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Tube-dwelling polychaetes from the Korytnica Basin (Middle Miocene; Holy Cross Mountains, Central Poland)

ABSTRACT: The assemblage of tube-dwelling polychaetes from the Korytnica Basin (Middle Miocene; Holy Cross Mountains, Central Poland) comprises 25 taxa recognized at their species or genus level. Of these, the nine species are established as new, viz. *Hydroides vesicularis* sp.n., *Hydroides vicinalis* sp.n., *Cementula rugosa* sp.n., *Cementula verrucifera* sp.n., *Placostegus echinatus* sp.n., *Spirorbis circuliferus* sp.n., *Pileolaria inflata* sp.n., *Pileolaria korytnicensis* sp.n., and *Janua miocaenica* sp.n.

Within the whole assemblage, indicated is the presence of the taxa referrable either to the present-day (and extant) or to the Upper Cretaceous genera, what indicates that the investigated Middle Miocene (Badenian) assemblage reveals the phyletic relations both to the Late Mesozoic as well as to the modern polychaete faunas.

Of the taxa belonging to the family Serpulidae RAFINESQUE, 1815, some are assigned to the genus *Semivermilia* TEN HOVE, 1975, which has not as yet been recorded from the fossil state, the same as the genera *Protolaeospira* PIXELL, 1912, and *Janua* SAINT-JOSEPH, 1894, of the family Spirorbidae PILLAI, 1970. To the recently revised, present-day spirorbid genera assigned are some formerly well established species, the taxonomy of which is proposed as *Pileolaria declivis* (REUSS, 1860) and *Janua heliciformis* (EICHWALD, 1830), although the latter does not occur in the Korytnica Basin.

INTRODUCTION

The tube-dwelling, epizoic polychaetes which are one of the commonest components of the present-day shallow-marine communities (*see* REGENHARDT 1961, BANSE 1963, BIANCHI 1981, JÄGER 1983), are relatively rare fossils in the Middle Miocene (Badenian) deposits of the Korytnica Basin, southern slopes of the Holy Cross Mountains, Central Poland. The ubiquitous fauna of the world-famous Korytnica Clays, composed of both the much diversified invertebrates (*see* BAŁUK & RADWAŃSKI 1977) and vertebrates (*see* RADWAŃSKA 1992), contains a poor assemblage of the polychaetes. These are represented, on one side, by the rock-boring forms of the family Spionidae, such as *Polydora ciliata* (JOHNSTON, 1838), and *P. hoplura* (CLAPARÈDE, 1869), as well as those of the family Sabellidae, viz. *Potamilla reniformis* (O.F. MÜLLER, 1771), which have

formerly been studied by RADWAŃSKI (1964, 1969, 1970) and which are commonly encountered both along the rocky seashores of the Korytnica Basin and on any skeletal material (corals, mollusk shells) available within the Korytnica Clays filling up that Basin (*see* RADWAŃSKI 1969, BAŁUK & RADWAŃSKI 1977). On the other side, the polychaetes are represented by the tube-dwelling forms which have hitherto subjected to a very limited research, and which are solely the matter of the present paper.

It is also to note that KERN (1979) and BAŁUK & RADWAŃSKI (1984) reported on the ichnofossil *Helicotaphrichnus commensalis* KERN, GRIMMER & LISTER, 1974, occurring within the columella of some gastropod shells (*see also* BAŁUK & RADWAŃSKI 1991), and attributable to the boring action of such present-day spionid polychaetes as *Polydora commensalis* ANDREWS, 1891, and *P. bioccipitalis* BLAKE & WOODWICK, 1972, the both of which are commensals to the hermit crabs occupying empty gastropod shells (*see* KERN 1979, p. 239; BALUK & RADWAŃSKI 1979a,b, 1984, 1991; WALKER 1992).

Another ichnofossil, *Tibikoia sanctacrucensis* BAŁUK & RADWAŃSKI, 1979, being the aggregates of faecal pellets, was ascribed to the life activity of polychaetes of the family Capitellidae, and related to the present-day species *Heteromastus filiformis* (CLAPARÈDE, 1864); its occurrence is confined to the topmost part of the Korytnica Clays (*see* BAŁUK & RADWAŃSKI 1979c).

