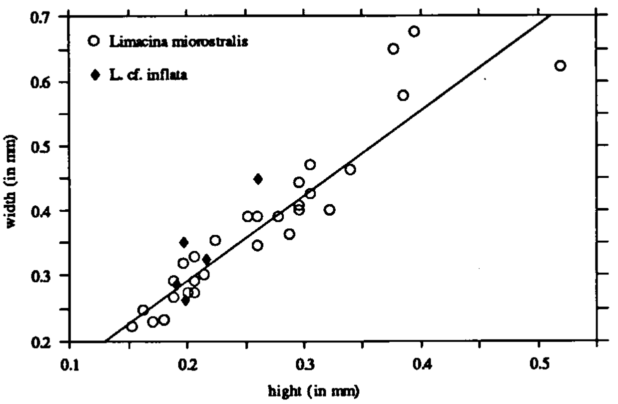


Fig. 5. Height/width (H/W) ratios of *Limacina miorostralis* and *L.* cf. *inflata*.

Material — Late Oligocene, Early Miocene:
— Egerian - LPG: Eggelsberg 1, 2060-2062m (1 specimen), coll. NHMW-GP (registr. no. 1990/1319/6).
— Karpatian [Laaer Formation] - Laa an der Thaya, Wienerberger claypit (former Brandhuber claypit), coll. NHMW-GP (leg. Rögl, 1967, registr. no. 1990/1316/3-16), 2/I/0,25-0,5m (1 specimen), 4/I/0,75-1,0m (11 specimens), 5/I/1,00-1,25m (10 specimens), 7/I/1,5-1,75m (4 specimens), 9/I/2,0-2,25m (4 specimens), 11/I/2,50-2,75m (8 specimens), 15/I/3,5-4m (1 specimen), III/0,2-0,3m (1 specimen), III/0,5-0,6m (1 specimen), III/0,6-0,7m (8 specimens), III/0,8-0,9m (12 specimens), III/0,9-1,0m (18 specimens), III/1,0-1,1m (1 specimen), III/1,1-1,2m (9 specimens); coll. NHMW-GP (leg. Rögl, 1966: registr. no. 1990/1316/17, 5 specimens); coll. NHMW-GP (registr. no. 1990/1315/1, 5 specimens).

Description — The available shells show a maximum of two whorls but the species may reach slightly more than three whorls (von Koenen, 1883; Kautsky, 1925; A.W. Janssen, 1984a). The shell

n = 30	min.	max.	R	x̄	s	V
H	0,152	0,518	0,366	0,260	0,083	31,808
W	0,223	0,679	0,456	0,379	0,122	32,238
H/W	0,575	0,828	0,253	0,689	0,062	9,006

Table 5. Dimensions of *Limacina miorostralis*.

width is *c* 1/3 in excess of its height. The first $1^1/_2$ whorls are faintly trochospiral and increase rapidly in width. After that the increase is even more rapid and the whorl height grows to such an extent that the whorl is in the same plane as the preceding whorl and then projects above it. The large body whorl, which is not preserved in any of the Austrian specimens, would even project above the apex. The aperture is large and near-circular and would in completely adult stage be more oval to semispherical and show a typical rostrum, which proceeds from the lower half of the apertural margin. The umbilicus is narrow. Growth lines may occasionally be observed. The specimens are often preserved as pyritic casts.

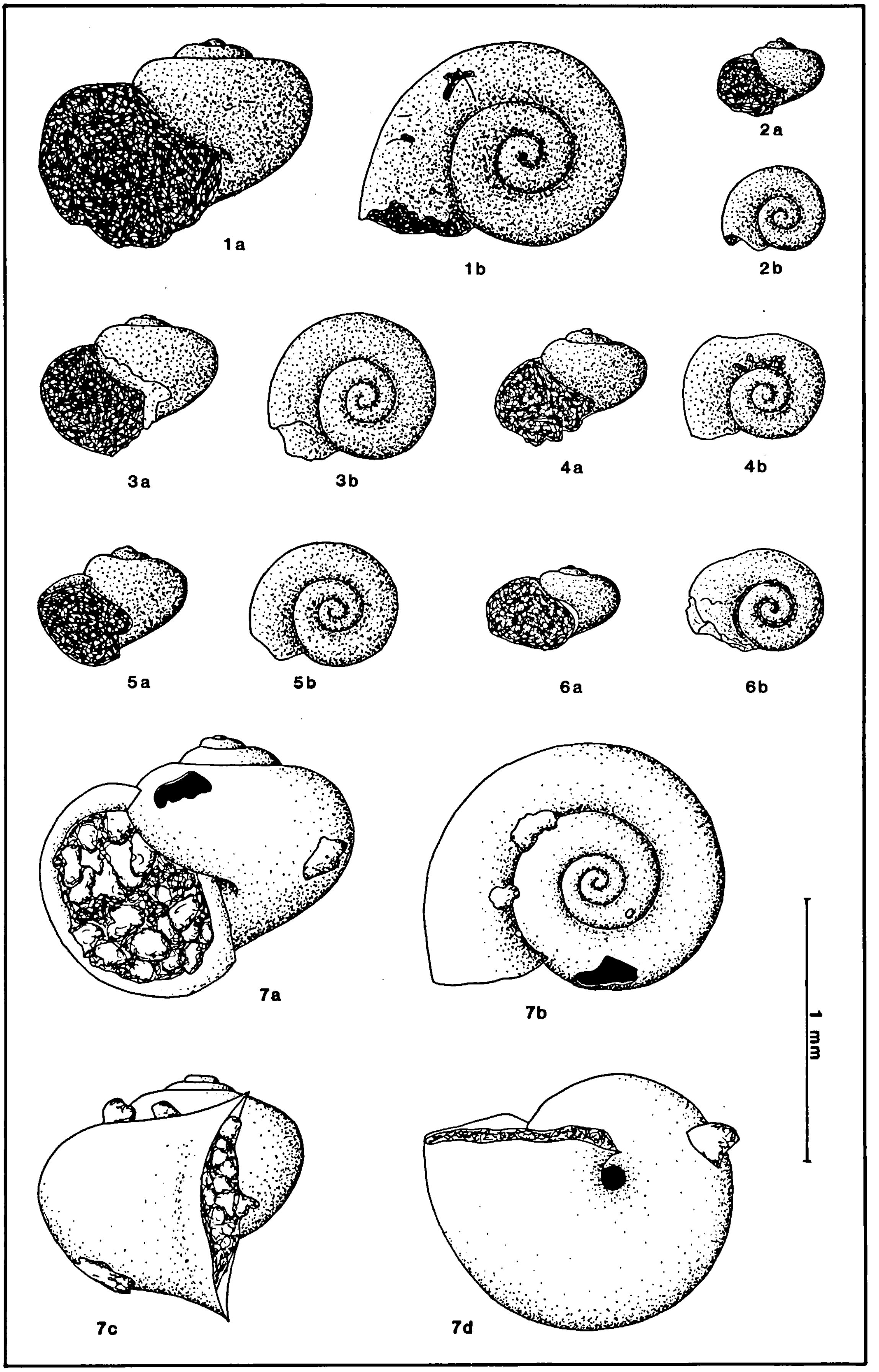
Dimensions — See Table 5 and Fig. 5.

Remarks — *Limacina miorostralis* is remarkably similar to the Recent *L. inflata* (d'Orbigny, 1836). Von Koenen (1883) considered the Miocene form conspecific with the Recent one, which he mentioned under the junior synonym *Spirialis rostralis* Eydoux & Souleyet, 1840. However, he pointed out not having seen Recent comparative material. In *L. inflata*, unlike *L. miorostralis*, the first whorl does not project above the second. Only the protoconch may project above the whorl spire. In addition, the umbilicus in *L. miorostralis* is slightly wider than in *L. inflata* and the rostrum shorter, which would be, at least in part, a matter of preservation of the fossil species. In *L. inflata* the rostrum proceeds also from the lower half of the apertural margin. Furthermore, *Limacina miorostralis* has a lesser H/W ratio, it is slightly wider than the modern species and the whorls increase more rapidly, but whorl height is less. The upper apertural margin in *L. miorostralis* rises higher above

PLATE 2

Figs 1-7. *Limacina hospes* Rolle, 1861.
1a-b, 5a-b: pyritic casts, Eggelsberg 1 (2110-2112 m), NHMW-GP (registr. no. 1990/1319/9a), Egerian [Lower Puchkirchen Group], apertural and apical views. 2a-b: pyritic cast, Schallerbach 2 (380 m), NHMW-GP (registr. no. 1990/1328/5a), Egerian [Lower Puchkirchen Group], apertural and apical views. 3a-b: pyritic cast, Schallerbach 2 (370 m), NHMW-GP (registr. no. 1990/1328/3, Egerian [Lower Puchkirchen Group], apertural and apical views. 4a-b: pyritic cast, Friedburg 1 (2160-2162 m), NHMW-GP (registr. no. 1990/1320/6), Egerian [Lower Puchkirchen Group], apertural and apical views. 6a-b: pyritic cast, Friedburg 1 (2120-2122 m), NHMW-GP (registr. no. 1990/1320/4), Egerian [Lower Puchkirchen Group], apertural and apical views. 7a-d: holotype, Mecklenburg, NHMW-GP (registr. no. 1859.XIII.233), Chattian, Sternberger Gestein, apertural, apical, lateral, and umbilical views.

PLATE 2



the last whorl and is wider, the aperture is more extended at the columellar side. Additionally, the whorls cover more of the preceding ones in *L. inflata*.

A very similar form is also the Middle Miocene *L. elevata* Collins, 1934, which its author considered distinct from *L. inflata* on account of its near-flat spire and less convex whorls. *Limacina zibinica* (Dieci, 1961) is a form with rapidly expanding whorl width as well, but the height appears less and the aperture is apparently shaped differently. This is not clearly visible from Dieci's illustration.

The name *L. miorostralis* is here used for the first time for Paratethys material. There were earlier finds in Austria, but these specimens were invariably referred to as *L. andrussowi* (Kittl, 1886) (see Rögl, 1967; Čtyroký *et al.*, 1968; Papp *et al.*, 1970; Steininger *et al.*, 1975). *Limacina andrussowi* should be removed from the Austrian faunal list. Krach (1981, p. 128, pl. 3, fig. 15a-b, pl. 5, fig. 14a-b) also illustrated under this name a form from Poland, which is presumably conspecific with *L. miorostralis* as well. *Limacina miorostralis* differs markedly from *L. andrussowi*: the whorls in the latter species increase very regularly and slowly in width and are less convex. The upper side of the spire is generally flat and the last whorl does never project above the preceding whorls. The spire may be elevated in many specimens and resemble that of *L. valvatina*. Moreover, the H/W ratio exceeds that of *L. miorostralis*.

The specimen from the Lower Puchkirchen Group is the oldest find of *L. miorostralis* to date. It is quite possible that *L.* cf. *inflata* from the Early Oligocene of Mississippi (MacNeil & Dockery, 1984, p. 244, pl. 65, fig. 13) may be referred here as well. Unfortunately, these authors did not illustrate an apical view.

Extra-Austrian distribution — North Sea Basin: Belgium [Miocene, Hemmoorian], Germany [Miocene, Hemmoorian], Denmark [Miocene, Hemmoorian], The Netherlands [Miocene, Hemmoorian and Reinbekian].

Limacina cf. **inflata** (d'Orbigny, 1836)
Pl. 3, Figs 5-8; Pl. 11, Fig. 3

* 1836 *Atlanta inflata* d'Orbigny, p. 174, pl. 12, figs 16-19.
1934 *Limacina inflata* (d'Orbigny) — Collins, p. 179 [*partim*], pl. 7, figs 3-6.
1979 *Spiratella inflata volhinica* Stancu, p. 1389, 1390 (*nom. nud.*).
1979 *Spiratella inflata* (d'Orbigny, 1836) — d'Alessandro *et al.*, p. 82, pl. 15, fig. 11a-b.
? 1984 *Limacina* cf. *L. inflata* (d'Orbigny) — MacNeil & Dockery, p. 244, pl. 65, fig. 13.
. 1990b *Limacina inflata* (d'Orbigny, 1836) — A.W. Janssen, pl. 2, figs 5-7, pl. 3, fig. 11.

(In addition to the first description only those citations that refer to Oligocene and Miocene occurrences are listed above).

Material — Miocene:
— Early Sarmatian: Aderklaa 82, 1040m (2 specimens), coll. NHMW-GP (registr. no. 1990/1290/1), Aderklaa 92, coll. NHMW-GP (registr. no. 1990/1296/1-4), 1120m (1 specimen), 1150m (1 specimen), 1170m (1 specimen), 1280m (1 specimen).

Description — The juvenile specimens, preserved as pyritic casts, show a nearly planispiral shell with a maximum of $1^1/_4$ whorls. The whorl width increases rapidly. In the largest specimens it may be seen that the protoconch projects a little above the first whorl. At the start of the second whorl the highest part is

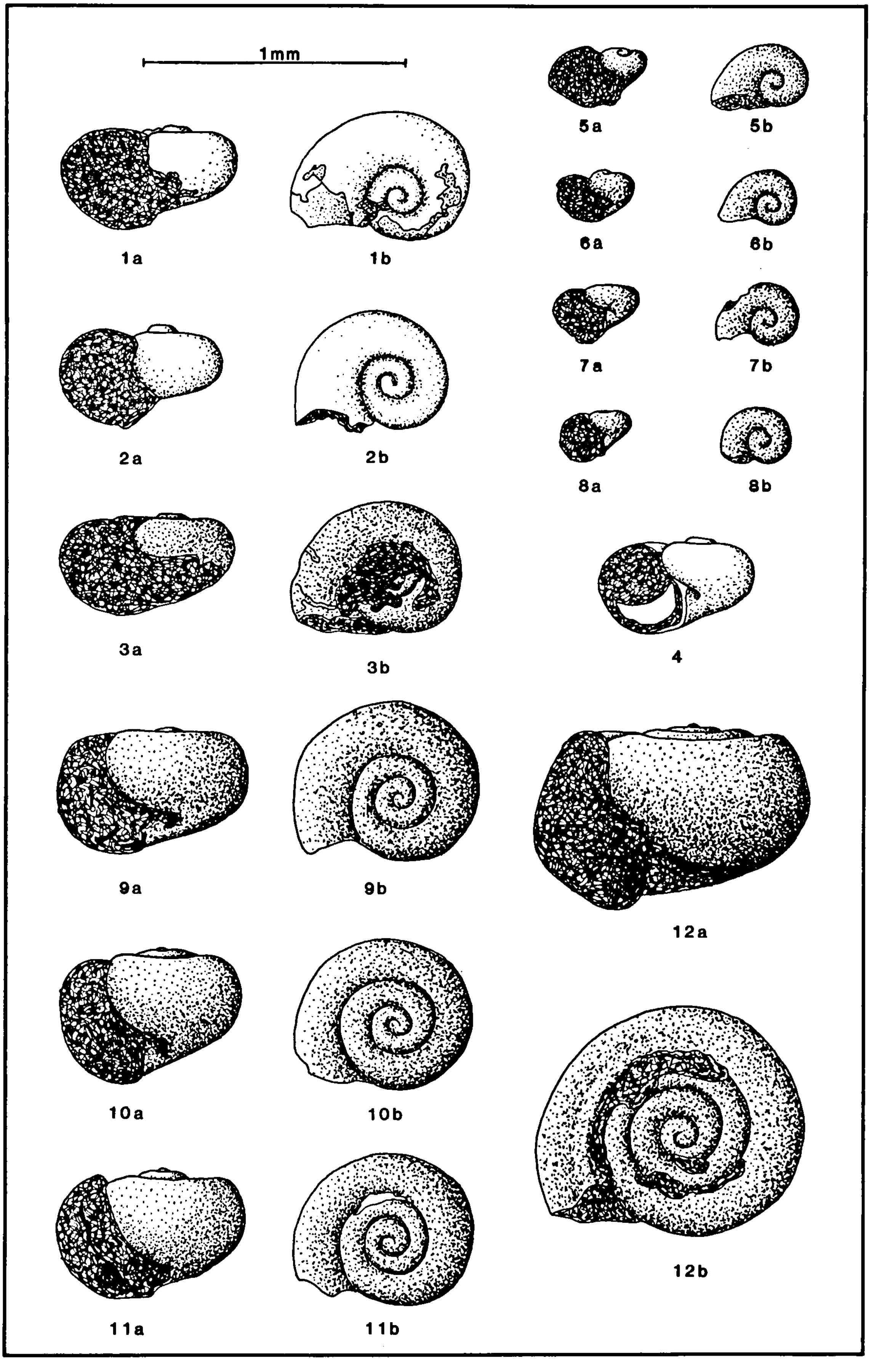
PLATE 3

Figs 1-4. *Limacina miorostralis* (Kautsky, 1925).
1a-b, 2a-b, 4a-b, Laa an der Thaya, NHMW-GP (registr. no. 1990/1316/5a), Karpatian [Laaer Formation], apertural and apical views. 3a-b: pyritic cast, Eggelsberg 1 (2060-2062 m), NHMW-GP (registr. no. 1990/1319/6), Egerian [Lower Puchkirchen Group], apertural and apical views.

Figs 5-8. *Limacina* cf. *inflata* (d'Orbigny, 1836).
5a-b: pyritic cast, Aderklaa 92 (1150 m), NHMW-GP (registr. no. 1990/1296/2), Early Sarmatian, apertural and apical views. 6a-b: pyritic cast, Aderklaa 92 (1280 m), NHMW-GP (registr. no. 1990/1296/4), Early Sarmatian, apertural and apical views. 7a-b: pyritic cast, Aderklaa 92 (1170 m), NHMW-GP (registr. no. 1990/1296/3), Early Sarmatian, apertural and apical views. 8a-b: pyritic cast, Aderklaa 82 (1040 m), NHMW-GP (registr. no. 1990/1290/1), Early Sarmatian, apertural and apical views.

Figs 9-12. *Limacina umbilicata* (Bornemann, 1855).
9a-b: pyritic cast, Puchkirchen 2 (2550-2552 m), NHMW-GP (registr. no. 1990/1326/6a), Kiscellian [Tonmergel Formation], apertural and apical views. 10a-b: pyritic cast, Puchkirchen 2 (2500-2502 m), NHMW-GP (registr. no. 1990/1326/2a), Kiscellian [Tonmergel Formation], apertural and apical views. 11a-b: pyritic cast, Puchkirchen 2 (2540-2542 m), NHMW-GP (registr. no. 1990/1326/5a), Kiscellian [Tonmergel Formation], apertural and apical views. 12a-b: pyritic cast, Oberhofen 1 (4210 m), NHMW-GP (registr. no. 1990/1322/10a), Egerian [Lower Puchkirchen Group]/[Kiscellian, Tonmergel Formation], apertural and apical views.

PLATE 3


1mm
1a
1b
2a
2b
3a
3b
4
5a
5b
6a
6b
7a
7b
8a
8b
9a
9b
10a
10b
11a
11b
12a
12b

n=5	min.	max.	R	x̄
H	0,188	0,259	0,071	0,211
W	0,268	0,455	0,187	0,341
H/W	0,549	0,731	0,182	0,627

Table 6. Dimensions of *Limacina* cf. *inflata*.

on the level of the protoconch again. The aperture is oval and occupies nearly half the width of the shell, whose height corresponds to 2/3 of the width.

Dimensions — See Table 6.

Remarks — As far as shell habit is concerned there are similarities to *L. inflata* and *L. miorostralis*. As only the protoconch projects above the first whorl and the whorls cover each other in a similar fashion as they do in *L. inflata*, these specimens might well be *L. inflata*. The fact that only juvenile pyritic casts are available and the morphology of the sunken apex cannot be appreciated, these have to be referred to as *L.* cf. *inflata*.

These are the first tentative Austrian specimens. As to the remaining Paratethys, Stancu (1979, pp. 1389, 1390) recorded in addition to six accompanying species from the Volhynian of Rumania *L. inflata volhinica* Stancu, but without description or illustration (*nomen nudum*). This may possibly be the same species. The specimen from the Dominican Republic described as *L. inflata* by Collins (1934, pl. 7, figs 7, 8) was found not to be that species (A.W. Janssen, 1990b), on account of its weak microsculpture.

Extra-Austrian distribution — Paratethys: Rumania [Middle Miocene, Sarmatian (Volhynian)]. Mediterranean area: Italy [Middle Miocene], Turkey [Middle Miocene]. Other areas: Mexico [Middle Miocene], ? U.S.A. [Early Oligocene], Australia [Miocene, Balcombian-Bairnsdalian (corresponding to Late Burdigalian-Serravallian)]. The species is also widely distributed in Quaternary sediments and its present-day distribution comprises all tropical and subtropical seas, *e.g.* also the Mediterranean, especially the western part (Bé & Gilmer, 1977, p. 775).

Limacina umbilicata (Bornemann, 1855)
Pl. 3, Figs 9-12; Pl. 10, Figs 3, 4

* 1855 *Valvatina umbilicata* Bornemann, p. 319, pl. 12, fig. 5a-c.
. 1868 *Valvatina umbilicata* Bornem. — von Koenen, p. 223, pl. 27, fig. 1a-h.
1886 *Valvatina umbilicata* Bornem. — Koch, p. 135.
1928 *Spirialis umbilicata* (Bornemann) — Zinndorf, p. 53, pl. 3, fig. 4a-c (copied from Bornemann).
1953 *Spirialis umbilicata* Born. — Voicu, p. 230.
1953 *Spirialis* cf. *umbilicata* Born. — Voicu, p. 235.
1964 *Valvatina umbilicata* — Gheorghian & Gheorghian, p. 179.
1964 *Spiratella umbilicata* (Bornemann) — Langer, p. 733.
. 1964 *Spiratella umbilicata* (Bornemann, 1855) — Tembrock, p. 320, pl. 3, fig. 1a-d.
. 1966 *Spiratella (Valvatina) umbilicata* — Korobkov, p. 86, pl. 3, figs 1-5 (figs 1-3 copied from Bornemann).
1967 *Spirialis umbilicata* (Bornemann) — Gheorghian *et al.*, pp. 10, 15.
. 1975 *Spiratella umbilicata* (Bornemann, 1855) — van den Bosch *et al.*, pl. 4, fig. 10.
. 1986 *Spiratella umbilicata* — A.W. Janssen, fig. 2.
1988 *Limacina umbilicata* — A.W. Janssen & King, figs 188, 194-197, 203, 206.