The studied material of the tube-dwelling polychaetes has been collected either personally by the author during her studies on the organic assemblage of the oyster shellbed being a littoral facies of the Korytnica Clays (RADWAŃSKA 1982), as well as on the selected groups of invertebrates (RADWAŃSKA & RADWAŃSKI 1984, RADWAŃSKA 1987) and on the teleost fish otoliths (RADWAŃSKA 1984, 1992). Included into the present study is also all the material either reported, primarily that one illustrated, or collected but remained undescribed by some of the former students (BAŁUK 1975; BAŁUK & RADWAŃSKI 1977, 1991).

PREVIOUS WORKS

The first account of the tube-dwelling polychaetes of the Korytnica Clays is that by PUSCH (1837, p. 181) who reported "*Serpula glomerata* L.", the nature of which cannot be recognized now. It passed almost a century when the next report appeared, by DEMBIŃSKA (1924), who recognized a rather rare occurrence (9 specimens) of the free-living species *Ditrupa cornea* (LINNAEUS).

Moreover, in the short monographic description, DEMBIŃSKA (1924) reviewed the taxonomy and occurrences of the tube-dwelling polychaetes noted

and/or collected by former authors (PUSCH, EICHWALD, REUSS, ALTH, ŁOMNICKI, OLSZEWSKI, TEISSEYRE, FRIEDBERG) from the countries (Volhynia and Podolia in the Ukraine) which at present are situated outside Poland. Of the present-day Polish countries only a few localities were noted (Wieliczka, *see* REUSS 1867; Bogucice, Żegocina, Gliwice Stare, Pińczów) to yield *Ditrupa cornea* (LINNAEUS), in one case (Pińczów) associated with "*Serpula lituites* ALTH (in coll.)". Both a needed revision of the taxonomy used by DEMBIŃSKA (1924) and an updating of the occurrence sites of the tube-dwelling polychaetes in Poland (*see also* FRIEDBERG 1907) are beyond of the scope of the present paper.

Concerning the polychaetes of the Korytnica Clays, in successive years KOWALEWSKI (1930, pp. 71 and 111) reported besides the common presence of *Ditrupa cornea* (LINNAEUS), on the species *Spirorbis obtectus* SEGUENZA, the occurrence of which he ascribed to its symbiotic relationship to the gastropod species *Ancilla glandiformis* (LAMARCK) on whose shells these polychaetes were found. Neither this relationship nor the taxonomy of this spirorbid species were accepted by BAŁUK & RADWAŃSKI (1977, p. 107).

When describing the fossils associated to the monographed gastropods, BAŁUK (1975, p. 15) reported (apart from *D. cornea*) on the frequent occurrence of fragmentary tubes of the four serpulid species: *Serpula quinquesignata* REUSS, *S. circumlobata* (BOETTGER), *S. septemcarinata* (BOETTGER), and *S. semicostata* (BOETTGER), all of them from the oyster shellbed exposed around Mt. Lysa (*see* BAŁUK & RADWAŃSKI 1977, RADWAŃSKA 1992). Of these species, the occurrence of *S. circumlobata* (BOETTGER) is not recognized in the present study.

When reviewing the occurrence of various endo- and epizoans of the mollusk shells in the Korytnica Clays, BAŁUK & RADWAŃSKI (1977) noted the genus *Spirorbis* locally numerous on some gastropod shells, especially in their apertural parts (*see* BAŁUK & RADWAŃSKI 1977, p. 107 and Pl. 6, Figs 1-2); the latter feature will be discussed hereafter in this paper.

DISTRIBUTION IN THE KORYTNICA BASIN

The tube-dwelling polychaetes are apparently very rare fossils in the Korytnica Basin. Both in the rocky-shore facies of the oyster shellbed, and in the Korytnica Clays, they occur sporadically in successive organic communities (*see* BAŁUK & RADWAŃSKI 1977, RADWAŃSKA 1992).

In the oyster shellbed they seem to be more common (*see* RADWAŃSKA 1982) than in the open part of the Basin in which the Korytnica Clays were

deposited. In both these deposits the polychaete tubes are found either isolated, having been detached from any soft substrata, or as epibiontic forms encrusting any skeletal materials available on the seafloor (primarily, coral colonies and mollusk shells). The former ones, except of the free-living species *Ditrupa cornea* (LINNAEUS), were certainly attached to such soft substrata as *e.g.* seagrasses and/or the kelp that have profusely thriven along the rocky shores (*see* BAŁUK & RADWAŃSKI 1977, Figs 5-6; RADWAŃSKA 1992, Fig. 2); possibly, they could also be attached to some soft-bodied animals, *e.g.* the sea fans, or the sponges, the presence of the latter of which is inferred from the occurrence of their associates, such as the cirripedes *Acasta* and the gastropods *Tenagodus* reported by BAŁUK & RADWAŃSKI (1967 *and* 1977, p. 97).