Material — Late Eocene-Late Oligocene:
— Priabonian: Puchkirchen 2, coll. NHMW-GP (registr. no. 1990/1326/10, 11), 2600-2602m (5 specimens), 2610-2612m (21 specimens).
— Kiscellian: Puchkirchen 2, coll. NHMW-GP (registr. no. 1990/1326/1-9), TMF: 2490-2492m (6 specimens), 2500-2502m (2 specimens), 2510-2512m (6 specimens), 2530-2532m (6 specimens), 2540-2542m (14 specimens), 2550-2552m (20 specimens), 2560-2562m (4 specimens), Bändermergel Formation: 2570-2572m (1 specimen), Fischschiefer Formation: 2590-2592m (2 specimens); Puchkirchen 3, coll. NHMW-GP (registr. no. 1990/1327/1, 2), K1/2610-2628,5m (1 specimen), K3/2647-2665,5m (1 specimen); Oberhofen 1, coll. NHMW-GP (registr. no. 1990/1322/4, 5), TMF: 2690m (1 specimen), 2720m (1 specimen).
— Kiscellian/Egerian: Oberhofen 1, coll. NHMW-GP (registr. no. 1990/1322/1-3, 6, 8, 10, 12), TMF/LPG: 2530m (1 specimen), 2570m (1 specimen), 2670m (1 specimen), 4150m (1 specimen), 4200m (4 specimens), 4210m (4 specimens), 4220m (8 specimens).
— Egerian - LPG: Eggelsberg 1, coll. NHMW-GP (registr. no. 1990/1319/11, 13), 2120-2122m (1 specimen), 2130-2132m (1 specimen); Schallerbach 2, coll. NHMW-GP (registr. no. 1990/1328/1), 340m (1 specimen); Weizberg 1, coll. NHMW-GP (registr. no. 1990/1330/1), 1800m (1 specimen).

Description — The spire is flat to slightly elevated, in the latter case forming an extremely obtuse angle. The whorls increase slowly and regularly in width and show deep sutures. In older specimens the last whorl is slightly angular adapically and shows a tendency to develop a shoulder. There is a maximum of $3^1/_2$ whorls. The aperture is rounded-semispherical to narrow-oval. Its width is half the height. The height of the entire shell equals $^3/_4$ its width. The H/W ratio is equal in juvenile and adult specimens. The umbilicus is generally filled in, but would be narrow.

Dimensions — See Table 7 and Fig. 6.

Remarks — All specimens at hand are preserved as pyritic casts. If shell were preserved the aperture would be strongly extended abapically (van den

n = 50	min.	max.	R	x̄	s	V
H	0,157	0,911	0,754	0,367	0,159	43,361
W	0,257	1,339	1,082	0,533	0,227	42,665
H/W	0,591	0,822	0,231	0,690	0,044	6,418

Table 7. Dimensions of *Limacina umbilicata.*

Bosch *et al.*, 1975, pl. 4, fig. 10), which is why the H/W ratio would increase.

Von Koenen (1868) recorded up to five whorls and described the last whorl as elevated. This tendency is in the Austrian material but indicated in the largest specimen (Pl. 3, Fig. 12). Here the fourth whorl projects slightly above the third.

Limacina andrussowi (Kittl, 1886) is rather similar to *L. umbilicata*, especially when young specimens are compared. However, with larger individuals it becomes apparent that the increase in whorl in the former species is more rapid and that a shoulder never forms. The H/W ratio of the lectotype (H=0.670 mm, W=0.946 mm, H/W=0.708) corresponds, however, roughly with the mean for the specimens of *L. umbilicata* measured.

Korobkov (1966) divided *L. umbilicata* into two species; *L. pseudoumbilicata* should comprise all specimens that develop a keel.

MacNeil & Dockery (1984, pl. 66, figs 1-5) illustrated *Limacina* sp. from the Early Oligocene of Mississippi, which could well be conspecific with Austrian finds. *Limacina umbilicata* is here recorded from the Austrian Tertiary for the first time.

Extra-Austrian distribution — Paratethys: Rumania [Miocene, Late Egerian-Early Eggenburgian], Soviet Union [Oligocene, Rupelian]. North Sea Basin: Belgium [Oligocene, Rupelian], Germany [Oligocene, Rupelian], The Netherlands [Oligocene, Rupelian].

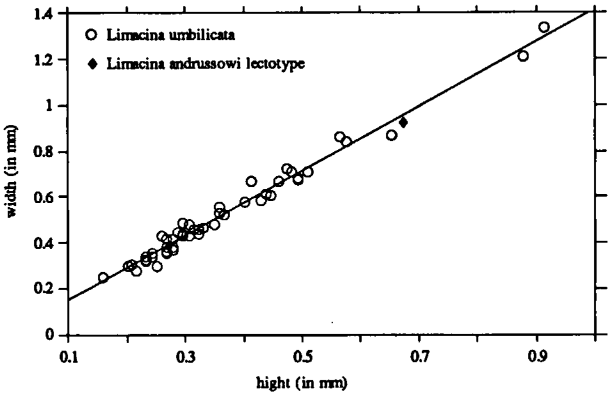


Fig. 6. Height/width (H/W) ratio of *Limacina umbilicata.*

Limacina sp. 1
Pl. 4, Figs 1, 2

Material — Eocene:
— Priabonian: Puchkirchen 2, 2610-2612m (2 specimens), coll. NHMW-GP (registr. no. 1990/1326/12).

Description — The specimens are preserved exclusively as pyritic casts. The shell shows *c* 2½ whorls. The first two whorls increase in width slowly, the last whorl rapidly in width and height and occupies nearly the entire shell height. The width of the shell slightly exceeds its height. The spire shows a very obtuse angle. The aperture is large and oval and attaches above the periphery of the preceding whorl. On account of the preservation it cannot be decided whether a narrow umbilicus was present or absent.

Dimensions — See Table 8.

H	0,545	0,357
W	0,616	0,473
H/W	0,885	0,755
A	128°	133,5°

Table 8. Dimensions of *Limacina* sp. 1.

Remarks — During the Eocene Limacinidae with a depressed spire and a large last whorl did occur, but these have a less narrow umbilicus and other differential features. These are: *L. pygmaea* (Lamarck, 1804) and *L. auriformis* (Curry, 1981), both from the French Eocene (Curry, 1981) and *L. korobkovi* (Tembrock, 1989) from the Late Eocene of the Priaral. Limacinidae without umbilicus are extremely rare; a few examples are the fossil species *Plotophysops bearnensis* Curry, 1981, *P. multispira* Curry, 1981 and *Limacina elongatoidea* (Aldrich, 1887) (see Collins, 1934, p. 178). All three species are high trochospiral. Amongst Recent species *Limacina bulimoides* (d'Orbigny, 1836) is the only form with an extremely narrow umbilicus.

The increase in whorl diameter of *Limacina* sp. 1 and its entire habit are similar to *L. hospes*, but the umbilical morphology suffices to tell them apart.

Limacina sp. 2
Pl. 4, Figs 3, 4

Material — Oligocene:
— Kiscellian, NP 22: Ottenthal, coll. PI (leg. Braunstein, registr. no. 2710), coll. GBA (leg. Stradner, registr. no. 1990/7/1).

Description — The shell is discoidal and shows a slightly sunken, concave spire. The whorls increase slowly at first, then rapidly in width and height. The umbilicus and aperture are not visible, because of poor preservation. All specimens are embedded in sediment and more or less crushed.

Dimensions — The largest width measurable is 1.4 mm.

Remarks — Many specimens may well have been larger than stated above, as very high and wide whorls can be recognised in sediment samples. Attempts at preparation of specimens were unfortunately unsuccessful because of the extreme fragility of the shells.

There is a certain resemblance to *L. jessyae* A.W. Janssen, 1989 from the Rupelian-Latdorfian of Denmark and The Netherlands, which has a very depressed, planorboid shell with concave spire. Its umbilicus is extremely wide and closely resembles the spire. Its whorls, however, increase less rapidly and substantially more regularly in width.

This find represents a mass occurrence of *Limacina*. In coeval strata similar *Limacina* levels occur in Hungary in the Tard Clay (Báldi, 1984). Already Lőrenthey (1903b) recorded a marl with pteropods from the surroundings of Budapest, which forms 'ein gut charakteristisches und leicht erkennbares Niveau'. He described the form as *Planorbis*-like, with depressed apex and partially covered whorls and proposed the name *Valvatella oligocaenica*. *Valvatella* is a junior synonym of *Limacina*. Lőrenthey also pointed out the poor state of preservation. Báldi (1986, pl. 1, figs 3, 4) figured specimens from the Tard Clay; in his fig. 3 an apparently dextral gastropod shell is depicted. Should this prove to be a *Limacina*, the umbilical side is up, as this genus is sinistral. In the Austrian specimens the umbilical side is unfortunately not visible.

Limacina sp. 3
Pl. 4, Fig. 5

Material — Oligocene:
— Egerian, Lower Puchkirchen Group: Diethaming 1, 970m (1 specimen), coll. NHMW-GP (registr. no. 1990/1317/14).

Description — The only pyritic cast available is almost as wide as high, slightly crushed and comprises 3¼ whorls. The spire is elevated. The first two whorls are equally wide, the last, however, is comparatively very wide and high. It shows distinct growth lines, which are preserved as impressions. The aperture is also partially crushed; it would have attached at the periphery of the preceding whorl and been obliquely oval. The umbilicus is narrow.

Dimensions — H=1,257mm, W=1,314mm, H/W =0,957.

Remarks — The first two whorls resemble *L. valvatina*, but in that species all whorls increase more regularly in width. This specimen might represent a new species.

Familia Creseiidae Rampal, 1973
Genus *Creseis* Rang, 1828

Diagnosis — Shell straight, needle-shaped to strongly horn-shaped with dorsal curvature, regularly conical or shell diameter in the older part slowly increasing or not increasing at all. Cross section and aperture circular, without lateral carinae, rarely with transverse ornamentation. Separation of proto-

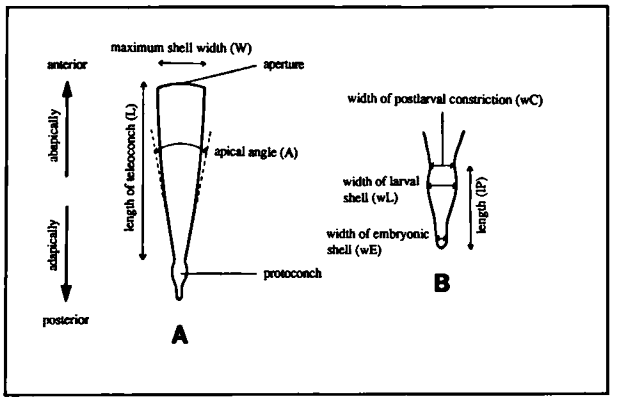


Fig. 7. Characters of the genus *Creseis*.
A – entire shell
B – protoconch.

PLATE 4

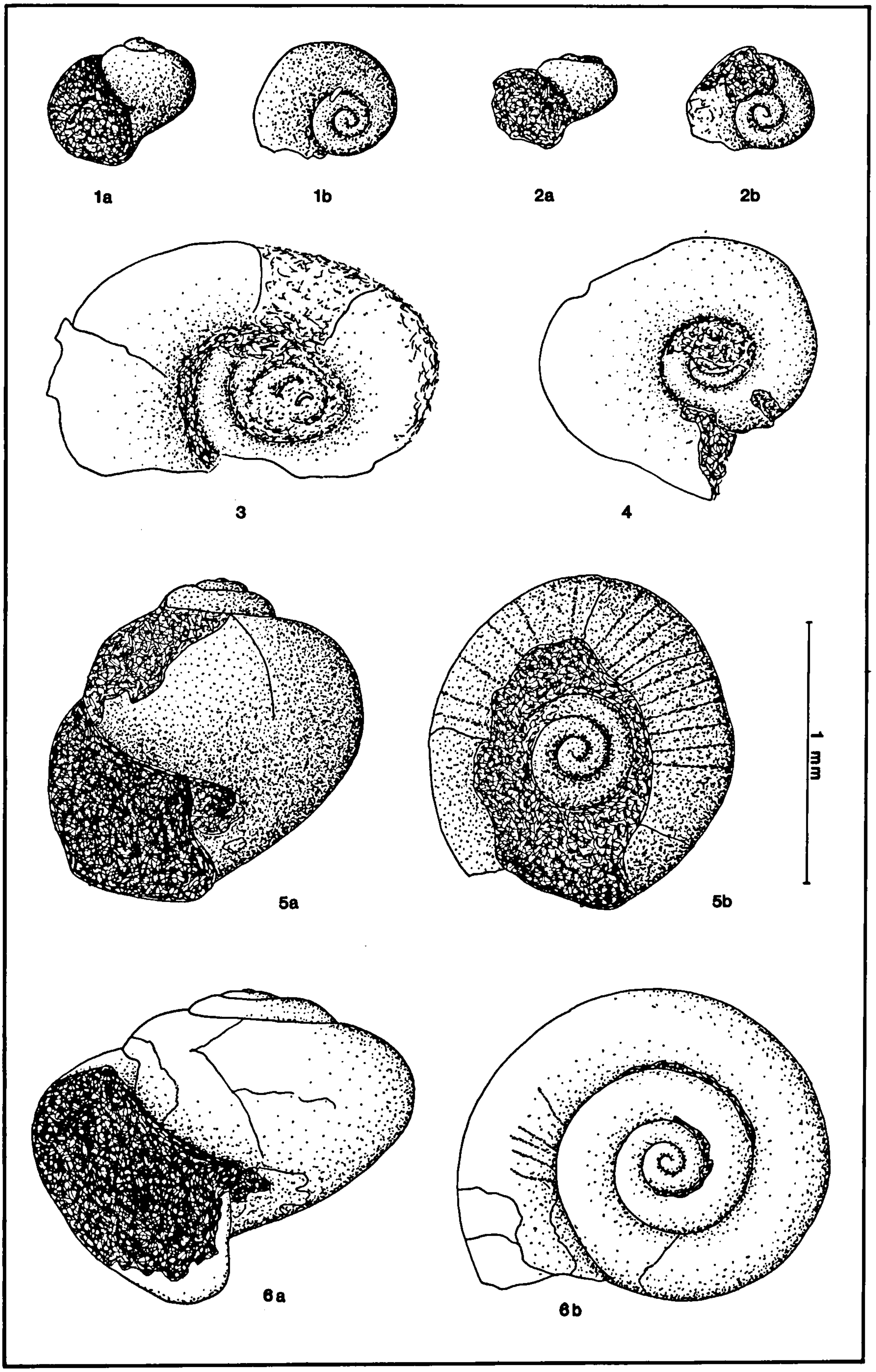
Figs 1, 2. *Limacina* sp. 1.
Pyritic cast, Puchkirchen 2 (2610-2612 m), NHMW-GP (registr. no. 1990/1326/12), Priabonian, apertural and apical views.

Figs 3, 4. *Limacina* sp. 2.
Ottenthal, GBA (registr. no. 1990/7/1), Kiscellian, nannoplankton zone NP 22, apical view.

Fig. 5. *Limacina* sp. 3.
Pyritic cast, Diethaming 1 (970 m), NHMW-GP (registr. no. 1990/1317/14), Egerian [Lower Puchkirchen Group], apertural and apical views.

Fig. 6. *Limacina tarchanensis* (Kittl, 1886).
Lectotype, Soviet Union, Crimea, between Cap Tarchan and Cap Chronevi, NHMW-GP (registr. no. 1990/1332/1), Badenian, apertural and apical views.

PLATE 4



conch from teleoconch distinct to barely visible. Larval shell often formed as bulb upon the rounded embryonic shell.
Type species — *Creseis virgula* Rang, 1828.
Stratigraphical range — Late Eocene-Recent.

Creseis spina (Reuss, 1867)
Pl. 5, Figs 1-6, 13-18, 21; Pl. 12, Figs 2

*v 1867 *Cl. spina* 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, p. 8, fig. 2, 2a.
1955 *Cleodora spina* Rss. — Luczkowska, p. 83.
non 1968 *Creseis spina* Reuss, 1867 — Sirna, p. 420, fig. 5.
non 1979 *Creseis spina* Reuss, 1867 — d'Alessandro *et al.*, p. 84, pl. 16, figs 1-4.
1980 *Cleodora spina* Reuss — Moisescu & Popescu, p. 217.
v. 1984b *Cleodora (Creseis) spina* Reuss, 1867 — A.W. Janssen, p. 66, pl. 1, figs 1a-b, 2a-b.

Material — Miocene:
— Badenian, BBZ: Wienerberger claypit: Walbersdorf, coll. NHMW-GP (leg. Steininger & Rögl, sample no. 430/Z, registr. no. 1990/1312/2; 25 protoconchs and a number of specimens in sediment); Marzer Kogel (reworked in Sarmatian), coll. NHMW-GP (leg. Rögl, 1976, registr. no. 1990/1313/2; 1 specimen).
Description — The teleoconchs (Pl. 5, Figs 16-18, 21; Pl. 12, Fig. 2) are slender, straight to slightly curved posteriorly and increasing in width gradually from apex to aperture. The apical angle is *c* 10°. The length reaches *c* 5 mm and the width 1 mm. There is no ornamentation. The cross section of the adult shell is circular over its entire length, which can only be seen in a specimen from Marzer Kogel (Pl. 5, Fig. 21), which is a pyritic cast. The specimens from Walbersdorf are crushed to such an extent that the cross section is preserved only just beyond the protoconch (Pl. 12, Fig. 2c). The aperture cannot be reconstructed, but will probably have been circular, just as in Recent species.

The well-preserved protoconchs (Pl. 5, Figs 1-6, 15; Pl. 12, Fig. 2) are also rotation-symmetrical. They are clearly separated from the teleoconch and represent elongated bulbs (larval shell), starting with a narrow, elongated, rounded tip, whose posterior end (embryonic shell) is very slightly bulbous in some specimens (Pl. 5, Fig. 2). In SEM it is seen that in one specimen there is on both sides of the protoconch a weak ridge, which starts at the onset of the larval phase and ends with it (Pl. 12, Fig. 2b). All other specimens are perfectly smooth. Growth lines are visible in SEM on larval and adult shells.

	min.	max.	R	$\bar{x}$	s	V
lP	0,429	0,482	0,053	0,456	0,018	3,888
wE	0,056	0,071	0,015	0,066	0,004	6,607
wL	0,143	0,170	0,027	0,154	0,008	5,000
wC	0,112	0,141	0,029	0,128	0,008	5,997
lP/wL	2,835	3,259	0,424	2,998	0,141	4,691
wL/wE	2,148	2,714	0,566	2,394	0,165	0,027
A	6°	11,5°	5,5°	9,125°	2,323	25,456°

Table 9. Protoconch dimensions and apical angles of *Creseis spina*.

	lectotype	paralectotype
lP	0,455	0,464
wE	0,071	0,071
wL	0,163	0,170
wC	0,154	0,152
lP/wL	2,791	2,729
wL/wE	2,296	2,394
A	12°	14,5°

Table 10. Protoconch dimensions and apical angles of the type material of *Creseis spina*.

Dimensions — See Tables 9, 10.
Remarks — The protoconchs correspond to those described by Reuss (1867) as *Cleodora (Creseis) spina*, which, unfortunately, are preserved as pyritic casts (Pl. 5, Figs 13, 14). Their teleoconch dimensions differ somewhat. The apical angle is slightly greater and the base of the teleoconch wider. These differences are considered unimportant, as there are variations within the material from Walbersdorf as well. The specimen illustrated in Plate 5, Figure 1 shows near-parallel sides.

For the measurement of the various protoconch dimensions a varying number of individuals was used as most specimens are fragmentary (which is the reason why in Table 11 no numbers are given).

Stancu (1978, p. 338) assigned *Creseis spina* to the genus *Styliola*. She remarked that Kittl (1886, p. 51) was not confident of the generic assignment either. Kittl had five specimens before him from Reuss's material and identified by him as *Cleodora (Creseis) spina* and *Cleodora (Creseis) subulata*. The latter is a synonym of the Recent *Styliola subula* (Quoy & Gaimard, 1827) (see van der Spoel, 1967, p. 63). Stancu remarked that Reuss's *Cleodora (C.) spina* lacked the protoconch. However, Reuss's fig. 9 (on pl. 6) does show the protoconch, and two original specimens surviving do so as well. It is quite possible that Stancu did examine the original material at Vienna, since A.W. Janssen (1984b, pp. 66, 67) pointed out that the samples of *C. spina* and *C. subulata* had been inadvertently switched. The specimens of *C. subulata* lack protoconchs; as they are very much deteriorated a proper placement is impossible. It seems to me that both forms are conspecific, as Kittl, Checchia-Rispoli (1921, p. 8) and Sirna (1968, p. 420) considered likely. Why Kittl interpreted the specimens of *C. subulata* to be embryonic shells remains a matter of conjecture. The doubts expressed by A.W. Janssen (1984b) over such an association are such that Reuss described the specimens of *S. subula* as 'unten scharf zugespitzt' and that they show a larger apical angle. That a species may be described as pointed and in fact only the protoconch is broken off has already been demonstrated with *Vaginella depressa* (see A.W. Janssen, 1985, p. 200). In any case, all specimens lack the oblique ridge dorsally which is typical for *Styliola*.

In comparison with Recent species *C. spina* is close to *Creseis chierchiae* (Boas, 1886) forma *constricta* Chen & Bé, 1964 as far as the protoconch is concerned (Pl. 5, Figs 7-12, 22; Pl. 12, Fig. 1). This forma represents smooth variants of *C. chierchiae* (see A.W. Janssen, 1990b), which, however, show larger apical angles (20°) and a shorter teleoconch than *C. spina*. A.W. Janssen (1990b, pl. 5, figs 1-4; pl. 12, fig. 1a-b) described *f.* cf. *chierchiae* from the Australian Early and Middle Miocene and gave protoconch dimensions of this and Recent f. *constricta*. The Miocene specimens show larger dimensions. The values for the Austrian specimens of *C. spina* are between both groups, but are markedly closer to the Recent specimens. My own measurements on *C. chierchiae* forma *constricta* confirm the strong resemblance between this species and *C. spina*. The former shows, however, more variation in protoconch proportions. The larval shell may appear hardly swollen; in such a case the protoconch is also longer (Pl. 5, Figs 11, 12).

n = 6	min.	max.	R	x̄
lP	0,381	0,482	0,101	0,425
wE	0,058	0,065	0,007	0,063
wL	0,125	0,155	0,030	0,138
wC	0,116	0,143	0,027	0,127
lP/wL	2,458	3,795	1,337	3,111
wL/wE	2,016	2,385	0,369	2,199
A	17,5°	22°	4,5°	19,833°

Table 11. Protoconch dimensions and apical angles of *Creseis chierchiae* forma *constricta*.