Outside the rocky shores, within the depositional area of the Korytnica Clays the tube-dwelling polychaetes occur usually as epizoans of the gastropod shells. Their rarity is evident when taking into account the data presented by BAŁUK & RADWAŃSKI (1977, 1979b, 1991) who inspected over 30,000 gastropod shells searched for various endo- and epibionts, and who found a very inferior number of specimens encrusted by single specimens of spirorbids or serpulids.

SYSTEMATIC ACCOUNT

The investigated polychaete material presented in this paper is composed solely of tubes, whose variable morphology (*see* idealized scheme *in* Text-fig. 1) is the only basis for differentiation of these paleontological subjects to classify them into particular taxa. Any inference on the soft parts of the body which have completely been lost during fossilization may only be taken from an analysis of the comparable present-day taxa. Such a comparison is, however, possible to be done at various taxonomical ranks in particular cases, regardless the extant or extinct nature of the distinguished species.

The general data on the biology and life requirements of the present-day polychaetes, and the dependence of morphological diversity of their tubes on biotope conditions have concisely been reviewed by TEN HOVE & VAN DER HURK (1993), and thus are not repeated here. Some of these data will be referenced and/or commented after the description of the species. Not included into this description is a peculiar material of calcified opercular caps of the tubes, *i.e.* the calottae, which makes up the subject of a separate paper (RADWAŃSKA 1994).

Abbreviations used in the measurement tables included in the description of particular species, are as follows:

Dt — diameter of the tube,
Dc — diameter of the coil,
L — length of the tube.

The studied material is housed at the collection of the Department of Paleontology, Faculty of Geology, University of Warsaw. The isolated tubes are kept under the collection numbers from *No. PK-001* onwards, whereas those attached to the gastropod shells are registered as *PK/GS*, starting with *No. PK/GS-01*. The comparative specimens of the present-day taxa, kindly forwarded by Dr. H. ZIBROWIUS, are referenced as coming from the ZIBROWIUS' Collection.

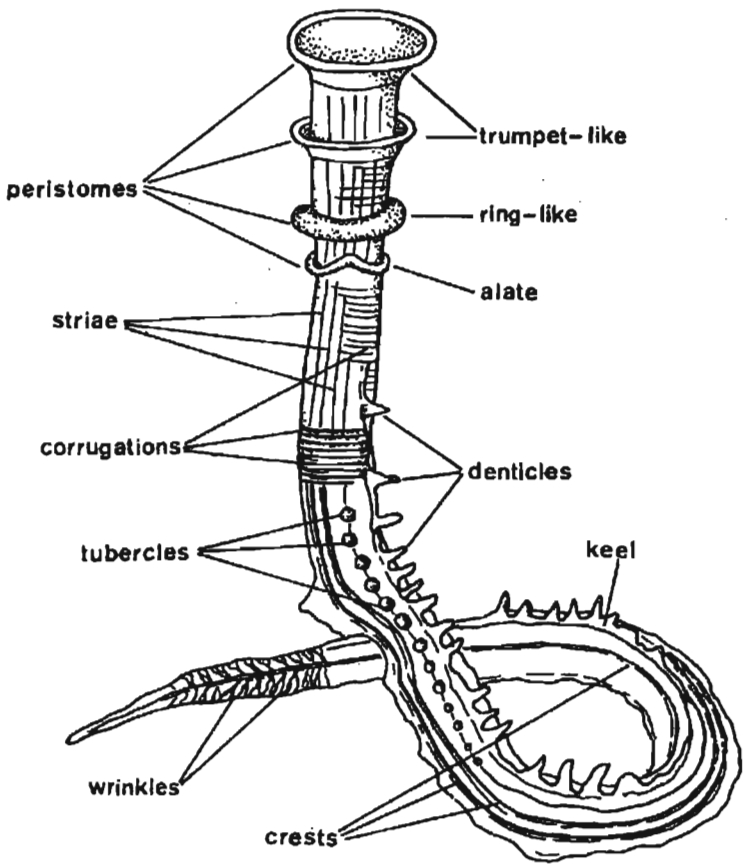


Fig. 1

Morphology of an idealized polychaete tube (*adopted from*: BIANCHI 1981, Fig. 6)