Amongst fossil forms *C. hastata* (Meyer, 1886) is very close to *C. spina* (see *Creseis* sp. 1). In the Paratethys, apart from *C. spina*, only *C. olteanui* Stancu, 1978 occurs (in the Rumanian Early Badenian). This species is easily separated from *C. spina*: it is, especially anteriorly, transversely ribbed and the protoconch shows a larger lP/wL ratio. The larval shell attaches to the embryonic shell without a special swelling. *Creseis borodiana* Pauca, 1969 and *C. fuchsi* Kittl, 1886 are no pteropods, but proved to belong to freshwater species of the genus *Orygoceras* Brusina, 1882 (see Stancu, 1978, p. 338; Lőrenthey, 1903a).

Krach (1981, p. 123, pl. 1, fig. 14; pl. 6, figs 9, 10) illustrated *Vaginella lapugyensis* Kittl, 1886 from the Badenian of Poland, which resembles *C. spina* (see also A.W. Janssen, 1984b, p. 67) and is in need of a direct comparison.

D'Alessandro & Robba (1980, p. 627) referred the specimens of Sirna (1968) and d'Alessandro *et al.* (1979) from San Nicola Varano to the slender *V. lapugyensis* Kittl, 1886, as the specimens display the characteristic lateral carinae, which never occur in *Creseis*. It is possible that Checchia-Rispoli's (1921) specimens belong to *L. lapugyensis* as well, which would imply that *C. spina* was restricted to the Paratethys.

An occurrence in the same stratigraphic level as Walbersdorf in the Czechoslowakian part of the Vienna Basin is implied from Toula (1900, p. 17), who recorded *V. lapugyensis* from Neudorf an der March (now Devinská Nová Ves), although the description of the protoconch matches *C. spina* better. After repeated examination of the handwritten label of the material from Neudörfl, which was initially considered to belong to the locality of the same name in the Burgenland (Zorn, in press), I have to refer this sample which yielded *C. spina* to the Czechoslowakian claypit of Neudorf.

This is the first record of *C. spina*, and in fact of the genus *Creseis*, from Austria.

Extra-Austrian distribution — Paratethys: Middle Miocene: Poland [Badenian, Wielician], Rumania [Badenian, Wielician]. Mediterranean area: ? Italy [Middle Miocene].

Creseis sp. 1
Pl. 5, Figs 19, 20

Material — Oligocene:
— Egerian, Lower Puchkirchen Group: Treubach 1, K4/1502-1506m (2 specimens), coll. NHMW-GP (registr. no. 1990/1329/1).

Description — These are pyritic casts of a protoconch with the youngest part of the teleoconch and a posterior fragment of the adult shell. The protoconch resembles that of *C. spina*, in that it is also distinctly separated from the teleoconch, but it is more voluminous. The tip is broken off. The adult shell is, just as in *C. spina*, narrow, conical and with circular cross section. But here again the larger dimensions must be noted. The junction with the teleoconch is substantially wider.

Dimensions — Protoconch, wL=0,192 mm, wPT= 0,179 mm, angle of the teleoconch junction=15°, teleoconch, A=13°.

Remarks — Specimens resembling *C. spina* were recorded by A.W. Janssen (1984b, p. 67) from the Oligocene and Miocene of the Aquitaine Basin (France), but these are stated to have smaller apical angles. These specimens and material from the Pliocene are also described as similar to *C. chierchiae* (see A.W. Janssen, 1990b).

Lozouet & Maestrati (1982, p. 183, fig. 8) recorded *C. hastata* (Meyer, 1886) from the Stampian of the Aquitaine Basin (Gaas). Their figure shows a strong resemblance between this species and *C. spina*, especially in its posterior third. The Austrian specimens of *C. spina* are unfortunately badly crushed in their upper two thirds. This may account for the fact why they appear wider than *C. hastata*. The latter species occurs also in the Early Oligocene (Meyer, 1886, p. 78, pl. 3, fig. 11; MacNeil & Dockery, 1984, p. 243, pl. 66, figs 6-13, 15-18) and the Late Eocene of Mississippi (Collins, 1934, p. 204, pl. 9, fig. 1; pl. 13, figs 1, 2). It may be conspecific with our Late Oligocene specimens. Curry (1981, p. 43, pl. 1, fig. 14a-e) recorded *C.* cf. *hastata* from the Early and Late Eocene of SW France.

Familia Cavoliniidae Fischer, 1883
Subfamilia Cavoliniinae van der Spoel, 1967
Genus *Clio* Linné, 1767

Diagnosis — Shell with more or less triangular cross section, dorsoventrally flattened, largest width at the aperture, strong lateral keels, aperture and cross section lenticular to triangular, generally with a few

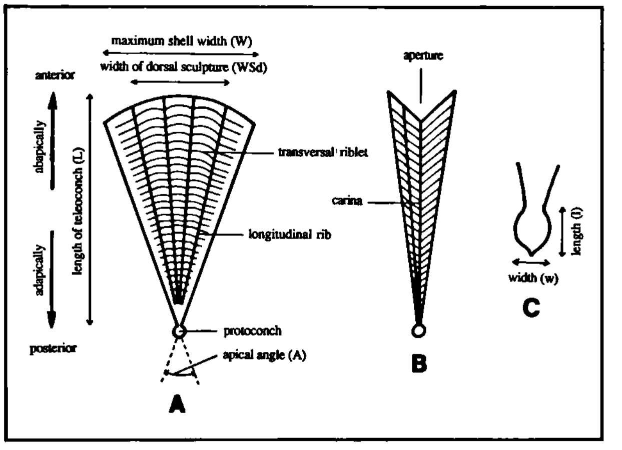


Fig. 8. Characters of the genus *Clio*.
A, B — dorsal and lateral views of entire shell, respectively
C — protoconch.

longitudinal ribs with varying numbers on dorsal and ventral sides, often transversely ribbed, occasionally with spines at the aperture. Protoconch oval to spherical and in some species with distinct tip, otherwise rounded.

Type species — *Clio pyramidata* Linné, 1767.

Stratigraphical range — Late Eocene-Recent.

Clio triplicata Audenino, 1896
Pl. 8, Fig. 7-9; Pl. 13, Fig. 3-8

* 1896 *Clio triplicata* Audenino, p. 106, pl. 5, fig. 4a-e.
1900 *Clio triplicata* Aud. — Verri & de Angelis d'Ossat, p. 271.
. 1904 *Cleodora triplicata* (Aud.) — Sacco, p. 13, pl. 4, fig. a-e (copied from Audenino).
. 1905 *C. trigona*, Seguenza — Bellini, p. 37 [*partim*], figs 31, 32.
v. 1924 *Balantium*. — Abel, p. 186, fig. 274.
v. 1968 *Clio* cf. *triplicata* Audenino, 1897 — Čtyroký, p. 95, figs 1, 2, pl. 1, figs 1-6.
v. 1968 *Clio* cf. *triplicata* Audenino — Čtyroký *et al.*, p. 133, pl. 4, fig. 14.
. 1972 *Clio triplicata* Audenino, 1899 — Robba, p. 496, pl. 58, figs 12, 13; pl. 59, figs 1-7.

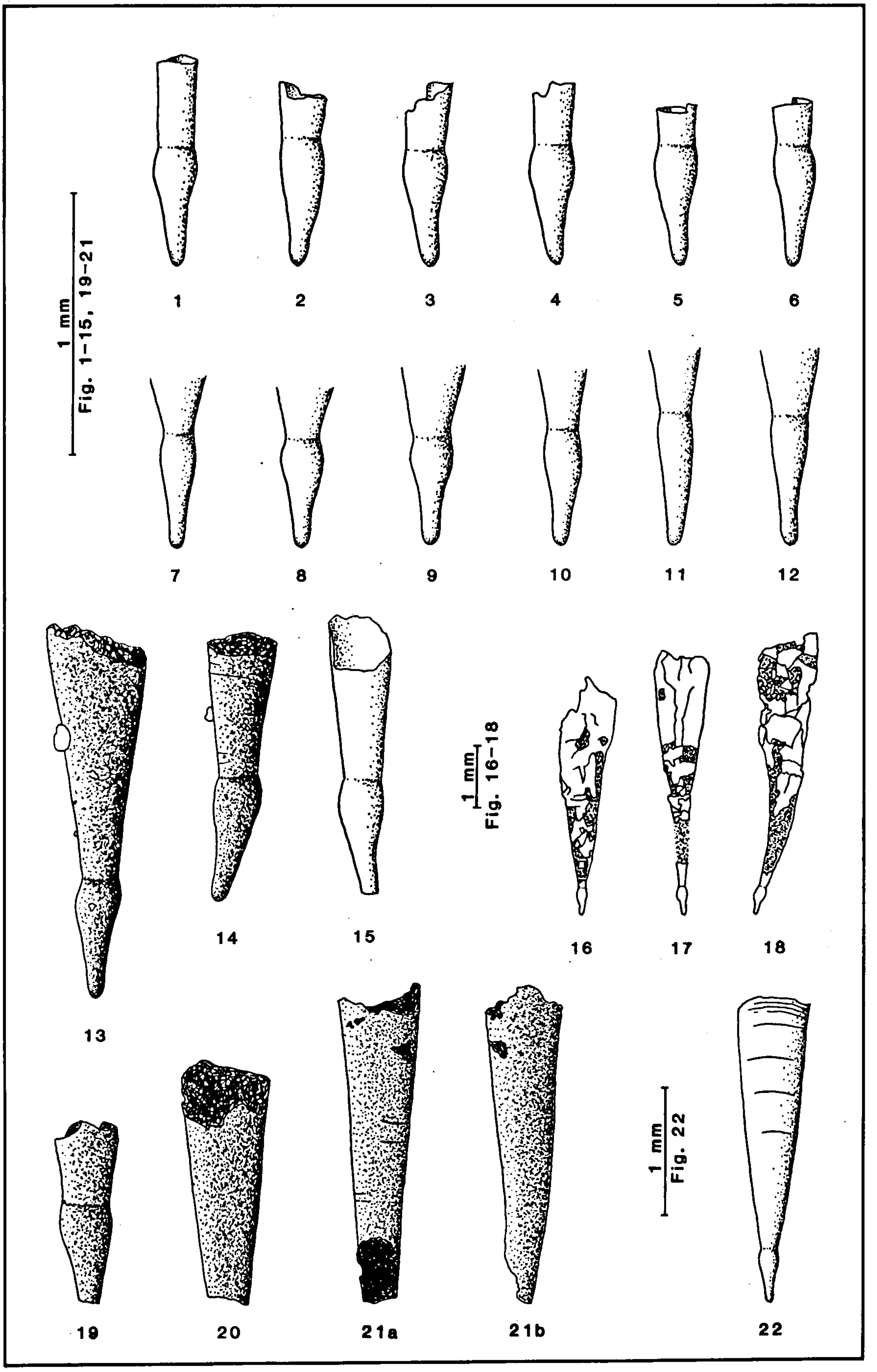
PLATE 5

Figs 1-6,13-18, 21. *Creseis spina* (Reuss, 1867).
1-6, 15-18: Walbersdorf, NHMW-GP (registr. no. 1990/1312/1-2), Badenian [Bulimina-Bolivina Zone], 1-6, and 15 are protoconchs, 16-18 are entire shells. 13, 14: Wieliczka, Poland, NHMW-GP (registr. no. 1867.VII.40), Badenian [Wielician], 13 is the lectotype, 14 is the only paralectotype. 21a-b: pyritic cast, Marzer Kogel, NHMW-GP (registr. no. 1990/1313/2), of Badenian age found reworked in Sarmatian strata, dorsal and lateral views.

Figs 7-12, 22. *Creseis chierchiae* (Boas, 1886) forma *constricta* (Chen & Bé, 1964).
SW of Salayer, Indonesia, NHMW-GP (registr. no. 1990/1333/1), Recent. 7-12: protoconchs, 22: entire shell.

Figs 19, 20. *Creseis* sp. 1.
Treubach 1 (K4/1502-1506 m), NHMW-GP (registr. no. 1990/1329/1), Egerian [Lower Puchkirchen Group], 19: protoconch, 20: part of teleoconch.

PLATE 5


1 mm
Fig. 1–15, 19–21
1
2
3
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12
13
14
15
1 mm
Fig. 16–18
16
17
18
19
20
21a
21b
1 mm
Fig. 22
22

v. *1973* *Clio* cf. *triplicata* Audenino, 1896 — Steininger *et al.*,p. 450.

non 1983 *Clio triplicata* Audenino, 1899 — Spano, p. 264, pl. 20, figs 1-8.

Material — Miocene:

— Eggenburgian, Haller Group, Haller Formation: Feyregg brook near Bad Hall, coll. NHMW-GP (leg. Steininger, 1976, registr. no. 1990/1323/1-2, leg. Zorn & Tanzer, 1989, registr. no. 1990/1324/1-2); Bad Hall (dig of well 1906), coll. PI (ex coll. Abel, registr. no. 2717); Bad Hall 1 (K1/14,0-15,2m), coll. RAG; Fraham 1 (K1/970-988m), coll. RAG, Gilgenberg 1 (K1/1156-1174m), coll. RAG; Geretsberg 1 (K2/1092,5-1095m, K4/1323-1325,5m), coll. RAG; Neukirchen 1, (K1/1024-1027,5m), coll. RAG; Perwang 1 (K2/1069-1072m), coll. NHMW-GP (registr. no. 1990/1341/1); Puchkirchen 1, (K1/500-505m, K2/589-594m, K4/800,5-806m), coll. RAG; Wartberg 4 (73,5m, 87,7-90,4m), coll. PI (registr. no. 2711/1, 3); Welser Heide 1 (406,4-410m), coll. GBA (registr. no. 1990/7); Zehrmühle 11, (139,9-140,1m, 3 specimens; 119m, 1 specimen), coll. PI (registr. no. 2712/1-2). — Ottnangian, Innviertel Group, Ottnang Formation: Ottnang-Schanze, coll. GBA (registr. no. 1990/7).

Description — *Clio triplicata* has a pointed, triangular shell with a mean apical angle of 52°. Both lateral sides are often slightly concave. The width equals 4/5 of the length. Dorsally three ribs run from the tip of the shell to the aperture and increase in width together with the shell. Near the tip these ribs are weakly separated from each other. They equal 3/4 of the shell width. The middle rib is in some specimens slightly stronger developed. Ventrally there is a single broad rib, which equals 2/5 of the shell width. This also becomes wider with shell growth. Faint indications of transverse ribs are visible in a single specimen on the lateral side next to the longtudinal rib. The apertural margin on both sides is abapically convex, the cross section of the aperture and the shell cannot be seen on account of the crushing. The tip with the protoconch shows a dorsal curvature. The latter has a near-circular cross section (Pl. 8, Fig. 9; Pl. 13, Fig. 5). Often the growth lines, running parallel to the aperture, are easily seen.

Dimensions — See Table 12.

Remarks — In Table 12 all measurements of 50 specimens are shown. It was only rarely possible to measure all dimensions of a single specimen.

	min.	max.	R	$\bar{x}$	s	V
L	5,18	12,02	6,84	8,04	2,07	25,71
W	4,82	6,91	2,09	5,85	0,66	11,33
L/W	1,07	1,31	0,24	1,20	0,10	8,59
WSd	3,24	5,83	2,59	4,00	0,73	18,27
W/WSd	1,38	1,73	0,35	1,53	0,10	6,85
A	37°	57,5°	20,5°	51,75°	3,95	7,63

Table 12. Dimensions of *Clio triplicata.*

Up to now all material from the Paratethys was referred to in the literature as *Clio* cf. *triplicata,* as there was no mention of the ventral side with the single broad rib (Čtyroký, 1968). However, this rib could be demonstrated in two specimens (Pl. 8, Fig. 7; Pl. 13, Fig. 4). That it is so rarely seen, is preservational matter. The specimens are often so badly crushed that indeed an extremely thin layer of sediment is present between both shell sides. This means that on one side the ventral rib is broken and on the other the dorsal relief is pressed on to the ventral side. In this way, it may appear as if only the dorsal side with three ribs were present, or imply similarly constructed dorsal and ventral sides (Abel, 1924).

That these, in fact, are not the dorsal sides, is readily apparent from the fact that growth lines with different courses may be observed. Dorsally these are more curved. In the curvature of the aperture this distinction should be apparent as well, but this cannot be ascertained due to poor preservation.

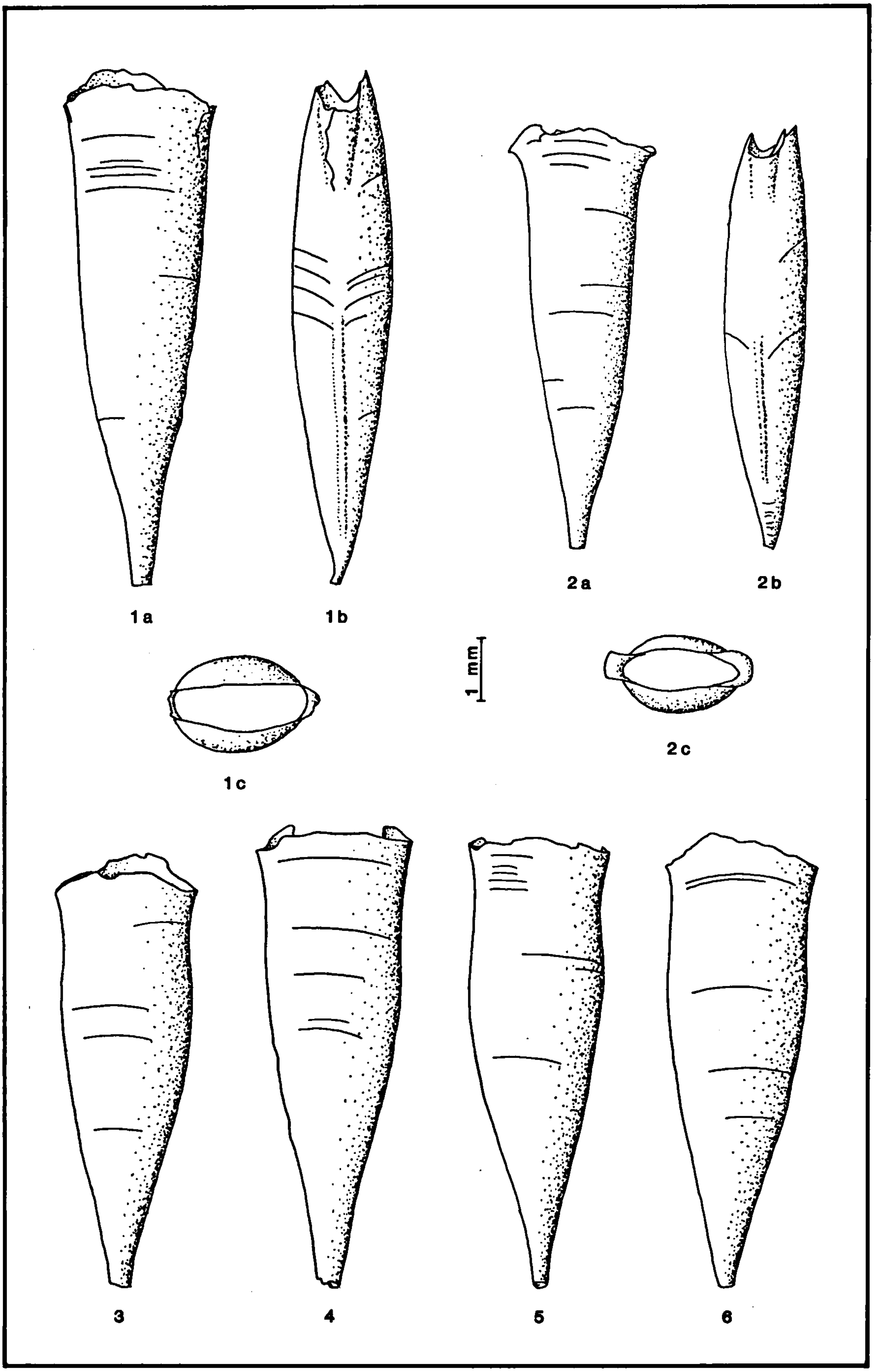
Audenino (1896) and Robba (1972) mentioned a shallow depression on the middle ventral rib, or two weak ribs. One of the Austrian specimens has, however, a single rib, and another specimen shows a very faint indication of a rib. It may be assumed that this is a preservational matter.

From the Miocene to the Recent many species of *Clio* occur with three dorsal and one ventral rib. *Clio trigona* (Seguenza, 1867) is most similar to the present species, to such an extent that they may be assumed conspecific, which would mean that Seguenza's name has priority. *Clio sinuosa* (Bellardi, 1872) also shows a strong resemblance, *i.e.* the L/B ratio is identical. Robba (1977) discussed the differences between both species: most conspicuous are

PLATE 6

Figs 1-6. *Vaginella austriaca* Kittl, 1886.
1-2: Baden, NHMW-GP (registr. no. 1990/1297/1, 1990/1299/1), Badenian [Upper Lagenidae Zone], 1: lectotype, 2: paralectotype, a - dorsal in Fig. 1, ventral in Fig. 2, b - lateral, c - apertural views. 3, 4, 6: Bad Vöslau, NHMW-Z (Edlauer collection, registr. no. 3345/1, 5, 10), Badenian [Upper Lagenidae Zone]. 5: Bad Vöslau, NHMW-GP (registr. no. 592/1964), Badenian [Upper Lagenidae Zone].

PLATE 6



the distinct transverse ribs in *C. sinuosa*. In addition, the ventral rib is comparatively wider and the lateral margins are hardly concave. *Clio sulcosa* (Bellardi, 1873) differs in having divided lateral ribs.

In the Haller Schlier often mass occurrences of *C. triplicata* (Pl. 13, Fig. 8) are found.

Extra-Austrian distribution — Paratethys: Miocene: Germany [Eggenburgian], Czechoslovakia [Eggenburgian]. Mediterranean area: Italy [Oligocene, Chattian; Miocene, Burdigalian, Langhian].

Clio sp. 1
Pl. 8, Fig. 6; Pl. 13, Figs 1, 2

Material — Miocene:

— Egerian, Upper Puchkirchen Group: Linz-Ebelsberg (Weikerlsee), coll. NHMW-GP (leg. Steininger, Rögl & Vavra, registr. no. 1978/2004, 2 specimens).

Description — These are two badly crushed specimens of a large species of *Clio*. The shell outline is near-triangular, the apical angle being *c* 38°. Both lateral margins appear to have an angular cross section and are especially posteriorly slightly convexly curved, which is why the width increases more rapidly in the younger shell part. The shell length is *c* 2/3 larger than its width.

In one of the specimens (Pl. 8, Fig. 6; Pl. 13, Fig. 1) possibly the inner view of the dorsal side is represented. An artificial cast reveals a median, flat and wide rib and on both sides an even flatter rib, which is half as wide and hardly separated from the outer flat shell part. This may be due to crushing. In addition, the shell surface is ornamented with strongly raised, transverse, adaperturally curved ribs, which are separated by comparatively wide interspaces and do not vary markedly in width and distance. On 1 cm shell length *c* 22 of such ribs may be counted. Shortly before reaching the shell margins they efface and run slightly flexuous. The aperture is badly visible and is apparently parallel to the ribs. Growth lines are not visible. Whether the second specimen, which shows the outer surface (Pl. 13, Fig. 2) represents the dorsal or the ventral side is even more difficult to determine, as it is badly crushed, to such an extent that longitudinal ribs cannot be recognised. The transverse ribs in the posterior half of the shell are not recognisable either. The margins of this specimen are hardly curved. A protoconch is not preserved in either specimen.

L	12,38	12,96
W	7,49	8,35
L/W	1,65	1,55
A	37°	38°

Table 13. Dimensions of *Clio* sp. 1.

Dimensions — See Table 13.

Remarks — *Clio nielseni* A.W. Janssen, 1990a from the Danish Late Oligocene differs in only few respects from the Austrian species: its apical angle is somewhat smaller (32°), the lateral margins are straight and the three dorsal ribs are equally broad. The number of transverse ribs in this species is 25 per cm shell length. *Clio guidottii* Simonelli, 1896 is also very similar. It shows, unlike *C. nielseni*, convex sides and a median rib which is broader than the lateral ribs, but it is substantially larger (max. 36 mm), has a smaller apical angle and has only *c* 10 transverse ribs per cm shell (A.W. Janssen, 1990a). A.W. Janssen, in his comparison of *C. nielseni* with *C. guidottii* pointed out the younger age of the latter, which he showed to be Pliocene.

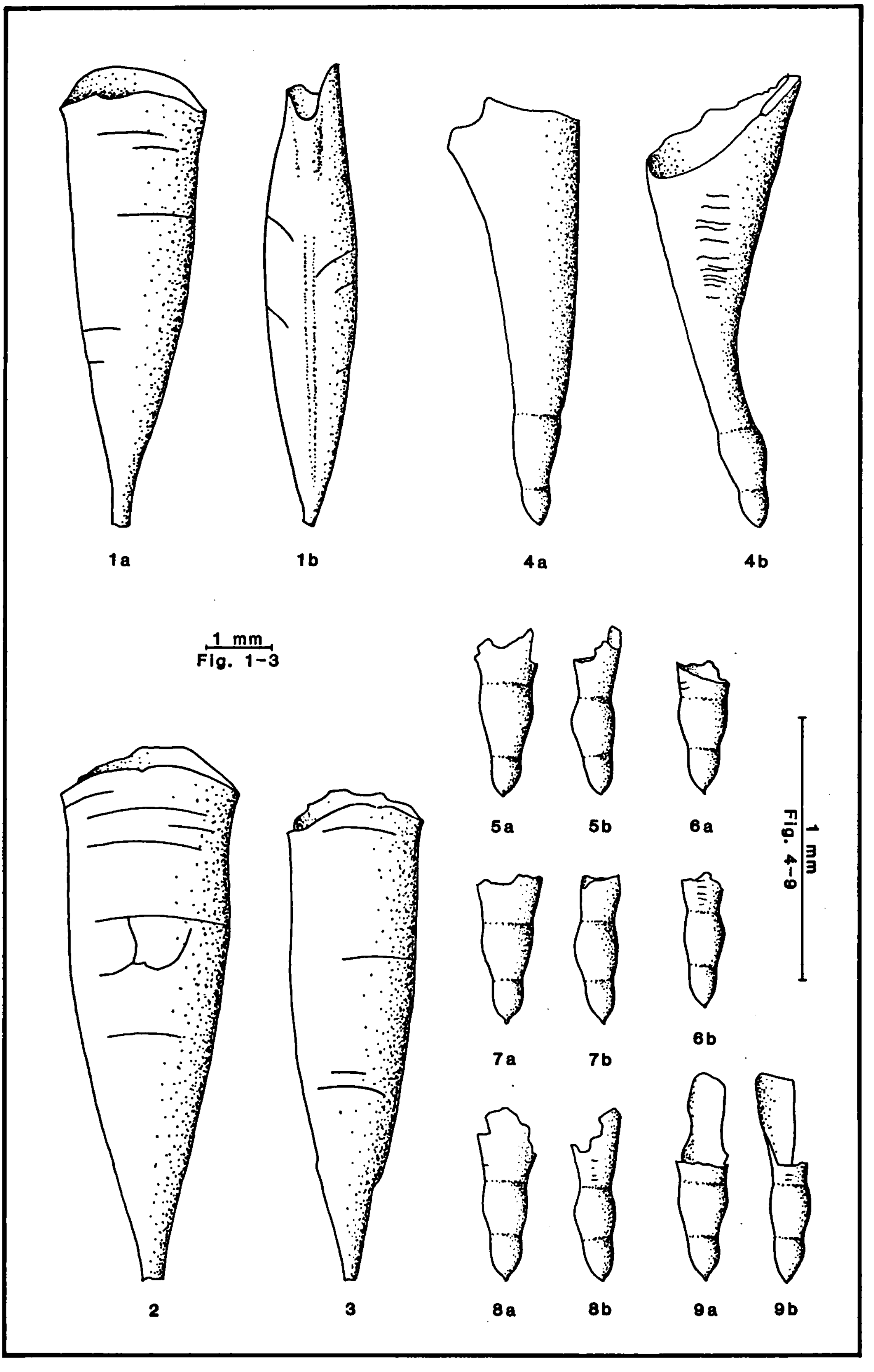
Robba (1977, p. 595, pl. 20, fig. 4; pl. 21, fig. 1) described *Clio* from the Serravallian and identified it as *C. guidottii*. This specimen was interpreted by A.W. Janssen (1990a) to be intermediate between *C. nielseni* and *C. guidottii*. The presence on Robba's specimens of 16 transverse ribs per cm lends support to this interpretation. The Austrian species, of earliest Miocene age, would fit well into such an evolutionary lineage with 22 ribs.

Clio lavayssei Rutsch, 1934 from the Early Miocene of Trinidad (Rutsch, 1934) and the Oligocene-Early Miocene of Italy (Bernasconi & Robba, 1982) does correspond with the Austrian form stratigraphically, but has only a single rib dorsally.

PLATE 7

Figs 1-9. *Vaginella austriaca* Kittl, 1886.
1: paralectotype, Baden, NHMW-GP (registr. no. 1990/1298/1), Badenian [Upper Lagenidae Zone], dorsal and lateral views. 2: Bad Vöslau, NHMW-GP (registr. no. 1990/1302/22), Badenian [Upper Lagenidae Zone], dorsal view. 3: Bad Vöslau, NHMW-Z (Edlauer collection, registr. no. 3345/4), Badenian [Upper Lagenidae Zone], dorsal view. 4: protoconch, Bad Vöslau, NHMW-GP (registr. no. 1990/1300/1), Badenian [Upper Lagenidae Zone], dorsal and lateral views. 5-9: protoconchs, Laa an der Thaya, NHMW-GP (registr. no. 1990/1316/1-2), Karpatian [Laaer Formation], a - dorsal views in Figs 5, 7, and 8, ventral views in Figs 6, and 9, b - lateral views.

PLATE 7



Clio pedemontana (Mayer, 1868) differs in having straight lateral margins and in lacking all longitudinal ribs, whereas *C. berglundi* Squires, 1989 does not show any transverse sculpture in its apical part.

Of Recent species, *C. recurva* (Children, 1823), which is the largest species, is most similar. However, its three dorsal ribs are nearly equally strong and the shell increases more gradually in width.

Whether the present species is a new taxon or is conspecific with *C. nielseni* may only be determined with additional material. In such a case it would be interesting to assess the morphology of the ventral side and the range of variation in the width of the longitudinal ribs and the convexity of the lateral margins.

Sieber (1953, pp. 374, 376) already recorded from the Oligocene 'Schlier' of Upper Austria a species of *Clio* which is reported to be larger than the Miocene form *(C. triplicata* is meant here). This might well be the same form. Unfortunately, Sieber did not give locality details, which precludes a restudy.

Clio sp. 2
Pl. 9, Fig. 2

v. 1968 *Vaginella austriaca* Kittl — Čtyroký *et al.*, p. 133 [*partim*], pl. 4, fig. 9.

Material — Miocene:
— Badenian, ULZ: Bad Vöslau, coll. NHMW-GP (registr. no. 1990/1304/1; 1 specimen).

Description — The single specimen available shows apart from the protoconch only the older part of the adult shell. The protoconch has a spherical embryonic shell, showing a distinct tip, and separated from the teleoconch by a sharp constriction. This corresponds to the larval shell. At the shell tip the upper shell layer is partially missing. Laterally it is seen that the protoconch joins the teleoconch without inclination. The latter is sack-like, straight in the older part and, just like the protoconch, of circular cross section, but in the upper part with a slight dorsal curvature. Here the cross section is already lenticular and indicates the dorsoventral flattening which is typical of *Clio*. Lateral carinae are not yet developed in this part of the shell.

Dimensions — Protoconch: l=0,277 mm, w=0,235 mm, l/w= 1,179, teleoconch: A=28.5°.

Remarks — This is the only record of *Clio* in the Austrian Middle Miocene. It cannot be referred to any of the known fossil species, as protoconchs are poorly known (di Geronimo, 1974: *C. pulcherrima*; A.W. Janssen, 1989: *C. blinkae*, *C. pauli*, *C. irenae*; A.W. Janssen, 1990a: *C. nielseni*). Most similar is the protoconch of the modern species *Clio cuspidata* (Bosc, 1802) (Pl. 9, Fig. 1; Pl. 12, Fig. 3), which is only slightly larger. It has a protoconch with an extremely long apical spine, which, however, is often broken off. The imperfect preservation of the apical part of *Clio* sp. 2 explains the lesser l/w ratio in comparison with specimens of *C. cuspidata*, of which the spines are broken off.

In the Paratethys *C. fallauxi* Kittl, 1886, *C. pedemontana* Mayer, 1868 (see Stancu, 1974; Krach, 1981) and *C. carinata* Audenino, 1896 (see Stancu, 1974) are recorded from the Badenian. The present protoconch might belong to one of these species. A difference in protoconch volume alone is not conclusive, as such a difference was observed in *C. pyramidata* and considered to be brought about by temperature fluctuations. The volume increases under low temperatures, since in colder areas larger eggs are produced and the veliger stage is suppressed (Biekart, 1989).

Genus *Vaginella* Daudin, 1800

Diagnosis — Shell elongate, sheath-like, dorsoventrally more or less flattened, in the older part rapid-

PLATE 8

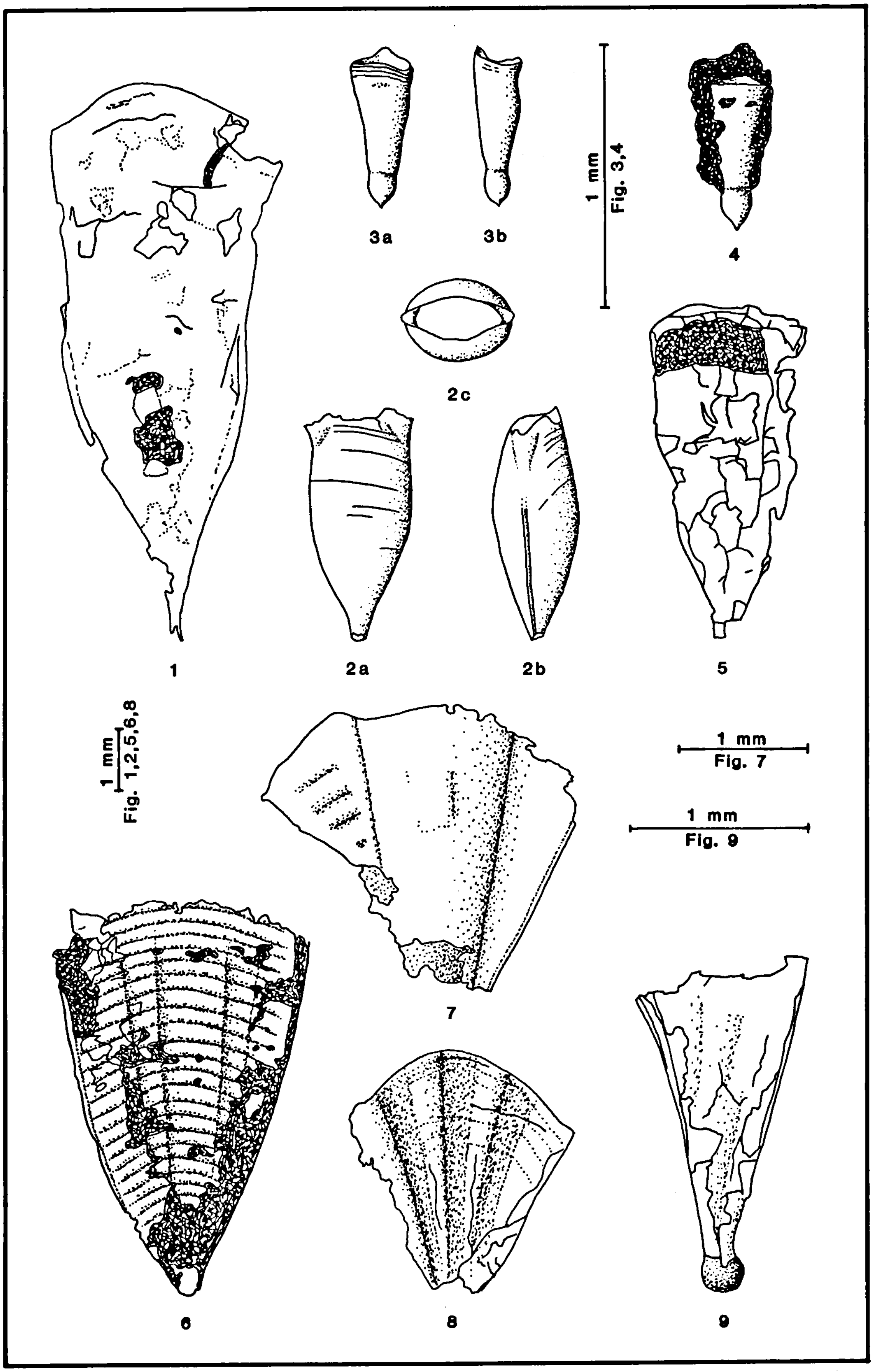
Figs 1, 2. *Vaginella depressa* Daudin, 1800.
1: Wartberg 4 (83,6 m), PI (registr. no. 2711/2), Eggenburgian [Haller Group, Haller Formation], badly crushed specimen. 2a-c: Forchtenau, NHMW-GP (registr. no. 1990/1306/1), Badenian [Spiroplectammina Zone], dorsal, lateral, and apertural views.

Figs 3-5. *Vaginella* sp. 1.
Walbersdorf, NHMW-GP (registr. no. 1885.XVII.137), Badenian [Bulimina-Bolivina Zone], 3a-b, 4a-b: protoconchs, dorsal and lateral views. 5: badly crushed teleoconch.

Fig. 6. *Clio* sp. 1.
Linz-Ebelsberg, Weikerlsee, NHMW-GP (registr. no. 1978/2004), Egerian [Upper Puchkirchen Group].

Figs 7-9. *Clio triplicata* Audenino, 1896.
7: Pfarrkirchen near Bad Hall, Feyregg brook, NHMW-GP (registr. no. 1990/1324/2), Eggenburgian [Haller Group, Haller Formation], ventral view. 8: Zehrmühle 11 (139,9-140,1m), PI (registr. no. 2712/2), Eggenburgian [Haller Group, Haller Formation], inner dorsal view. 9: Wartberg 4 (73,5m), PI (registr. no. 2711/1), Eggenburgian [Haller Group, Haller Formation], protoconch.

PLATE 8


1
2a
2b
2c
3a
3b
4
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1 mm
Fig. 3,4
1 mm
Fig. 1,2,5,6,8
1 mm
Fig. 7
1 mm
Fig. 9

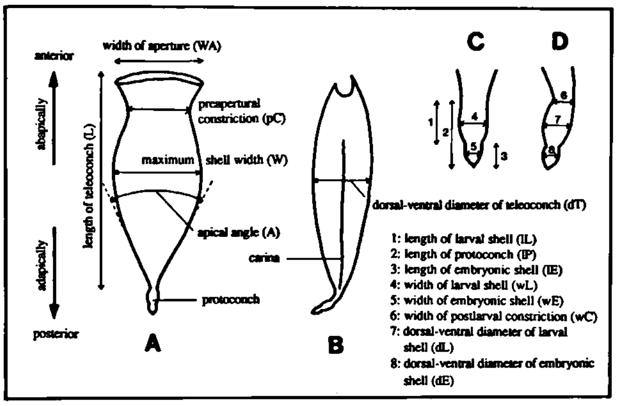


Fig. 9. Characters of the genus Vaginella.
A, B - dorsal and lateral views of entire shell, respectively
C, D - dorsal and lateral views of protoconch, respectively.

ly, then more slowly increasing in width and, occasionally, a subsequent partial decrease in the form of a pre-apertural constriction. Lateral, rounded carinae, which may be of different lengths, aperture slit-like, extended at the margins, occasionally with folds running parallel to shell axis, but otherwise shell without ornamentation. Protoconch generally well separated from teleoconch, joining it in an even plane or ventrally inclined, embryonic shell with apical spine, cup-shaped, larval shell dorsoventrally flattened, generally elongate.

Type species — *Vaginella depressa* Daudin, 1800.

Stratigraphical range — Oligocene-Late Miocene.

Vaginella austriaca Kittl, 1886

Pl. 6, Figs 1-6; Pl. 7, Figs 1-9; Pl. 12, Figs 4, 5; Pl. 14, Figs 1-8; Pl. 16, Figs 1-4

. *1849* *Creseis vaginella* — Hörnes *in* Czizek, p. 16.
v. 1856 *Vaginella depressa* Daud. — Hörnes, p. 663, pl. 50, fig. 42a.
? *1866* *Vaginella depressa* — Suess, p. 131.
? *1877* *Vaginella depressa* Daud. — Karrer, pp. 139, 176.
*v 1886 *Vaginella austriaca* Kittl, p. 54, pl. 2, figs 8-12.
? *1888* *Vaginella depressa* Daud. — Handmann, p. 142.
1904 *Vaginella austriaca* Kittl. — Sacco, p. 15, pl. 4, fig. 11.
. 1921 *Vaginella austriaca* Kittl. — Checchia-Rispoli, p. 13, fig. 5,a.
. 1934 *Vaginella floridana* Collins, p. 216, pl. 13, figs 22, 23.
1942 *Vaginella depressa* var. *austriaca* Kittel — Toth, p. 512.
. 1949 *Clio vrázi* Vasicek, p. 35, fig. 1; pl. 1, figs 2a-b, 3.
? 1951 *Vaginella depressa* — Tauber, p. 61, pl. 1, fig. 25.
? *1956* *Vaginella depressa* Daud. — Sieber, p. 246.
. 1956 *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 [*non* fig. 9].
. 1968 *Vaginella austriaca* Kittl, 1886 — Sirna, p. 423, fig. 10.
. *1970* *Vaginella austriaca* Kittl — Papp *et al.*, p. 31.
. 1971 *Vaginella austriaca* Kittl, 1886 — Robba, p. 86, pl. 3, figs 12-17.
. *1973* *Vaginella depressa* Daudin, 1800 — Steininger *et al.*, p. 450.
. 1974 *Vaginella austriaca* Kittl, 1886 — Stancu, p. 188, pl. 2, figs 1a-b, 2, 5, 6; pl. 3, figs 1a-b, 2-9.
. *1975* *Vaginella austriaca* — Steininger *et al.*, p. 16.
. 1977 *Vaginella austriaca* Kittl, 1886 — Robba, p. 587, pl. 17, figs 1-4; pl. 18, fig. 4.
1978 *Vaginella austriaca* Kittl, 1886 — Robba & Spano, p. 762-764, pl. 76, fig. 4.
1979 *Vaginella austriaca brevior* Krach, p. 655, fig. 1.
. 1979 *Vaginella austriaca* Kittl, 1866 — d'Alessandro *et al.*, p. 85, pl. 15, fig. 25; pl. 16, figs 21-35.
. 1980 *Vaginella austriaca* Kittl, 1886 — d'Alessandro & Robba, p. 620, 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, p. 5-6, figs 11-14.
. 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.
1983 *Vaginella austriaca* Kittl, 1886 — Spano, p. 255, pl. 16, figs 1-8.
v. 1984b *Vaginella austriaca* Kittl, 1886 — A.W. Janssen, p. 73, pl. 4, figs 1-8.
. 1985 *Vaginella austriaca* Kittl, 1886 — A.W. Janssen, p. 199, figs 8-9.