Class **Polychaeta** GRUBE, 1850
Order **Sedentarida** LAMARCK, 1818
Family **Serpulidae** RAFINESQUE, 1815*
Subfamily **Filograninae** RIOJA, 1923
Genus *Filograna* OKEN, 1815

Filograna sp.
(Text-fig. 2 and Pl. 1, Figs 1-3)

MATERIAL: 10 specimens.
DIMENSIONS (*in* mm):

Coll. numbers	Dt	L	Figured in Text-fig. 2	Pl. 1
PK-001	1.0	8.0	a	Fig. 1
PK-002	0.7	4.8	c	Fig. 2
PK-003	0.7	2.5	b	Fig. 3

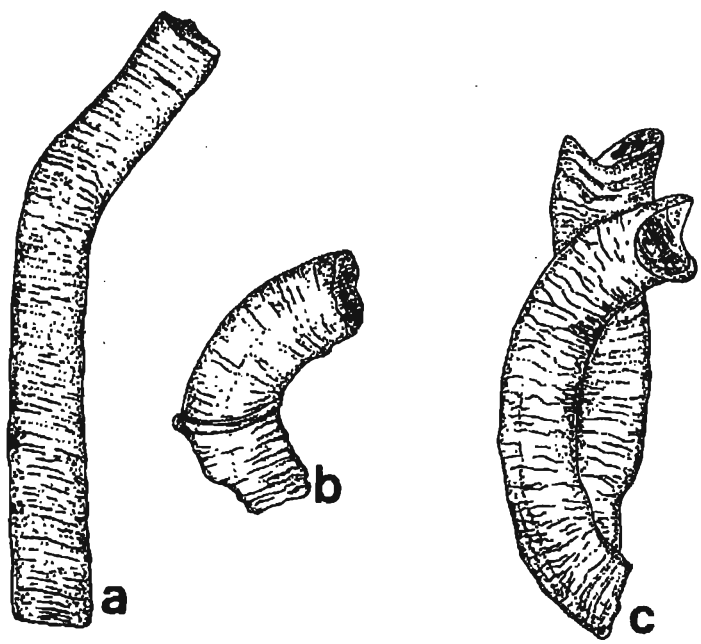


Fig. 2. *Filograna* sp.

a — Specimen No. PK-001, × 10; b — No. PK-003, c — No. PK-002, both × 15

* This authorship has recently been recognized by JÄGER (1993, p. 74). Formerly, it has commonly been ascribed either to SAVIGNY (1818, or 1820), SAVIGNY *in* LAMARCK (1818), LAMARCK (1818), or even BURMEISTER (1837) and JOHNSTON (1865).

DESCRIPTION: Tubes friable, opaque, slighty curved, sometimes adhering to each other longitudinally. The tubes are circular in section, and their surface is furnished with delicate, transverse corrugations. Peristomes seldom appear, and develop along half a margin only.

REMARKS: The studied specimens, due to their dimensions, general outline, characteristic intergrowths along the tubes, and the character of the peristomes are the closest to those of the present-day forms described as "*Filograna* sp." by BIANCHI (1981, p. 137, Fig. 51) from the Mediterranean, and this involved their assignment to the genus *Filograna* OKEN, 1815. The Korytnica specimens differ from these of the genus *Josephella* CAULLERY & MESNIL, 1896, by their greater dimensions, and from those of the genus *Hyalopomatus* MARENZELLER, 1878, by the number of tubes in aggregates and the mode of their intergrowths.

Subfamily **Serpulinae** MACLEAY, 1840
Genus *Serpula* LINNAEUS, 1767

Serpula curvata SCHMIDT, 1950
(Text-fig. 3 and Pl. 1, Figs 4-10)

1950. *Serpula curvata* n.sp.; W.J. SCHMIDT, p. 160, Text-fig. 3.
1955. *Serpula curvata* W.J. SCHMIDT; W.J. SCHMIDT, p. 55, Pl. 6, Fig. 2.