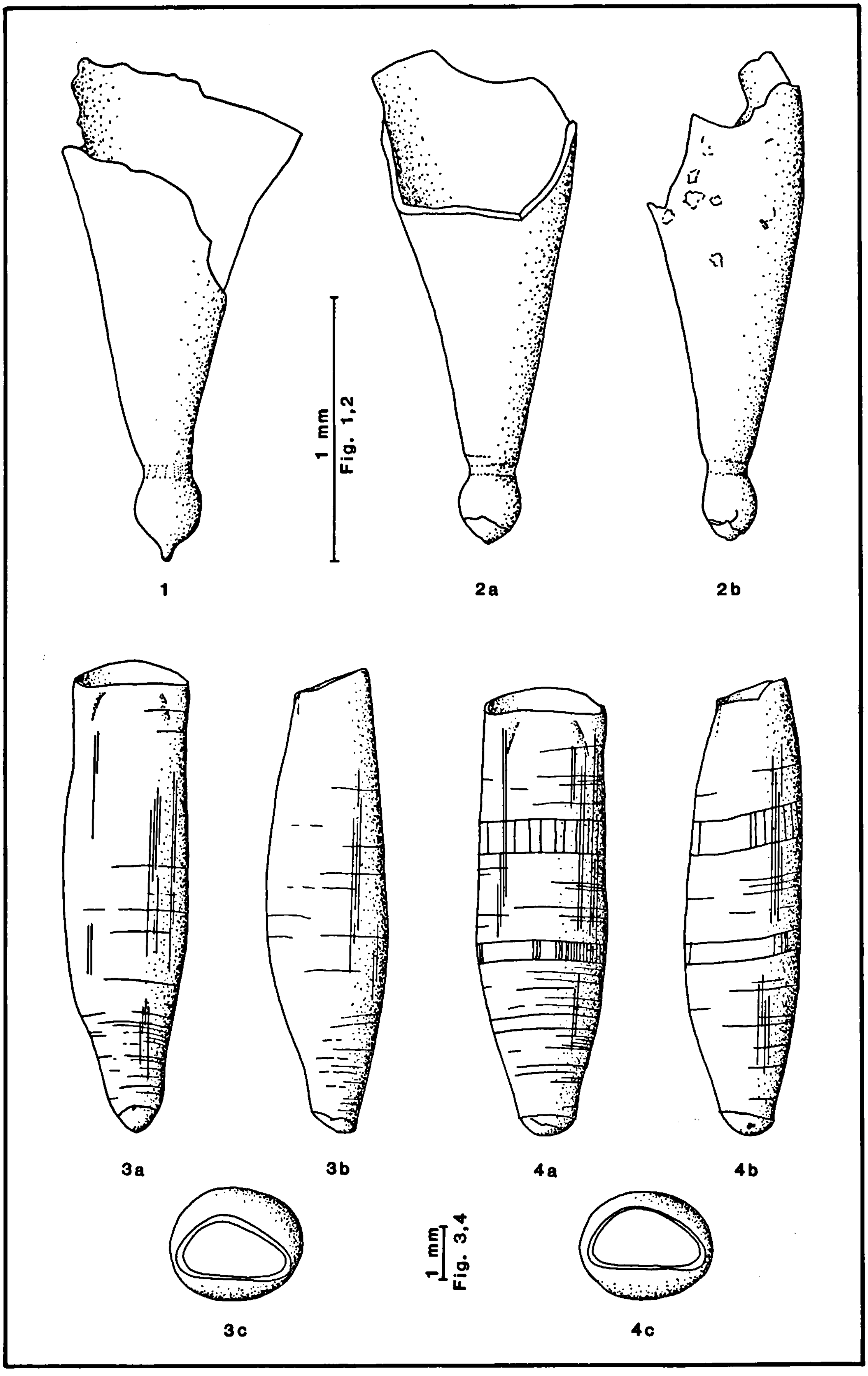
PLATE 9

Fig. 1. *Clio cuspidata* (Bosc, 1802).
Protoconch, Mediterranean sea, S of Crete, 34°43'N 25°51,6'E-34°41,6'N 25°49,9'E, 1626-1433m, Meteor expedition 5/1, station 19 Ku, NHMW-GP (registr. no. 1990/1334/1), Recent, dorsal view.

Fig. 2. *Clio* sp. 2.
Protoconch, Bad Vöslau, NHMW-GP (1990/1304/1), Badenian [Upper Lagenidae Zone], dorsal and lateral views.

Figs 3a-c, 4a-c. *Cuvierina paronai* Checchia-Rispoli, 1921.
Bad Vöslau, Badenian [Upper Lagenidae Zone], 3: Senckenberg Museum Frankfurt (coll. H. Neuenhaus ex Crecelius, registr. no. 48854), 4: NHMW-GP (registr. no. 1990/1302/25), ventral, lateral, and apertural views.

PLATE 9



Material — Miocene:

— Badenian - LLZ: Grund, coll. GBA (1 fragment, registr. no. 1990/7). ULZ - Bad Vöslau, coll. GBA (2 specimens, 2 fragments, registr. no. 1990/7), coll. NHMW-GP (1 specimen, 5 protoconchs, registr. no. 1990/1300/1; 3 fragments, registr. no. 1990/1301/1-3; 4 specimens, 13 fragments, paralectotypes, registr. no. 1851.XIII.17, 1869.I.54, 1866.I.596, 1864.I.141, 1863.XV.1234, 1874.XXIX.53; 16 specimens, 8 fragments, ex coll. Fuchs, registr. no. 1990/1302/1-24; 13 specimens, 12 fragments, 1 cast, ex coll. Chlupač, registr. no. 592/1964; 16 specimens, 18 fragments, 2 casts, registr. no. 1990/1303/1-36), coll. NHMW-Z, coll. Edlauer (11 specimens, 2 fragments, registr. no. E 3345), coll. Senckenberg Museum, Frankfurt (7 specimens, 3 fragments, coll. H. Neuenhaus ex Crecelius, registr. no. 4885a); Sooß, coll. GBA (1 specimen, 7 fragments, registr. no. 1990/7), coll. NHMW-GP (1 specimen, registr. no. 1309/1; 3 specimens, 2 fragments, 1 cast, registr. no. 1863.XV.1199, 1869.I.148, 1872.XXX.87); Baden, coll. GBA (1 specimen, 1 fragment, registr. no. 1990/7), coll. NHMW-GP (2 specimens, 8 fragments, 1 cast, paralectotypes, registr. no. 1864.I.122, 1869.I.233; 1 specimen, lectotype, registr. no. 1990/1297/1; 1 specimen, paralectotype, registr. no. 1990/1298/1; 1 specimen, paralectotype, registr. no. 1990/1299/1); Baden-Sooß, Wienerberger claypit, coll. NHMW-GP (registr. no. 1990/1310/1); Mettersdorf, coll. NHMW-GP (2 specimens, registr. no. 1990/1305/1); Aderklaa 78, 1669,2-1683m (13 specimens), coll. NHMW-GP (registr. no. 1990/1289/1). SZ - Forchtenau, coll. NHMW-GP (1 specimen, paralectotype, registr. no. 1869.I.606; 4 fragments, registr. no. 1866.I.1208).

— Karpatian [Laaer Formation]: Laa an der Thaya, coll. NHMW-GP (a few specimens in pieces of sediment, leg. Sovis, registr. no. 1990/1314/1; 2 specimens, syntypes, registr. no. 1870.I.IV.49; leg. Rögl, 1967, 7 protoconchs, sample no. 18/II/0-0,5m, 11/I/2,5-2,75m, registr. no. 1990/1316/1-2).

— Eggenburgian [Haller Formation]: Pfarrkirchen near Bad Hall, Feyregg brook, coll. NHMW-GP (leg. Steininger, 1976, registr. no. 1990/1323/2).

Description — The dorsoventrally flattened shell is elongate, lance-shaped, apically with an acute angle. The greatest width of the shell is at the aperture and equals 1/3 of the length, its dorsoventral diameter equalling only one fifth. The flattening increases towards aperture. Aperture slit-like and extended at the lateral ends. The dorsal apertural lip projects slightly above the ventral one. On both sides of the shell are slightly thickened keels, which start just above the protoconch and disappear gradually in adapertural direction. In lateral view the shell is straight to slightly curved. Over almost the entire length of the teleoconch the cross section is oval, but it becomes circular in the middle of the posterior half for a short stretch, then towards the tip the dorsoventral diameter becomes larger than wide and just above the protoconch there is another dorsoventral flattening. This part of the shell with the adjoining protoconch shows a ventral inclination. Shell surface with arched growth lines running parallel to the aperture.

The protoconch has a sharp tip and shows two constrictions, one between the embryonic and larval shell, and the other between the larval shell and the teleoconch. In SEM in the first constriction longitudinal ridges and after the second constriction at both sides of the teleoconch horizontal grooves (Pl. 16) may be seen, which decrease in strength dorsally and ventrally and proceed in apertural direction towards the beginning of the carinae. The horizontal grooves are visible in light microscopy as well. The embryonic shell has a near-circular cross section, whereas the larval shell shows a stronger dorsoventral flattening.

Dimensions — See Tables 14, 15 and Fig. 10.

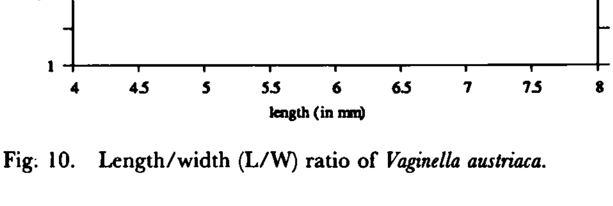


Fig. 10. Length/width (L/W) ratio of *Vaginella austriaca*.

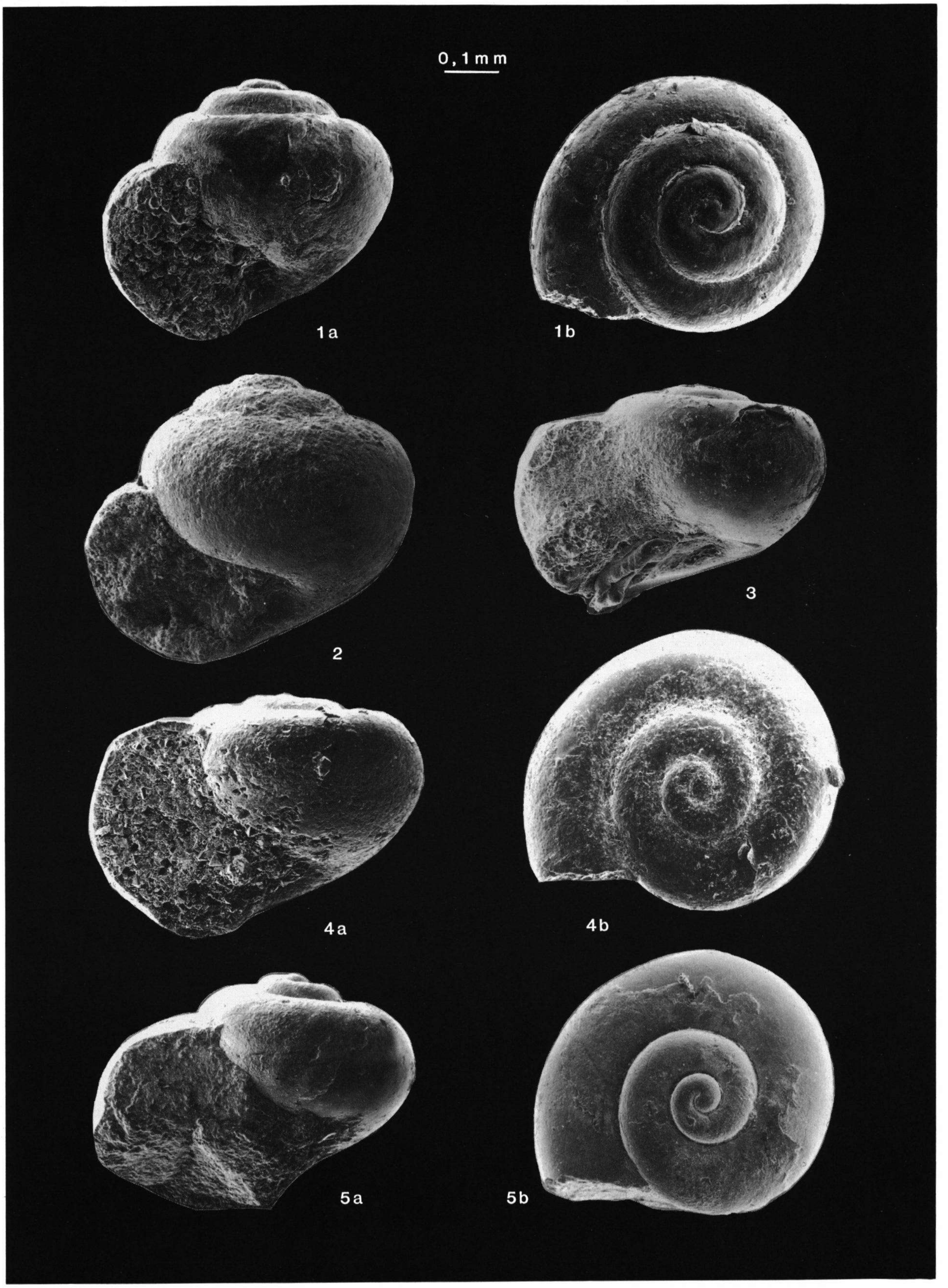
PLATE 10

Figs 1, 2. *Limacina valvatina* (Reuss, 1867).
1a-b: pyritic cast, Aderklaa 85 (1550m), NHMW-GP (registr. no. 1990/1293/6), Badenian [Spiroplectammina Zone], apertural and apical views. 2: pyritic cast, Aderklaa 82 (1460m), NHMW-GP (registr. no. 1990/1290/6), Badenian [Bulimina-Rotalia Zone], apertural view.

Figs 3a-b, 4a-b. *Limacina umbilicata* (Bornemann, 1855). Pyritic casts, Puchkirchen 2 (2540-2542m), NHMW-GP (registr. no. 1990/1326), Kiscellian [Tonmergel Formation], apertural and apical views.

Fig. 6a-b. *Limacina hospes* Rolle, 1861.
Pyritic cast, Eggelsberg 1 (2040-2042m), NHMW-GP (registr. no. 1990/1319/3), Egerian [Lower Puchkirchen Group], apertural and apical views.

PLATE 10



	min.	max.	R	x̄	s	V
L	4,75	8,31	3,56	6,59	0,82	12,50
W	1,58	2,95	1,37	2,25	0,26	11,65
dT	1,01	1,87	0,86	1,48	0,17	11,22
L/W	2,49	3,64	1,15	3,01	0,26	8,66
W/dT	1,34	1,83	0,49	1,53	0,08	5,53
L/dT	3,70	5,83	2,13	4,59	0,44	9,49
A	19,5°	37°	17,5°	27,34°	3,03°	11,09

Table 14. Teleoconch dimensions of *Vaginella austriaca*.

	min.	max.	R	x̄
l	0,357	0,438	0,081	0,388
lE	0,125	0,152	0,027	0,142
lL	0,205	0,304	0,099	0,244
wE	0,092	1,119	0,027	0,106
wL	0,161	0,188	0,027	0,180
dE	0,089	0,107	0,018	0,100
dL	0,143	0,152	0,009	0,150
wC	0,116	0,125	0,009	0,118
l/wL	1,972	2,576	0,604	2,152
lE/wE	1,252	1,421	0,169	1,332
lL/wL	1,133	1,788	0,655	1,355
l/lL	1,441	1,742	0,301	1,587

Table 15. Protoconch dimensions of *Vaginella austriaca*.

Remarks — A few specimens (Pl. 6, Figs 3-6; Pl. 7, Fig. 2) show a slight pre-apertural constriction, such as is typical for *V. depressa*. Since other features correspond closely to *V. austriaca* these specimens are placed there. D'Alessandro & Robba (1980, pl. 63, figs 1, 3) illustrated similar shells of *V. austriaca*.

A.W. Janssen (1985) related the above-mentioned grooves at the base of the teleoconch, which he noted as 'wrinkles' on adult specimens of *V. depressa* and *V. austriaca*, to a shell metamorphosis. He found for the first time juvenile individuals of both species, which do not show the adult habit and do not possess these wrinkles. The shells are extremely fragile and substantially more flattened dorsoventrally than the adults. He assumed that during ontogeny the developing soft parts exercise pressure on the shell, resulting in a dorsoventral widening of the shell and wrinkles on both sides to withstand this. Subsequent recalcification of the inner shell wall lends the shell more stability.

Vaginellids from Bad Vöslau and Sooß (Karrer, 1877; Handmann, 1888) and from the Burgenland Tertiary (Tauber, 1951; Sieber, 1956) recorded in the literature as *V. depressa* are all probably *V. austriaca*, as Kittl (1886) was the first to distinguish the slender species, by erecting *V. austriaca*. Additionally, from the localities mentioned, exclusively *V. austriaca* is known to date, with the exception of a single specimen of *V. depressa* from Forchtenau.

Extra-Austrian distribution — Paratethys: Miocene: Czechoslovakia [Early Badenian], Rumania [Early Badenian], Hungary [Early Badenian], Poland [Early Badenian], Germany [Ottnangian]. Mediterranean area: Middle Miocene: Italy ['Elveziano', Langhian, Serravallian], Spain [Langhian-Early Serravallian], Turkey ['Vindobonian'], France [Tortonian]. North Sea Basin: Miocene: Belgium [Hemmoorian], The Netherlands [Hemmoorian], Germany [Hemmoorian], Denmark [Hemmoorian, Reinbekian]. Other areas: U.S.A. [Early Miocene (as *V. floridana* Collins)].

Vaginella depressa Daudin, 1800
Pl. 8, Figs 1, 2; Pl. 15, Figs 3, 5, 6

* 1800 *Vaginella depressa* Daudin, p. 145, pl. 11, fig. 1.
non v. 1856 *Vaginella depressa* Daud. — Hörnes, p. 663, pl. 50, fig. 42a.
v. 1886 *Vaginella depressa* Daudin. — Kittl, p. 57, pl. 2, figs 17-22.

PLATE 11

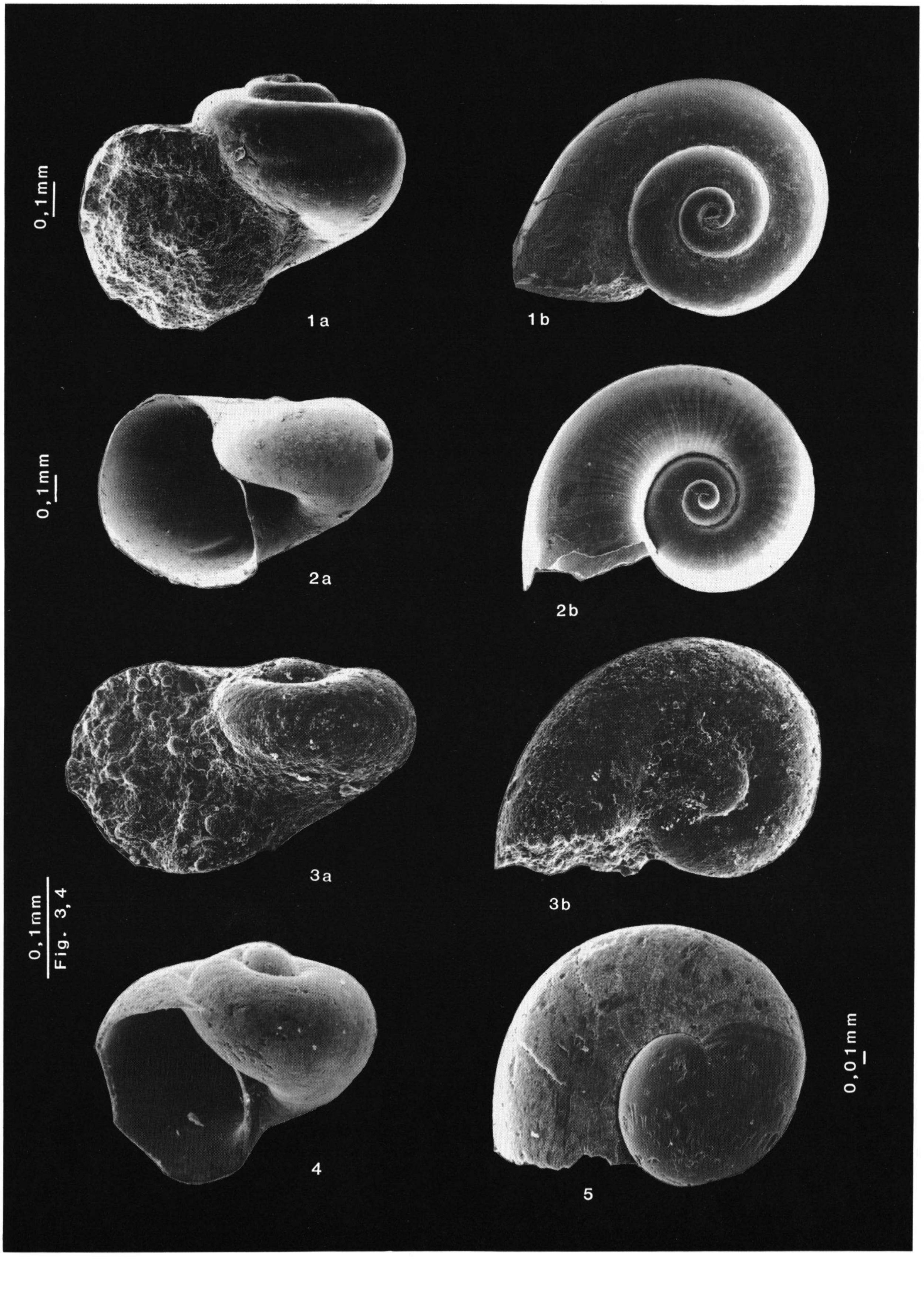
Fig. 1a-b. *Limacina hospes* Rolle, 1861
Pyritic cast, Eggelsberg 1 (2110-2112m), NHMW-GP (registr. no. 1990/1319/9, Egerian [Lower Puchkirchen Group], apertural and apical views.

Fig. 2a-b. *Limacina miorostralis* (Kautsky, 1925).
Winterswijk-Miste, The Netherlands, NHMW-GP (registr. no. 1990/1337/1), Early Miocene, apertural and apical views.

Fig. 3a-b. *Limacina* cf. *inflata* (d'Orbigny, 1836).
Pyritic cast, Aderklaa 92 (1150 m), NHMW-GP (registr. no. 1990/1296/2), Early Sarmatian, apertural and apical views.

Figs 4, 5. *Limacina valvatina* (Reuss, 1867).
4: juvenile, Hainburg borehole, PI (registr. no. 2709), Badenian [Bulimina-Bolivina Zone], apertural view. 5: juvenile, Walbersdorf, NHMW-GP (registr. no. 1990/1312/3), Badenian [Bulimina-Bolivina Zone], apical view.