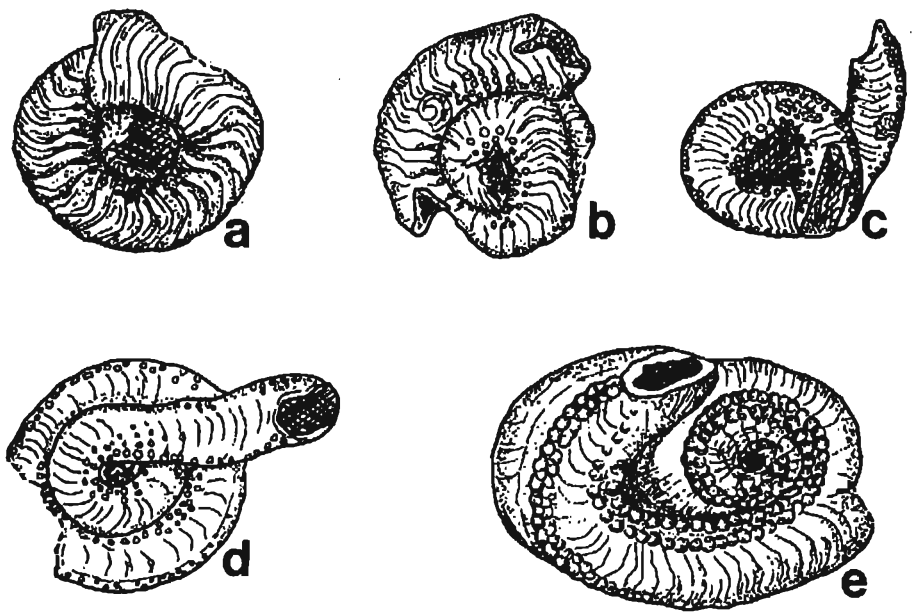


Fig. 3. *Serpula curvata* SCHMIDT, 1950

a — Specimen No. PK-006, b — No. PK-005, c — No. PK-007, d — No. PK-008, e — No. PK-010; all × 10

MATERIAL: 40 specimens.
DIMENSIONS (*in* mm):

Coll. numbers	Dt	Dc	Figured in Text-fig. 3	Figured in Pl. 1
PK-004	0.7	3.5	–	Fig. 4
PK-005	0.8	3.7	b	Fig. 5
PK-006	0.8	3.0	a	Fig. 6
PK-007	0.6	2.5	d	Fig. 7
PK-010	1.0	4.5	e	Fig. 10

DESCRIPTION: Tubes with lustrous outer surface, irregularly coiled ball-like. The tubes are circular in section, and their outer surface is furnished with pronounced, transverse corrugations, bending posteriorly. In some specimens, the corrugations pass into two or three rows of granules on the lateral walls.

REMARKS: The studied specimens are concordant with the holotype of the species (SCHMIDT 1950, Fig. 3), which has hitherto been the only illustrated specimen of the species (*see* SCHMIDT 1969, p. 21). The Korytnica material is much richer, what allows to study the variability of its sculpture. Thus, distinguished are specimens close to the holotype, sculptured by transverse corrugations only (*see* Text-fig. 3*a* and Pl. 1, Fig. 6), as well as specimens featured either by less distinct corrugations passing into granules (*see* Text-fig. 3*b* and Pl. 1, Fig. 5), or by almost indiscernible corrugations and well pronounced granules (*see* Text-fig. 3*e* and Pl. 1, Fig. 10). Between these extremes there occur intermediate forms, which demonstrate the intraspecific variability of the species.

Serpula sp.
(Text-fig. 4 and Pl. 3, Figs 3-5)

MATERIAL: 8 specimens.
DIMENSIONS (*in* mm):

Coll. numbers	Dt	Dc	L	Figured in Text-fig. 4	Figured in Pl. 3
PK-023	0.8	2.3	–	a	Fig. 3
PK-024	0.7	–	3.2	c	Fig. 4
PK-025	1.0	–	4.2	b	Fig. 5

DESCRIPTION: Tubes smooth, of lustrous surface, coiled more or less regularly into a spiral, which becomes straightened anteriorly. The tubes are circular in section, and their outer surface is furnished only by delicate transverse corrugations. Peristomes appear rarely.

REMARKS: The studied specimens are close to those of the present-day species *Serpula lobiancoi* RIOJA, 1917, known from the Mediterranean (*see* BIANCHI 1981, Figs 7f and 15), and this involved their assignment to the genus *Serpula* LINNAEUS, 1767. They differ from those of the preceding species, *Serpula curvata* SCHMIDT, 1950, by their mode of coiling and by their sculpture.