PLATE 11



. 1889 *Vaginella depressa* Daudin. — Benoist, p. 28, pl. 2, fig. 4a-c.
? *1898* Vaginella spec. aff. *depressa* Daud. — Abel, p. 219.
1904 *Vaginella depressa* Daud. — Sacco, p. 15, pl. 4, fig. 10a-b.
? 1921 *Vaginella depressa* Daudin. — Checchia-Rispoli, p. 15, fig. 6.
. 1960 *Vaginella depressa* Daudin — Wenz & Zilch, p. 50, fig. 170.
. 1966 *Vaginella depressa* Daudin, 1800 — Strausz, p. 489, fig. 218.
. 1968 *Vaginella depressa* Daudin — Čtyroký *et al.*, p. 132,pl. 4, figs 1, 2.
. 1968 *Vaginella depressa* Daudin, 1800 — Sirna, p. 424, fig. 12.
. 1971 *Vaginella depressa* Daudin, 1800 — Robba, p. 89, pl. 4, figs 6, 7.
1971 *Vaginella* cf. *depressa* Daudin — Jung, p. 214, pl. 19, figs 5-7.
. 1972 *Vaginella depressa* Daudin, 1800 — Robba, p. 502, pl. 59, fig. 12; pl. 60, fig. 8.
non 1973 *Vaginella depressa* Daudin, 1800 — Steininger *et al.*, p. 450.
. *1975* *Vaginella depressa* — Steininger *et al.*, tab. 1.
1979 *Vaginella* aff. *depressa* Daudin, 1800 — d'Alessandro *et al.*, p. 86, fig. 23.
. 1983 *Vaginella depressa* Daudin, 1800 — Spano, p. 257, pl. 16, fig. 9; pl. 17, figs 1-7; pl. 18, figs 1-5.
v. 1984b *Vaginella depressa* Daudon, 1800 — A.W. Janssen, p. 75, pl. 3, fig. 11a-b, pl. 4, figs 9-13.
v. 1985 *Vaginella depressa* — A.W. Janssen, p. 200, figs 10-13.
. 1986 *Vaginella depressa* — A.W. Janssen, fig. 5.
. 1990b *Vaginella depressa* Daudin, 1800 — A.W. Janssen, p. 43, pl. 7, figs 8-12; pl. 8, figs 1-8.

Material — Miocene:
— Badenian, Spiroplectammina Zone: Forchtenau coll. NHMW-GP (1 specimen, registr. no. 1990/1306/1).
— Eggenburgian, Haller Group, Haller Formation: Wartberg 4, 83,6m (1 specimen), 87,7-90,4m (many specimens), coll. PI (registr. no. 2711/2, 3); Neukirchen 1 coll. NHMW-GP (K1/1021-1027m, several specimens, registr. no. 1990/1331/1).

Description — Most specimens are very badly crushed and up to twice the size of the Forchtenau specimen (Pl. 8, Fig. 2; Pl. 15, Fig. 3), which is the only well preserved one. The last-named specimen shows a bulbous, thickset shell. The width, which is largest in the middle of the shell, equals half the length and the dorsoventral diameter equals nearly a third of the length. The cross section is apically circular, in the middle elliptical and towards the aperture it reaches its greatest flattening. The aperture is, as in all vaginellids, slit-like and lightly extended at the extreme ends. Below this is a very slight constriction. The lateral carinae are restricted to the posterior half. The shell surface is smooth, except for growth lines.

The Early Miocene specimens do not show a preapertural constriction. Also, in them the largest width is at the aperture, a genuine bulge does not occur. The apical angle is comparable with that of the Forchtenau specimen and is about 45°. A protoconch was not found.

Dimensions — See Tables 16, 17 and Fig. 11.

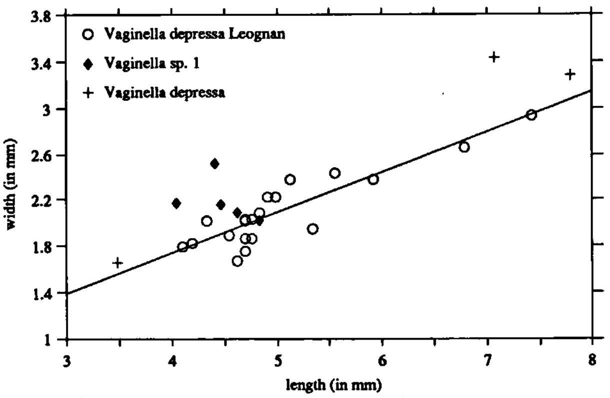


Fig. 11. Length/width (L/W) ratios of *Vaginella depressa* and *Vaginella* sp. 1.

PLATE 12

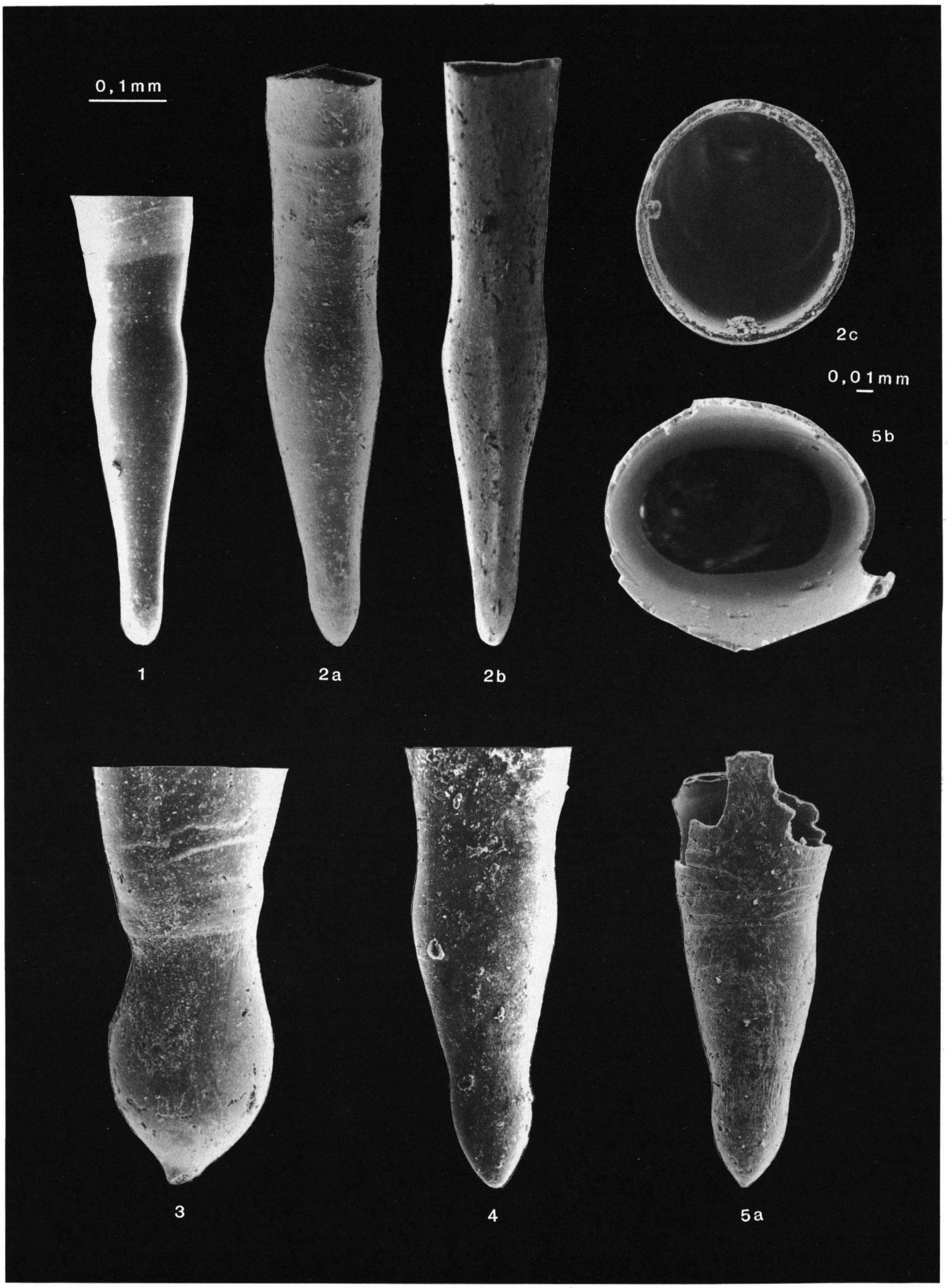
Fig. 1. *Creseis chierchiae* (Boas, 1886) forma *constricta* (Chen & Bé, 1964)
Protoconch, SW of Salayer, Indonesia, NHMW-GP (1990/1333/1), Recent.

Fig. 2a-c. *Creseis spina* (Reuss, 1867).
Protoconch, Walbersdorf, NHMW-GP (registr. no. 1990/1312/2), Badenian [Bulimina-Bolivina Zone], dorsal, lateral, and apertural views.

Fig. 3. *Clio cuspidata* (Bosc, 1802).
Protoconch, Mediterranean sea, S of Crete, 34°43'N 25°51,6'E-34°41,6'N 25°49,9'E, 1626-1433m, Meteor expedition 5/1, station 19 Ku, NHMW-GP (registr. no. 1990/1334/1), Recent.

Figs 4, 5. *Vaginella austriaca* Kittl, 1886.
4: protoconch, Bad Vöslau, NHMW-GP (registr. no. 1990/1300/1), Badenian [Upper Lagenidae Zone], dorsal view.
5a-b: protoconch, Laa an der Thaya, NHMW-GP (registr. no. 1990/1316/2), Karpatian [Laaer Formation], dorsal and apertural views.

PLATE 12



	Forchtenau	Haller Schlier	
L	3,46	7,78	7,06
WA	1,66	3,29	3,44
pC	1,52	—	—
W	1,55	2,74	2,74
dT	1,31	—	—
L/W	2,06	2,36	2,05
A	45,5°	48°	49°

Table 16. Dimensions of *Vaginella depressa.*

n = 30	min.	max.	R	x̄	s	V
L	3,89	7,70	3,81	5,24	1,01	19,18
WA	1,68	2,95	1,27	2,17	0,32	14,74
pC	1,55	2,52	0,97	1,93	0,25	13,04
W	1,66	2,67	1,01	2,05	0,29	13,97
dT	1,15	2,33	1,18	1,68	0,29	17,31
L/W	2,14	2,94	0,80	2,46	0,24	9,85
A	42,5	62,5	20,00	53,37	5,08	9,52

Table 17. Dimensions of *Vaginella depressa* from Léognan.

Remarks — The Badenian specimen corresponds most closely with material from the type area Léognan (Pl. 15, Figs 1, 2, 4), although it is slightly smaller. The Early Miocene individuals differ especially in lacking the pre-apertural constriction. In them the L/W ratio is also lower. It remains to be seen in how far compaction may have altered this. For the time being, the Austrian specimens are not separated, since the French material is also very variable. Especially the large differences in size are conspicuous. The Austrian material would then represent the two extremes. However, amongst the Léognan specimens there are individuals in which the pre-apertural constriction is poorly developed. Many adult specimens show a vertical folding at the aperture, which is not developed in the Austrian material.

It should also be pointed out that Robba (1971, p. 90) considered a specimen from the Wartberg 4 borehole (Pl. 8, Fig. 1; Pl. 15, Fig. 5) not to belong to *V. depressa* on account of the lacking median swelling, but, rather, to be close to *V. rzehaki* Kittl, 1886. Unfortunately, the type material of this large species is not well preserved. The lectotype is more slender and in fact resembles a large *V. austriaca.*

Vaginella depressa was formerly described as acuminate (Kittl, 1886; Čtyroký *et al.*, 1968). A.W. Janssen (1984b, p. 75; 1985, p. 200) was the first to remark that really just the protoconchs had broken off and he also found the first protoconchs, which he described as similar to those of *V. austriaca.* A distinguishing feature would be the straighter to vertical junction between the protoconch and the adult shell (A.W. Janssen, 1985, p. 202).

Vaginella chattica R. Janssen, 1979 shows similarities to *V. depressa.* Different are the larger apical angle, the stronger swelling anteriorly and especially the two long, parallel grooves dorsally running vertically with respect to the shell axis.

Vaginella eligmostoma Tate, 1887 and *V. inflata* Hayward, 1981 from Australia are conspecific with *V. depressa* (see A.W. Janssen, 1990b).

The only other record of *V. depressa* from Austria is the one by Abel (1898), who mentioned *V.* spec. aff. *depressa* from the 'Eggenburg Series' at Kühnring, Lower Austria.

Extra-Austrian distribution — Paratethys: Middle Miocene: Poland [Badenian], Hungary [Badenian]. Mediterranean area: Italy [Oligocene-Middle Miocene], France [Early Miocene, Burdigalian]. North Sea Basin: Early Miocene: Germany [Vierlandian], Denmark [Vierlandian]. Other areas: Australia [Early-Middle Miocene], Japan [Early-Middle Miocene], Caribbean [Miocene].

Vaginella sp. 1

Pl. 8, Figs 3-5; Pl. 15, Fig. 7

Material — Miocene:

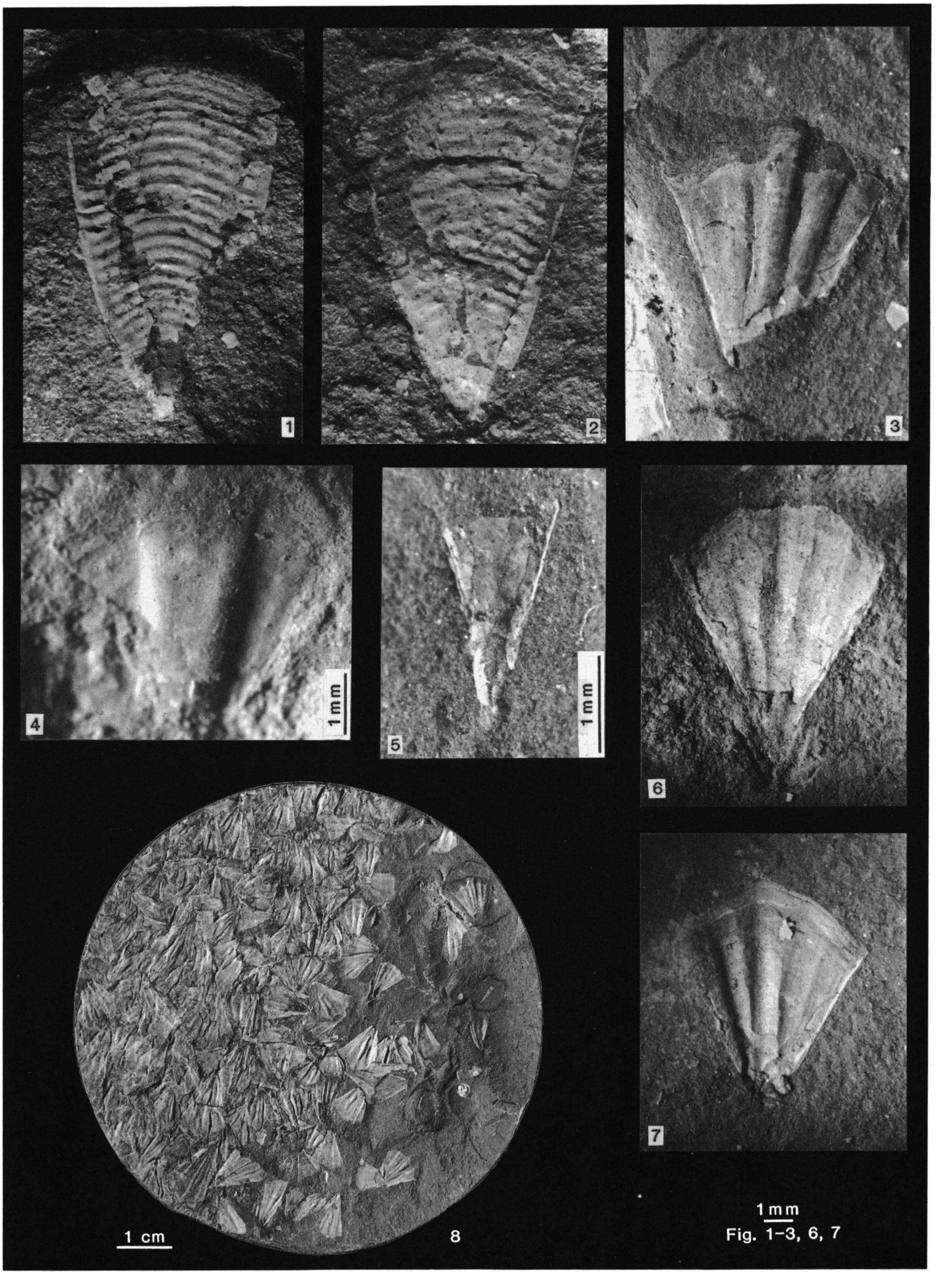
— Badenian, BBZ: Walbersdorf, coll. NHMW-GP (2 protoconchs and several specimens in pieces of sediment, registr. no. 1933.X.99, 1885.XVII.137).

PLATE 13

Figs 1, 2. *Clio* sp. 1.
Linz-Ebelsberg, Weikerlsee, NHMW-GP (registr. no. 1978/2004), Egerian [Upper Puchkirchen Group].

Figs 3-8. *Clio triplicata* Audenino, 1896.
3, 5, 8: Wartberg 4 (73,5m), PI (registr. no. 2711/1), Eggenburgian [Haller Formation], 3 - dorsal view, 5 - protoconch, 8 - core surface with mass occurrence. 4: Pfarrkirchen near Bad Hall, Feyregg brook, NHMW-GP (registr. no. 1990/1324/2), Eggenburgian [Haller Formation], ventral view. 6: Zehrmühle 11 (139,9-140,1m), PI (registr. no. 2712/2), Eggenburgian [Haller Formation], dorsal view. 7: Zehrmühle 11 (119m), PI (registr. no. 2712/1), Eggenburgian [Haller Formation], dorsal view.

PLATE 13



Description — The very badly crushed specimens are thickset, with the length generally equalling twice the width. A pre-apertural constriction appears to be missing. The dorsoventral shell diameter and the aperture can no longer be observed on account of the poor preservation, neither are the carinae which are typical for *Vaginella*. Assignment of these specimens to *Vaginella* is supported by protoconch morphology. It was possible to prepare two uncrushed protoconchs (Pl. 8, Figs 3, 4), which show a near-globular embryonic shell with distinct tip and a very elongate larval shell with straight to slightly concave margins. A constriction between the protoconch and teleoconch can only be seen laterally and on one side only, probably the dorsal side.
Dimensions — See Tables 18, 19.

n = 5	min.	max.	R	x̄
L	4,03	4,82	0,79	4,46
W	2,02	2,52	0,50	2,19
L/W	1,75	2,39	0,64	2,05

Table 18. Teleoconch dimensions of *Vaginella* sp. 1.

lP	0,464	0,473
lE	0,125	0,143
lL	0,339	0,330
wE	0,091	0,111
lE/wE	1,374	1,288

Table 19. Protoconch dimensions of *Vaginella* sp. 1.

Remarks — The protoconchs differ from those of other known species. As with *Clio*, there are only few finds of protoconchs with *Vaginella*; only those of *V. austriaca*, *V. depressa* and *V. lapugyensis* and, preserved as fragments, of *V. bicarinata* and *V. victoriae* (see A.W. Janssen, 1984a, 1985, 1990b) have been described.

The embryonic shell of the Walbersdorf specimen is shorter and more globular and the larval shell markedly longer than in *V. austriaca*; the larval shell in the latter species is more clearly separated from the teleoconch and possesses more convex lateral margins.

In the Paratethys vaginellids are very rare in the Late Badenian. In the Early and Middle Badenian of Poland *V. rzehaki* occurs, but this species is more slender and is substantially larger-sized.

Vaginella sp. indet.

Material — Miocene:
— Ottnangian, Innviertel Group [Braunauer Formation]: Braunau, borehole, coll. GBA (registr. no. 1990/7; 1 specimen). Ottnanger Formation: Ottnang-Schanze, coll. GBA (registr. no. 1990/7; 1 specimen).
Remarks — This material, indeterminate because of its very poor state of preservation, is here mentioned as it represents the only finds of *Vaginella* from the Ottnangian.

Subfamilia Cuvierininae van der Spoel, 1967
Genus *Cuvierina* Boas, 1886

Diagnosis — Shell bottle-shaped, maximum width posteriorly, round to more oval cross section, aper-

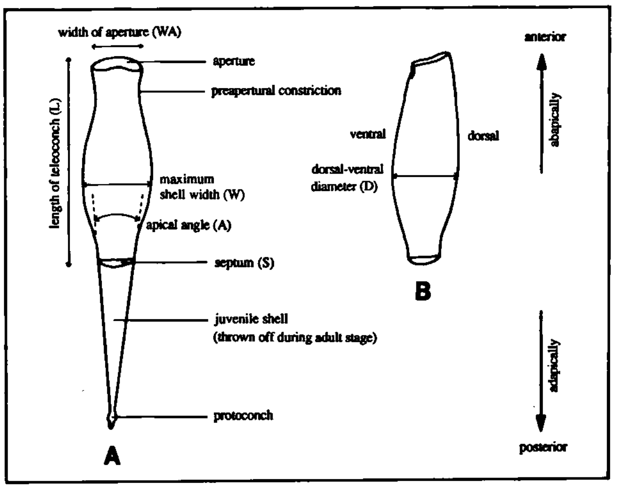


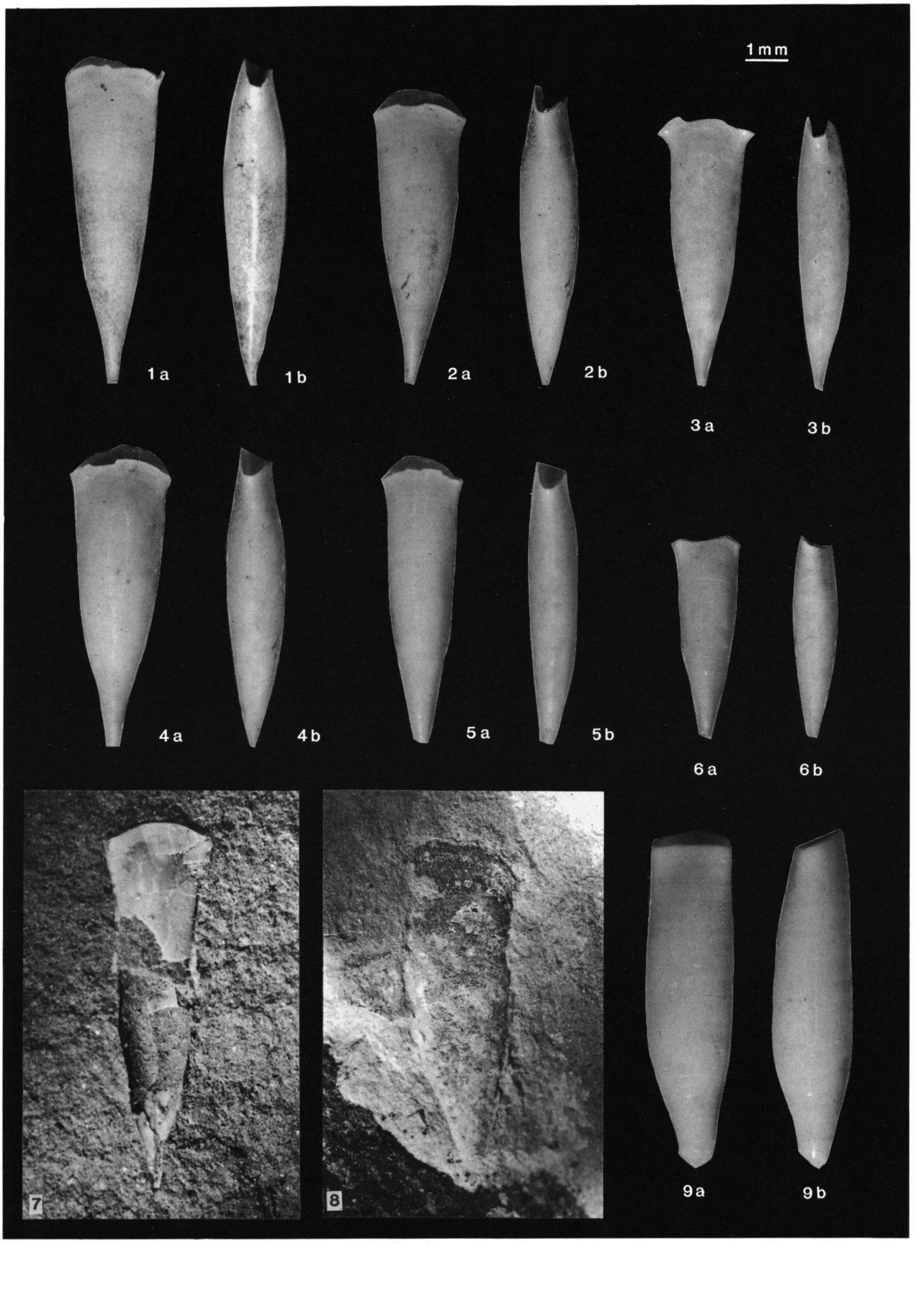
Fig. 12. Characters of the genus *Cuvierina*.
A, B – ventral and lateral views, respectively.