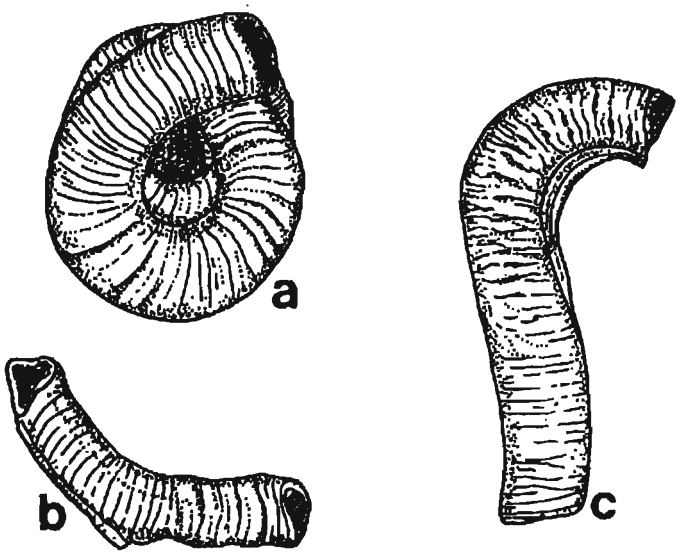


Fig. 4. *Serpula* sp.

a — Specimen No. PK-023, b — No. PK-025, c — No. PK-024; all × 15

Genus *Hydroides* GUNNERUS, 1768

Hydroides vesicularis sp.n.
(Text-fig. 5 and Pl. 2, Figs 1-6)

HOLOTYPE: The specimen No. PK-011, presented in Text-fig. 5*a* and Pl. 2, Fig. 1.
TYPE LOCALITY: Korytnica, 24 km SSW of Kielce, southern slopes of the Holy Cross Mountains, Central Poland.
TYPE HORIZON: Middle Miocene (Badenian).
DERIVATION OF THE NAME: Latin *vesicularis* — covered by vesicles.
MATERIAL: 170 specimens.
DIMENSIONS (*in* mm):

Coll. numbers	Dt	Dc	L	Figured in Text-fig. 5	Figured in Pl. 2
PK-011 — holotype	1.8	—	8.5	a	Fig. 1
PK-012	2.0	—	9.0	—	Fig. 2
PK-013	2.0	—	8.0	c	Fig. 3
PK-016	1.0	4.0	—	d	Fig. 6

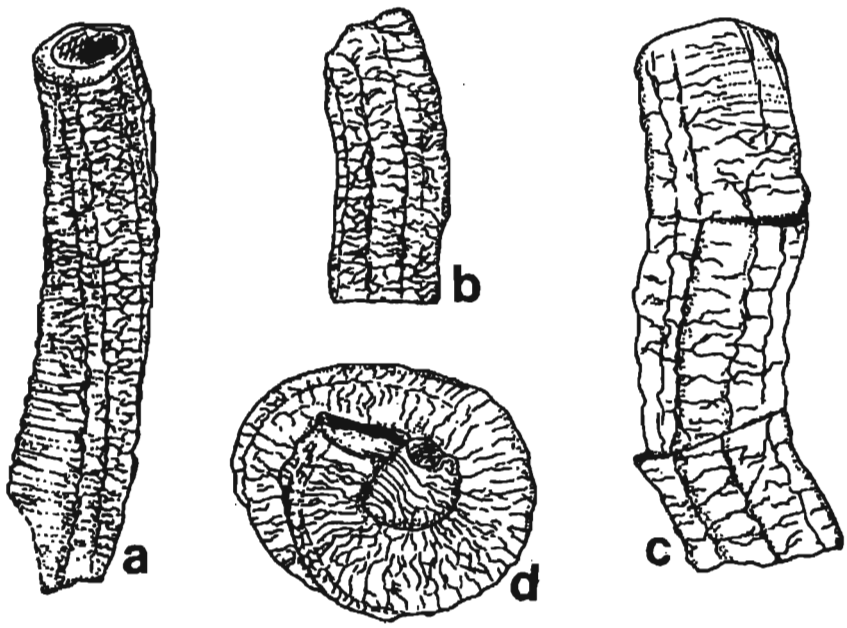


Fig. 5. *Hydroides vesicularis* sp.n.

a — Holotype (Specimen No. PK-011); b-d — paratypes (b — No. PK-015, c — No. PK-013, d — No. PK-016); all × 10