PLATE 14

Figs 1-8. *Vaginella austriaca* Kittl, 1886.
1-4: Baden, NHMW-GP, Badenian [Upper Lagenidae Zone], 1 - lectotype (registr. no. 1990/1297/1), 2-4 - paralectotypes (nos 1990/1298/1, 1990/1299/1, 1864.I.122), dorsal and lateral views. 5: paralectotype, Bad Vöslau, NHMW-GP (registr. no. 1851.XIII.17), Badenian [Upper Lagenidae Zone], dorsal and lateral views. 6: paralectotype, Sooß, NHMW-GP (registr. no. 1863.XV.1199), Badenian [Upper Lagenidae Zone], dorsal and lateral views. 7: Laa an der Thaya, NHMW-GP (registr. no. 1990/1314/1), Karpatian [Laaer Formation], 8: Pfarrkirchen near Bad Hall, Feyregg brook, NHMW-GP (registr. no. 1990/1323/2), Eggenburgian [Haller Formation].

Fig. 9a-b. *Cuvierina paronai* Checchia-Rispoli, 1921.
Bad Vöslau, Senckenberg Museum Frankfurt (coll. H. Neuenhaus ex Crecelius, registr. no. 4885a), Badenian [Upper Lagenidae Zone], ventral and lateral views.

PLATE 14



ture kidney-shaped to rounded-triangular. Conical posterior part of the teleoconch with protoconch shed and remaining adult shell closed by secondary septum. Often weak longitudinal lines on shell surface, otherwise smooth, occasionally with a preapertural constriction.

Type species — *Cuvierina columnella* (Rang, 1827).

Stratigraphical range — Middle Miocene-Recent.

Cuvierina paronai Checchia-Rispoli, 1921
Pl. 9, Figs 3, 4; Pl. 14, Figs 9

- * 1921 *Cuvierina Paronai* Checchia-Rispoli, pp. 6, 29, fig. 1, 1a-b.
- 1955 *Cuvierina Paronai* Checchia-Rispoli — Nicosia, p. 369.
- . 1968 *Cuvierina paronai* Checchia-Rispoli, 1921 — Sirna, p. 427, fig. 17.
- . 1977 *Cuvierina paronai* Checchia Rispoli, 1921 — Robba, p. 610, pl. 24, fig. 5; pl. 25, figs 2-4.
- . 1978 *Cuvierina paronai* Checchia Rispoli, 1921 — Robba & Spano, p. 777, pl. 81, figs 3-4.
- . 1979 *Cuvierina paronai* Checchia Rispoli, 1921 — d'Alessandro *et al.*, p. 89, pl. 16, figs 69-81.
- . 1980 *Cuvierina paronai* Checchia Rispoli, 1921 — d'Alessandro & Robba, p. 643, pl. 72, figs 5-7; pl. 73, figs 1-4.

Material — Miocene:
— Badenian, ULZ: Bad Vöslau, Breyers claypit: 1 specimen in collection NHMW-GP (ex coll. Fuchs, registr. no. 1990/1302/25) and 1 specimen in collection of the Senckenberg Museum Frankfurt (coll. H. Neuenhaus ex Crecelius, registr. no. 4885a).

Description — The shell is straight, tube-shaped and dorsoventrally flattened to varying degrees over its entire length. The largest diameter is just below the middle where the cross section is near-circular. Adapically the shell rejuvenates under an angle of 30° to a cone up to the point where the shedding of the posterior part took place. Here the shell is closed by a convex calcified septum. This and the cross section of the conical part are also near-circular. The septum is oblique with regard to the shell axis, in such a way, that its surface projects higher ventrally. The shedding of the conical part in *Cuvierina* in various specimens of the same species does not occur at exactly the same spot, which explains why the septa show different diameters.

Towards the aperture the cross section becomes more elliptical. Shortly before the aperture the shell reveals an arched depression ventrally, which is why the apertural margin approximates a straight margin ventrally, or is even lightly concave, whereas the dorsal side is strongly convex. The top of this convexity lies slightly left from the middle. The curved dorsal apertural lip projects above the ventral margin (Pl. 9, figs 3c, 4c).

The shell surface shows distinct transverse growth lines, as well as a longitudinal fine ornamentation. In the more thickset specimen these features are especially prominent.

Dimensions — See Table 20.

L	7,56	7,78
W	2,26	2,15
L/W	3,35	3,62
WA	2,11	1,92
dT	2,00	1,92
S	0,98	0,74
A	33°	28,5°

Table 20. Dimensions of *Cuvierina paronai.*

Remarks — The above-mentioned features correspond more or less with the original description by Checchia-Rispoli (1921), but that author described the shell surface as smooth, whereas the Austrian specimens show a fine ornamentation which is typical for the genus *Cuvierina.* That surface features may vary from smooth to lightly sculptured has been noted previously by Bé *et al.* (1972, p. 50) for the Recent species *C. columnella.*

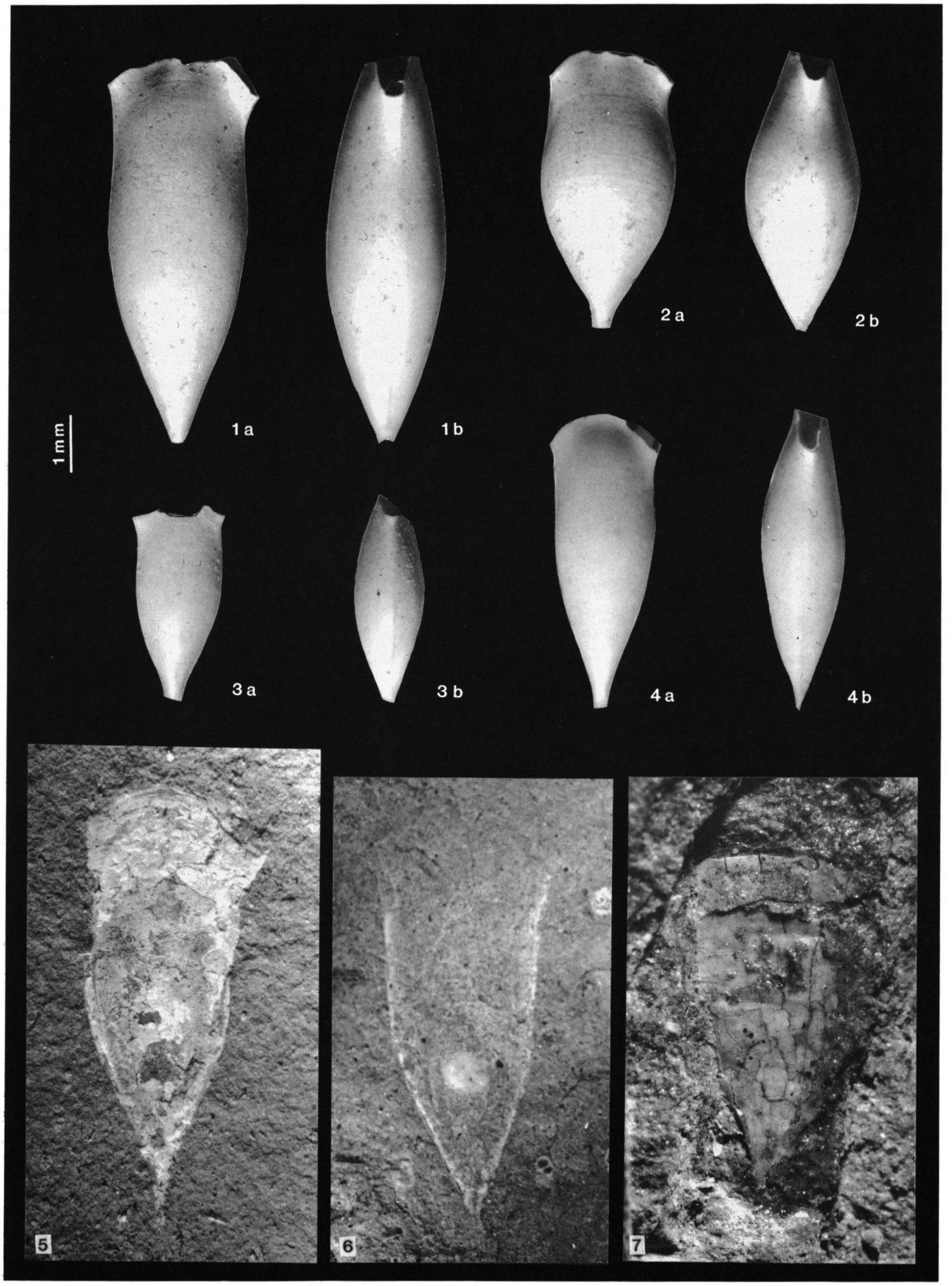
Checchia-Rispoli (1921) pointed out differences that exist in the L/W ratio, which makes specimens to appear slender to more thickset. From the measurements he presented a range between 2.2 and 3.5 may be determined with a mean of 3.0. D'Alessan-

PLATE 15

Figs 1-6. *Vaginella depressa* Daudin, 1800.
1, 2, 4: Léognan, France, NHMW-GP (registr. no. 1990/1338), Burdigalian. 3a-c: Forchtenau, NHMW-GP (registr. no. 1990/1306/1), Badenian [Spiroplectammina Zone], dorsal, lateral, and apertural views. 5: Wartberg 4 (83,6 m), PI (registr. no. 2711/2), Eggenburgian [Haller Group, Haller Formation], badly crushed specimens. 6: Neukirchen 1 (K1/1021-1027m), NHMW-GP (registr. no. 1990/1331/1), Eggenburgian [Haller Group, Haller Formation], badly crushed specimen.

Fig. 7. *Vaginella* sp. 1.
Walbersdorf, NHMW-GP (registr. no. 1885.XVII.137), Badenian [Bulimina-Bolivina Zone].

PLATE 15



dro *et al.* (1979) mentioned a mean of 3.16, while D'Alessandro & Robba (1980) gave 3.14 and Robba (1977) 2.94. Of the two specimens at hand one exceeds this mean and should therefore be seen as an example of a very slender specimen (Pl. 9, Fig. 3; Pl. 14, Fig. 9), as should the specimen measured by Sirna (1968) with an L/W ratio of 3.64, whereas the second specimen approaches mean values (Pl. 9, Fig. 4).

The aperture of the Austrian specimens (Pl. 9, Figs 3c, 4c) slightly differs from Italian material in that the dorsal margin projects on the left-hand side, while the Italian specimens show symmetrical apertures. However, as only two specimens are available and the other features correspond well, there is no need to separate them from *C. paronai.*

Cuvierina paronai is very similar to *C. columnella urceolaris* (Mörch, 1850), a fossil and Recent species, but this has a lesser L/W ratio, which is to say that the width is nearly equal but the latter species is shorter, which results in a more thickset shell form. D'Alessandro & Robba (1980) gave as mean 2.57. Additionally, the dorsal apertural margin is markedly less convex.

D'Alessandro & Robba (1980) also discussed the differences between these two species and *C. grandis* d'Alessandro & Robba, 1980, which, as far as habit and apertural outline are concerned, resembles *C. paronai*, but which is substantially larger-sized. Also, its L/W ratio is higher (3.92) and it shows a pre-apertural constriction and a smaller apical angle (23°). In the literature the mean values for this angle range between 36.5 and 33.2°.

Many authors have pointed out the differences between *C. paronai* and the Pliocene *C. astesana* Rang, 1829 (see *e.g.* Checchia-Rispoli, 1921; Robba, 1977). The latter species shows in its posterior part a less strong rejuvenation and a distinct constriction beneath the aperture. Clearly different is also the form of the aperture, it being more slit-like in *C. astesana.* D'Alessandro & Robba (1980) stressed the higher L/W ratio of *C. astesana.* Robba (1977) and Robba & Spano (1978) illustrated specimens of *C. paronai,* in which the posterior part has not been shed.

The genus *Cuvierina* is here described for the first time from the Austrian Tertiary and even for the Paratethys.
Extra-Austrian distribution — Italy, Middle Miocene [Langhian, Serravallian].

Conclusions

In this paper the Austrian pteropods from the following Tertiary sedimentary basins have been studied: Vienna Basin (including Eisenstädter Basin), Molasse Zone (including Waschberg Zone) and Lavanttal Basin.

Five genera (*Limacina, Creseis, Clio, Vaginella* and *Cuvierina*) and eighteen species have been identified and discussed. A stratigraphical range from Late Eocene (Priabonian) to Middle Miocene (Early Sarmatian) could be shown for pteropods in Austria. Up to now, a range from Late Oligocene to Late Badenian for three genera and five species was known.

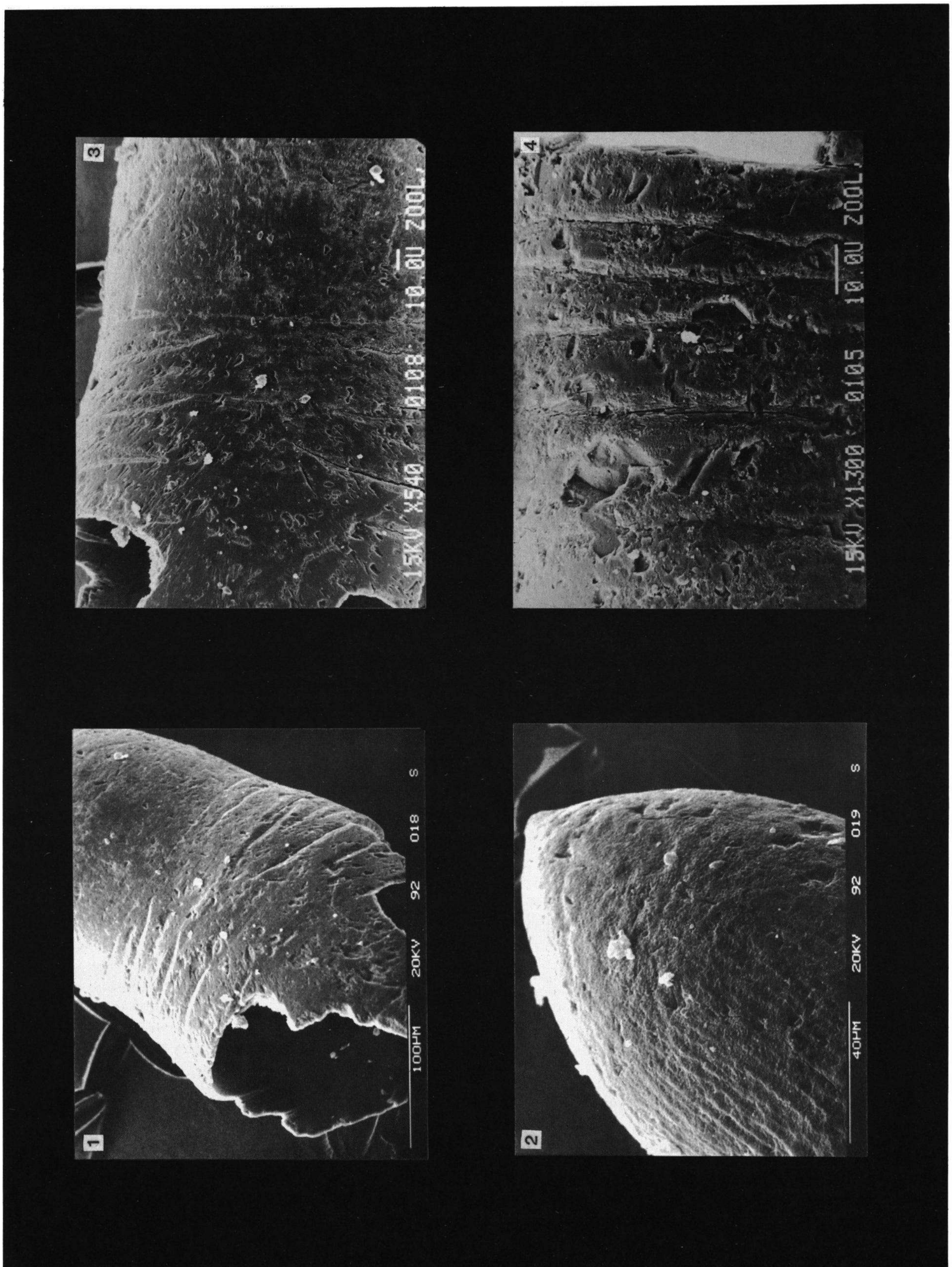
The genera *Creseis* and *Cuvierina* with the species *Creseis spina, Creseis* sp. 1 and *Cuvierina paronai* as well as the following taxa have been found for the first time in Austria: *Limacina miorostralis, Limacina umbilicata, Limacina* cf. *inflata*, and six additional species that could not be related to known species (*Limacina* spp. 1-3, *Clio* spp. 1-2, *Vaginella* sp. 1). These may turn out to be undescribed species in future. To date this material is still insufficient, despite the fact that protoconchs could be described for the first time (*Clio* sp. 2, *Vaginella* sp. 1). Since protoconchs are extremely rare, it cannot be excluded that the teleoconchs of the same species have already been described in the literature. One genus (*Cuvierina*) and two species (*C. paronai* and *L. miorostralis*) are recorded for the first time from the Paratethys bioprovince.

The stratigraphic distribution of *Limacina valvatina* and *Vaginella austriaca* could be extended. *Limacina valvatina* occurs in the Egerian, Karpatian and Middle to Late Badenian, while *V. austriaca* occurs in the Eggenburgian, Karpatian and Early to Middle Badenian. *Limacina* cf. *valvatina*, which is tentatively separated from *L. valvatina* for the time being, is found in the Late Kiscellian and Egerian. For *Lima-*

PLATE 16

Figs 1-4. *Vaginella austriaca* Kittl, 1886.
Protoconch, Laa an der Thaya, NHMW-GP (registr. no. 1990/1316/2), Karpatian [Laaer Formation]. 1, 3, 4 - microstructures near the constriction between protoconch and teleoconch, 2 - tip of protoconch and microstructures at the constriction between embryonic and larval shell.

PLATE 16


1
100μM 20KV 92 018 S
2
40μM 20KV 92 019 S
3
15KV X540 0108 10.0U ZOOL
4
15KV X1300 0105 10.0U ZOOL

cina hospes (Early Egerian), *Clio triplicata* (Eggenburgian, Ottnangian) and *Vaginella depressa* (Eggenburgian, Middle Badenian) the stratigraphic distribution as previously indicated in the literature could be confirmed. *Limacina* sp. 1 and *L. umbilicata* occur in the Priabonian, the latter species being dominant throughout the Oligocene. *Limacina* sp. 2 is known from nannoplankton zone NP 22 (Kiscellian), *Limacina* sp. 2 and *Creseis* sp. 1 from the Early Egerian, *L. miorostralis* from the Karpatian and *L.* cf. *inflata* from the Early Sarmatian. *Clio* sp. 1 is restricted to the Late Egerian, whereas *Clio* sp. 2 and *Cuvierina paronai* are confined to the early Middle Badenian. *Vaginella* sp. 1 and *Creseis spina* occur only in the Late Badenian. The greatest species diversity is found in the Egerian and Badenian. Stratigraphical range charts for all species are given in Zorn (in press).

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References

Abel, O., 1898. Studien in den Tertiärbildungen von Eggenburg. — Beitr. Paläont. Geol. Österr.-Ungarn, 11(4): 211-226, figs 20-22.

Abel, O., 1924. Lehrbuch der Paläozoologie. Jena (Gustav Fischer Verlag), 523 pp., 700 figs.

Alessandro, A. d', A. Laviano, G. Ricchetti & A. Sardella, 1979. Il Neogene del Monte Gargano. — Boll. Soc. paleont. Ital., 18(1): 9-116, 32 figs, 2 tabs, 19 pls.

Alessandro, A. d', & E. Robba, 1980. Pteropodi neogenici della Puglia (Italia meridionale). — Riv. Ital. paleont. strat., 86(3): 605-698, 14 figs, pls 61-77.

Audenino, L., 1896. I pteropodi miocenici del Monte dei Cappuccini in Torino. — Boll. Soc. malac. Ital., 20: 79-113, pl. 5.

Báldi, T., 1984. The terminal Eocene and Early Oligocene events in Hungary and the separation of an anoxic, cold Paratethys. — Eclogae geol. Helv., 77(1): 1-27, 12 figs.

Báldi, T., 1986. Mid-Tertiary stratigraphy and paleogeographic evolution of Hungary. Budapest (Akadémiai Kiadó), 201 pp., 91 figs, 16 tabs, 11 pls, 4 maps.

Bé, A.W.H., & R.W. Gilmer, 1977. A zoogeographic and taxonomic review of euthecosomatous Pteropoda. *In*: A.T.S. Ramsey (ed.). Oceanic micropalaeontology, 1: 733-808, 31 figs, 4 tabs, 10 pls. London (Academic Press).

Bé, A.W.H., C. MacClintock & D. Chew Currie, 1972. Helical shell structure and growth of the pteropod Cuvierina columnella (Rang) (Mollusca, Gastropoda). — Biomineralisation Forschungsber., 4: 47-79, 10 figs, 17 pls.

Bellini, R., 1905. Les ptéropodes des terrains tertiaires et quaternaires d'Italie. — Ann. Soc. roy. zool. malac. Belg., 40: 23-45, 1 tab., 47 figs.

Benoist, E.-A., 1889. Coquilles fossiles des terrains tertiaires moyens du sud-ouest de la France. Description des céphalopodes, ptéropodes et gastéropodes opisthobranches (Acteonidae). — Actes Soc. linn. Bordeaux, (5)42(2): 11-84, pls 1-5.

Bernasconi, M.P., & E. Robba, 1982. The thecosomatous pteropods: a contribution toward the Cenozoic Tethyan paleobiogeography. — Boll. Soc. paleont. Ital., 21(2-3): 211-222, 5 figs, 7 tabs.

Biekart, J.W., 1989. Euthecosomatous pteropods as paleohydrological and paleoecological indicators in a Tyrrhenian deepsea core. — Palaeogeogr., Palaeoclimatol., Palaeoecol., 71: 205-224, 6 figs, 2 tabs, 2 pls.

Boekschoten, G.J., 1969. Fossilführung und Stratigraphie des Oligo-Miozäns von fünf norddeutschen Bohrungen. — Meyniana, 19: 1-77, 9 figs, 24 tabs, 3 pls.

Bornemann, J.G., 1855. Die mikroskopische Fauna des Septarienthones von Hermsdorf bei Berlin. — Z. dt. geol. Ges., 7: 307-371, pls 12-21.

Bosch, M. van den, M.C. Cadée & A.W. Janssen, 1975. Lithostratigraphical and biostratigraphical subdivision of Tertiary deposits (Oligocene-Pliocene) in the Winterswijk-Almelo region (eastern part of the Netherlands). — Scripta Geol., 29: 167 pp., 37 figs, 10 tabs, 23 pls, 2 encls.

Checchia-Rispoli, G., 1921. I pteropodi del Miocene garganico. — Boll. R. Com. geol. Ital., 48(2): 1-28, 1 pl.

Collins, L., 1934. A monograph of the American Tertiary pteropod mollusks. — Johns Hopkins Univ. Stud. Geol., 11: 137-234, pls 7-14.

Čtyroký, P., 1968. Find of Clio Linnaeus, 1767 (Gastropoda, Thecosomata) in the Burdigalian of the Vienna Basin. — Vest. Ustr. Ust. Geol., 43: 95-100, 2 figs, 1 pl.

Čtyroký, P., A. Papp & F. Steininger, 1968. Spiratellacea (Gastropoda) aus dem Miocän der Paratethys. — G. Geol. (2), 35, 2, Com. Med. Neog. Strat. Proc. 4. Session: 129-142, tab. 1, pl. 4.

Curry, D., 1981. Ptéropodes éocènes de la Tuilerie de Gan (Pyrénées-Atlantiques) et de quelques autres localités du SW de la France. — Cahiers Micropaléont., 4: 35-44, 1 pl.

Daudin, C., 1800. Nouveau genre de ver à tube calcaire, voisin des serpules et des dentales. — Bull. Soc. philom., (2)43: 145, fig. 1, pl. 11.

Dieci, G., 1961. Pteropodi langhiani di Rio delle Bàgole (Montegibbio, Appennino settentrionale modenese). — Boll. Soc. paleont. Ital., 1(2): 31-42, pls 15, 16.

Erünal-Erentöz, L., 1958. Mollusques du Néogène des Bassins de Karaman, Adana et Hatay (Turquie). — M. T. A. E. (Publ. Inst. Etud. Rech. Min. Turquie), C 4: 232 pp., 36 pls.

Geronimo, I. di, 1974. Molluschi pelagici in livelli di Marne mioceniche presso Vetto (R. Emilia). — Conchiglie, 10 (9-10): 181-192, 1 pl.

Gheorghian, M., 1975. Holostratotypus und Faziostratotypen der Egerer Schichtengruppe. 10. Faziostratotypus: Talmacel. — *In*: T. Báldi *et al.* Chronostratigraphie und Neostratotypen, OM Egerien. Die Egerer, Pouzdraner, Puchkirchener Schichtengruppe und die Bretkaer Fm.: 176-178. Bratislava (Veda Verlag Slowak. Akad. Wiss.).

Gheorghian, M., & M. Gheorghian, 1964. Asupra unor marne cu Spirialis in Bazinul Lapusului. — Dari Seama Sedint., 49 (2a): 177-182, 3 figs, 2 pls.

Gheorghian, M., M. Iva & M. Gheorghian, 1967. Consideratii asupra genului Spirialis. — Dari Seama Sedint., 53(2): 5-16, pls 1-3.

Glibert, M., 1952. Faune malacologique du Miocène de la Belgique. 2. Gastéropodes. — Mém. Inst. roy. Sci. nat. Belg., 121: 197 pp., 5 tabs, 10 pls.

Handmann, P.R., 1888. Kurze Beschreibung (Charakteristik) der häufigsten und wichtigsten Tertiärconchylien des Wiener Beckens. Münster, 164 pp., 8 pls.

Hörnes, M., 1849. Verzeichniss der Fossilreste des Tertiärbeckens von Wien. *In*: J. Czizek. Erläuterungen zur geognostischen Karte der Umgebungen Wiens, Anhang: 1-44, Wien (W. Braumüller).

Hörnes, M., 1856. Die fossilen Mollusken des Tertiär-Beckens von Wien. 1. Univalven. — Abh. k.k. geol. Reichsanst., 3: 736 pp., 52 pls, 1 map.

Janssen, A.W., 1972. Die Mollusken-Fauna der Twistringer Schichten (Miocän) von Norddeutschland. — Scripta Geol., 10: 96 pp., 42 figs, 4 tabs, 11 pls.

Janssen, A.W., 1984a. Mollusken uit het Mioceen van Winterswijk- Miste. Een inventarisatie, met beschrijvingen en afbeeldingen van alle aangetroffen soorten. Amsterdam (K.N.N.V., N.G.V., R.G.M.), 451 pp., 7 figs, 4 tabs, 82 pls.

Janssen, A.W., 1984b. Type specimens of pteropod species (Mollusca, Gastropoda) described by Rolle (1861), Reuss (1867) and Kittl (1886), kept in the collection of the Naturhistorisches Museum at Vienna. — Meded. Werkgr. Tert. Kwart. Geol., 21(2): 61-91, 1 tab., pls 1-6.

Janssen, A.W., 1985. Evidence for the occurrence of a "skinny" or "minute stage" in the ontogenetical development of Miocene Vaginella (Gastropoda, Euthecosomata) from the North Sea and Aquitaine basins. — Meded. Werkgr. Tert. Kwart. Geol., 21(4): 193-204, 13 figs.

Janssen, A.W., 1986. Pteropoden aus dem Tertiär, eine Bitte um Unterstützung. — Der Geschiebesammler, 19(4): 148, 149, 11 figs.

Janssen, A.W., 1989. Some new pteropod species from the North Sea Basin Cainozoic (Mollusca, Gastropoda, Euthecosomata). — Meded. Werkgr. Tert. Kwart. Geol., 26(3): 91-133, 5 figs, 8 pls.

Janssen, A.W., 1990a. Pteropod species (Mollusca, Gastropoda, Euthecosomata) from the Late Oligocene of Mogenstrup, Jylland, Denmark. — Contr. Tert. Quatern. Geol., 27(2-3): 10 figs, 1 pl.

Janssen, A.W., 1990b. Pteropoda (Gastropoda, Euthecosomata) from the Australian Cainozoic. — Scripta Geol., 91: 1-76, 3 figs, 8 tabs, 9 pls.

Janssen, A.W., & C. King, 1988. Planktonic molluscs (Pteropods). *In*: R. Vinken *et al.* (eds). The Northwest European Tertiary Basin. Results of the International Geological Correlation Programme Project no. 124. — Geol. Jb., (A)100: 356-368, figs 188-207.

Janssen, R., 1979. Die Mollusken des Oberoligozäns (Chattium) im Nordsee-Becken, 2. Neogastropoda, Euthyneura, Cephalopoda. — Arch. Moll., 109(4/6): 277-376, pls 15-18, 18a.

Jorgulescu, T.T., 1953. Contributinui la studiul micropaleontologic al miocenului superior din Muntenia de Est (Prahova si Buzau). — An. Com. Geol., 26: 5-222, 4 figs, 9 pls.

Jung, P., 1971. Fossil mollusks from Carriacou, West Indies. — Bulls Am. Paleont., 61(269): 147-262, 2 figs, 2 tabs, 21 pls.

Karrer, F., 1877. Geologie der Kaiser Franz Josefs Hochquellen-Wasserleitung. — Abh. k.k. geol. Reichsanst., 9: 420 pp., 96 figs, 20 pls.

Kautsky, F., 1925. Das Miocän von Hemmoor und Basbeck-Osten. — Abh. preuß. geol. Landesanst., neue Folge, 97: 255 pp., 12 pls.

Kittl, E., 1886. Ueber die miocenen Pteropoden von Oesterreich-Ungarn, mit Berücksichtigung verwandter Vorkommnisse der Nachbarländer. — Ann. k.k. naturhist. Hofmus., 1(2): 47-74, pl. 2.

Koch, F.E., 1886. Literatur-Notizen B) Ernst Kittl: Ueber die miocänen Pteropoden von Oesterreich-Ungarn. — Arch. Ver. Freunde Naturgesch. Mecklenburgs, 40: 133-135.

Koenen, A. von, 1868. Das marine Mittel-Oligozän Nord-Deutschlands und seine Molluskenfauna. 2. Teil. — Palaeontographica, 16(6): 223-295, pls 26-30.

Koenen, A. von, 1883. Die Gastropoda Holostomata und Tectibranchiata, Cephalopoda und Pteropoda des Norddeutschen Miozän (2. Teil von: Das norddeutsche Miozän und seine Molluskenfauna). — N. Jb. Mineral. Geol. Paläont., Beil.-Bd. 2: 223-376, pls 5-7.

Korobkov, I.A., 1966. Krylonogie (Mollusca Pteropoda) Paleogenovykh otlozhenij Juga SSSR. (Pteropoda from Palaeogene deposits in the South of the USSR.) — Vopr. Paleont., 5: 71-137, pls 131-139.

Krach, W., 1979. Biostratigraphical extension of Miocene Pteropoda of Poland. — Ann. géol. Pays hellén., Tome hors série, 2, 7th Internat. Congr. Medit. Neog.: 653-661, 2 tabs, 4 figs.

Krach, W., 1981. Slimaki skrzydonogi (Pteropoda) w Miocenie Polski i ich znaczenie stratygraficzne. (The pteropods in the Miocene of Poland and their stratigraphic significance). — Prace Geol. Polska Akad. Nauk, 121: 116-140, 3 tabs, 6 pls.

Krach, W., & W. Nowak, 1956. Miocen okolicy Andrychowa. (Le Miocène des environs d'Andrychów). — Rocz. Polsk. Tow. Geol., 25(1): 9-54, 5 figs, 1 pl.

Langer, W., 1964. Kurze Bemerkungen zur Mikro- und Megafauna des nordwestdeutschen Mittel-Oligozäns. — N. Jb. Geol. Paläont. Mh. B: 730-736.

Lőrenthey, E., 1903a. Einige Bemerkungen über Orygoceras Fuchsi Kittl. sp. — Földtani Közlöny, 63: 518-520.

Lőrenthey, E., 1903b. Pteropodenmergel in den alttertiären Bildungen von Budapest. — Földtani Közlöny, 63: 520-524.

Lozouet, P., & P. Maestrati, 1982. Nouvelles espèces de mollusques de l'Oligocène (Stampien) pour les bassins de Paris et d'Aquitaine. — Arch. Moll., 112(1-6): 165-189, 10 figs, 6 pls.

Luczkowska, E., 1955. O Tortonskich otwornicach z warstw Chodenickich i Grabowieckich okolic Bochni (Tortonian Foraminifera from the Chodenice and Grabowiec Beds in the vicinity of Bochnia). — Rocz. Pol. Towar. Geol., 23: 77-156, 4 figs, 1 tab.

MacNeil, F.S., & D.T. Dockery, 1984. Lower Oligocene Gastropoda, Scaphopoda, and Cephalopoda of the Vicksburg

Group in Mississippi. — Bull. Miss. Dept. Nat. Res., Bureau Geol., 124: 415 pp., 16 figs, 72 pls.

Martinell, J., & J. de Porta, 1981. Presencia de Vaginella austriaca Kittl (Pteropoda) y fauna malacologia acompanante en el Mioceno de Catalunya. — Iberus, 1: 1-8, 2 figs, 1 tab., 1 pl.

Meyer, O., 1886. Contributions to the Eocene paleontology of Alabama and Mississippi. — Bull. geol. Surv. Alabama, 1(2): 63-85, 3 pls.

Moisescu, V., & G. Popescu, 1980. Chattian-Badenian biochronology in Romania by means of molluscs. — An. Inst. Geol. Geofizica, 56: 205-224, 2 pls.

Nicosia, M., 1955. La fauna miocenica di "La Portella" presso Roccapalumba (Sicilia). — Boll. Serv. geol. Ital., 77 (2-3): 363-376, 2 pls.

Niedzwiedzki, J., 1883. Stosunki géologiczne formacji solonosnej Wieliczki i Bochni. — Kosmos, 8: 387-401, fig. 5.

Nordsieck, F., 1972. Die miozäne Molluskenfauna von Miste-Winterswijk NL (Hemmoor). Stuttgart (Gustav Fischer Verlag), 187 pp., 3 figs, 9 tabs, 33 pls.

Paghida, N., 1960. Microfauna din Buglovianul de pe dreapta Prutului. — An. Stiint. Univ. Iasi, (2)4: 315-329, 2 pls.

Pana, I., G. Caraivan, A. Tudoran, O. Lazar, D. Butiu & D. Csobuka, 1988. Ptéropodes et heteropodes actuels et fossiles (Pléistocénes, Badeniens) et leur implication dans la constitution des roches génératrices de pétrole. — An. Univ. Geol., 37: 57-64, 2 pls.

Papp, A., F. Rögl & F. Steininger, 1970. Führer zur Paratethys-Exkursion 1970 in die Neogen-Gebiete Österreichs. Wien, 57 pp.

Rado, G., & M. Tudor, 1971. Corrélation du Tortonien des synclinaux de Slanic, Drajna et Melicesti avec d'autres bassins de la Paratéthys. — Földtani Közlöny, 101(2-3): 285-291, 1 fig., 2 tabs.

Rasmussen, L.B., 1968. Molluscan faunas and biostratigraphy of the marine younger Miocene formations in Denmark, 2. Paleontology. — Danm. geol. Unders., (2)92: 265 pp., 27 pls.

Reuss, A.E., 1867. Die fossile Fauna der Steinsalzablagerung von Wieliczka in Galizien. — Sitz.-Ber. k. Akad. Wiss., math.-naturw. Cl., 55(1): 17-182, 6 tabs, 8 pls.

Richter, R., 1943. Einführung in die zoologische Nomenklatur durch Erläuterung der internationalen Regeln. Frankfurt am Main (W. Kramer), 154 pp.

Robba, E., 1971. Associazioni a pteropodi della Formazione di Cessole (Langhiano). — Riv. Ital. Paleont., 77(1): 19-126, 9 figs, 2 tabs, 5 pls.

Robba, E., 1972. Associazioni a pteropodi nel Miocene inferiore delle Langhe (Piemonte). — Riv. Ital. Paleont., 78(3): 467-524, 6 figs, 3 tabs, pls 57-60.

Robba, E., 1977. Pteropodi serravalliani delle Langhe (Piemonte). — Riv. Ital. Paleont., 83(3): 575-640, 7 figs, pls 17-25.

Robba, E., & C. Spano, 1978. Gasteropodi pelagici nel Miocene Medio del Campidano meridionale (Sardegna). — Riv. Ital. Paleont., 84(3): 751-796, 6 figs, pls 76-81.

Rögl, F., 1967. Die miozäne Foraminiferenfauna von Laa an der Thaya in der Molassezone von Niederösterreich. Ph.D. thesis, Fak. Univ. Wien, 131 pp., 14 figs, 9 pls, 1 encl. (unpublished)

Rolle, F., 1861. Über einige neue oder wenig gekannte Mollusken-Arten aus Tertiär-Ablagerungen. — Sitz.-Ber. k. Akad. Wiss., math.-naturw. Cl., 44: 3-21, pls 1, 2.

Rutsch, R., 1934. Beiträge zur Kenntnis tropisch-amerikanischer Tertiärmollusken. 2. Pteropoden und Heteropoden aus dem Miocaen von Trinidad (Brit. Westindien). — Eclogae geol. Helv., 27(2): 299-326, fig. 1, pl. 8.

Sacco, F., 1904. I Molluschi dei terreni terziarii del Piemonte e della Liguria, 30: 203 pp., 31 pls. Torino (Clausen).

Sieber, R., 1953. Eozäne und oligozäne Makrofaunen Österreichs. — Sitz.-Ber. Österr. Akad. Wiss., math.-naturwiss. Kl., (1), 162(5): 359-376.

Sieber, R., 1956. Die Tortonfauna von Mattersburg und Forchtenau (Bgld.). — Verh. geol. Bundesanst., (1956): 236-249.

Sirna, G., 1968. Pteropodi del Miocene di S. Nicola Varano (Gargano) con descrizione di due nuove specie. — Geol. Romana, 7: 417-430, 20 figs.

Spano, C., 1983. I Cavoliniidae del Miocene inferiore di Castelsardo (Sardegna settentrionale). — Riv. Ital. Paleont. Strat., 89(2): 243-282, 8 figs, pls 16-20.

Spoel, S. van der 1967. Euthecosomata, a group with remarkable developmental stages (Gastropoda, Pteropoda). Gorinchem (J. Noorduijn & Zoon N.V.), 375 pp., 366 figs, 17 tabs.

Stancu, J., 1974. Asociatia de heteropode si pteropode Badenian inferioare din depresiunea Getica-Judetul Mehedinti. — Dari Seama Sedint., 60(3): 181-190, 1 tab., 3 pls.

Stancu, J., 1978. Nouvelles espèces d'Heteropoda et de Pteropoda dans le Badénien inférieur (Langhien) en Roumanie. — Dari Seama Sedint., 64: 333-340, 3 pls.

Stancu, J., 1979. Ptéropodes et hétéropodes du Miocène de Roumanie. — Ann. géol. Pays hellén., Tome hors série, 3, 7th Intern. Congr. Medit. Neog.: 1388-1392, 3 tabs.

Steininger, F., P. Čtyroký, O. Hölzl, J. Kókay, W.R. Schlickum, O. Schultz & F. Strauch, 1973. Die Molluskenfaunen des Ottnangien. *In*: A. Papp, F. Rögl & J. Seneš (eds). Chronostratigraphie und Neostratotypen, 3, (M2) Ottnangien: 380-615, 30 pls, Bratislava (Verlag Slowakische Akad. Wiss.).

Steininger, F., A. Papp, I. Cicha & J. Seneš, 1975. Excursion "A": Marine Neogene in Austria and Czechoslovakia. — 6. Congr. Reg. Com. Med. Neog. Strat. 1975 Bratislava, 183 pp.

Strausz, L., 1966. Die miozän-mediterranen Gastropoden Ungarns. Budapest (Akadémiai Kiado), 695 pp., 221 figs, 79 pls.

Suess, E., 1866. Untersuchungen über den Charakter der österreichischen Tertiärablagerungen. — Sitz.-Ber. Akad. Wiss., 54: 87-152, 2 pls.

Tauber, A.F., 1951. Grundzüge der Geologie. *In*: Burgenland. Landeskunde. — Burgenländ. Landesreg. (ed.): 39-85, 1 tab., 4 pls, Wien (Österr. Bundesverlag).

Tembrock, M.L., 1964. Einige Beispiele von Faziesabhängigkeit bei tertiären Gastropoden. — Ber. geol. Ges. DDR, 9(3): 311-337, pls 3-8.

Toth, G., 1942. Paläobiologische Untersuchungen über die Tortonfauna der Gaadener Bucht. — Palaeobiologica, 7(5-6): 498-530, 5 figs, pls 15, 16.

Toula, F., 1900. Über den marinen Tegel von Neudorf an der March (Dévény-Ujfalu) in Ungern. — Verh. Ver. Nat. Heilkde., 20: 3-30.

Vasicek, M., 1949. Novi pelagicti opistobranchi ti z moravského tortonu. (New pelagic Opisthobranchia from the Moravian Tortonian). — Vest. stát. geol. úst. CSR, 24: 31-36, 1 fig., 1 pl.

Verri, A., & G. de Angelis d'Ossat, 1900. Secondo contributo allo studio del Miocene nell'Umbria. — Boll. Soc. geol. Ital., 19(1): 240-279.

Voicu, G., 1953. Studiu micropaleontologic al stratelor de Cornu depe flancul sudic al cuvetei de slanic, intre V. Prahovei si V. Varbilaului. — An. Com. Geol., 26: 223-264, 2 figs, 1 encl.

Wenz, W. & A. Zilch, 1960. Gastropoda, 2. Euthyneura. *In*: O.H. Schindewolf. Handbuch der Paläozoologie, 6(2): 834 pp., 2515 figs, Berlin (Bornträger).

Zinndorf, J., 1928. Die Versteinerungen aus den Tertiär-Ablagerungen von Offenbach a. M. 1. Teil, Die Conchylien des Rupeltones (Septarientones). — Ber. Offenb. Ver. Naturk., 66-68: 65 pp., 6 pls.

Zorn, I., in press. Pteropoda (Thecosomata, Gastropoda). *In*: Catalogus Fossilium Austriae. Ein systematisches Verzeichnis aller auf österreichischem Gebiet festgestellten Fossilien. - VIc3c, Österr. Akad. Wiss. (ed.), 5 tabs, 3 figs, 5 pls.

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