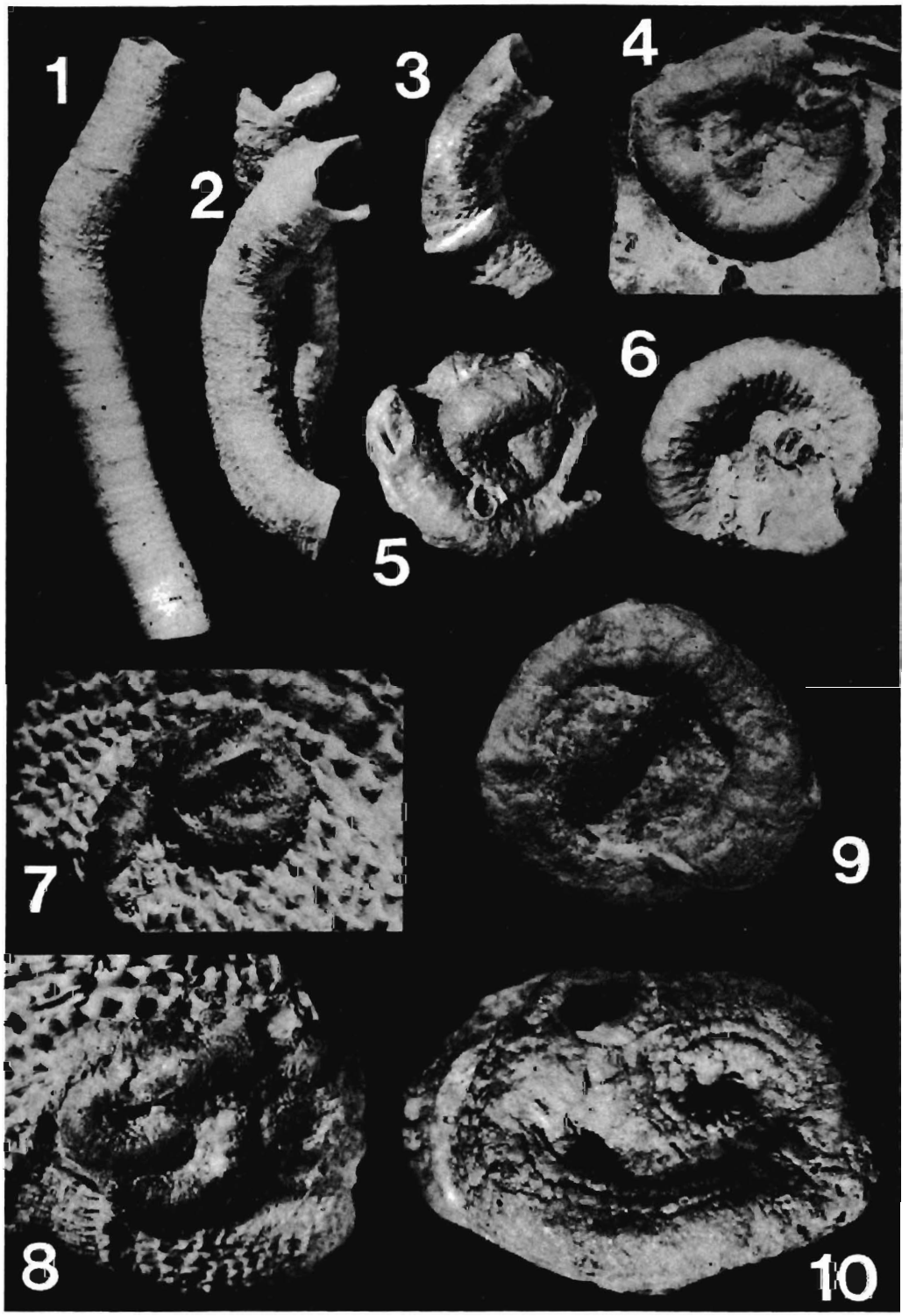
DIAGNOSIS: Tube massive, opaque, circular in section; outer surface totally covered with dense, transverse corrugations, and irregular vesicles; all these surface elements are superposed by a flat, wide, longitudinal ridge, and by two narrow crests situated along both sides of the ridge, and separated from it by shallow grooves.

DESCRIPTION: Tubes massive, opaque, adhered to the substrate along almost the whole length, and only the anterior parts may be upright. The shape of tubes varies from almost straight, through slightly curved, to spirally coiled. The section of tubes is circular. Sculpture developed variably, ranging from very delicate to much pronounced as a flat ridge, and two parallel edges separated from the ridge by shallow grooves. The whole surface is covered by densely spaced transverse corrugations and by vesicles.

PLATE 1

1-3 — *Filograna* sp.; 1 — Specimen No. PK-001, × 10; 2 — No. PK-002, 3 — No. PK-003, both × 15

4-10 — *Serpula curvata* SCHMIDT, 1950; 4 — Specimen No. PK-004, 5 — No. PK-005, 6 — No. PK-006, 7 — No. PK-007, 8 — No. PK-008, 9 — No. PK-009, 10 — No. PK-010; 4-9 × 10, 10 × 15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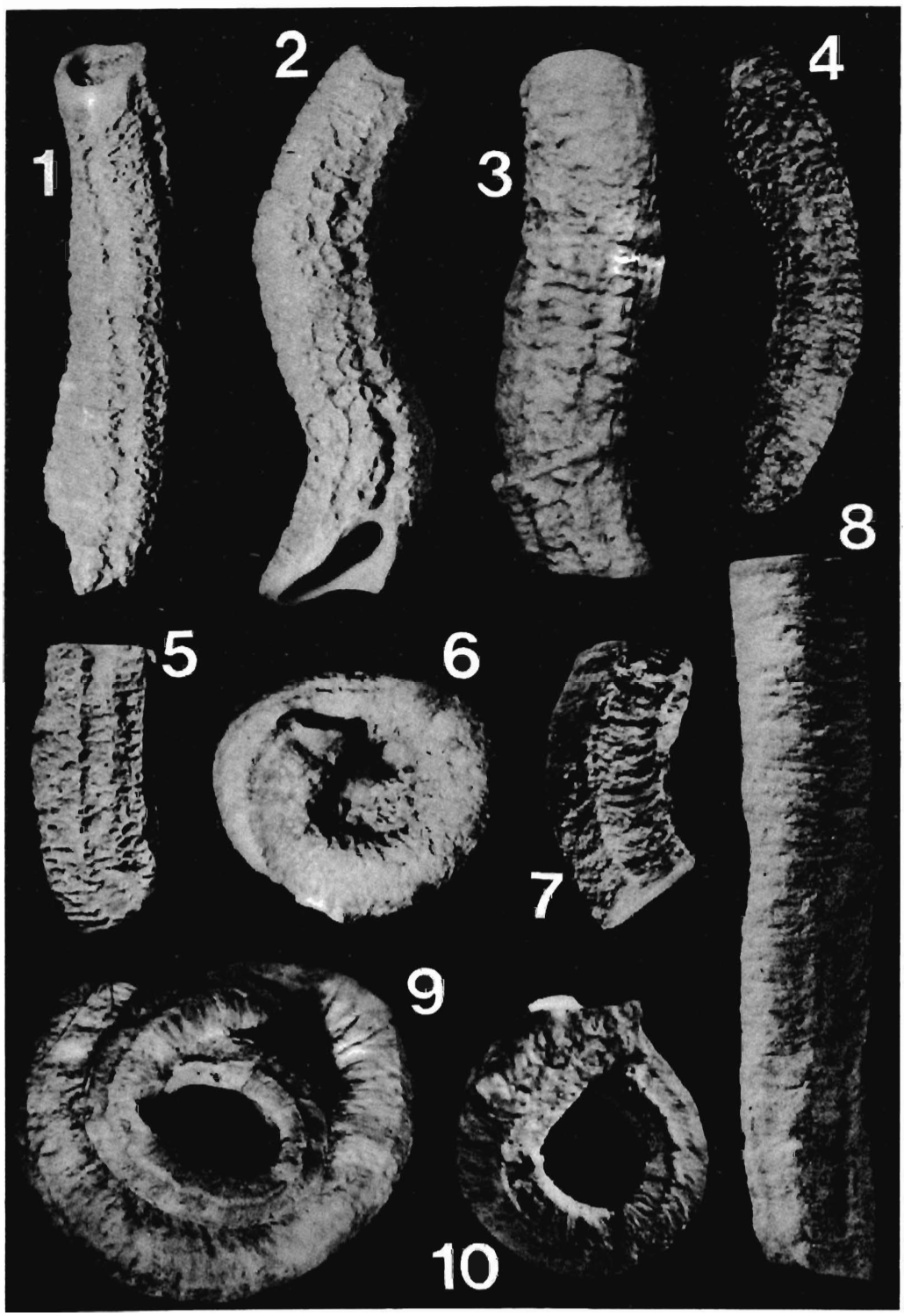
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REMARKS: The studied specimens, due to their dimensions and mode of adherence to the substrate, are close to those of various present-day species of the genus *Hydroides* GUNNERUS, 1768 (*see* BIANCHI 1981). The new species, *Hydroides vesicularis* sp.n., differs from all the present-day congeners by its characteristic sculpture and vesicular outer surface.

Hydroides vicinalis sp.n.
(Text-fig. 6 and Pl. 2, Figs 7-10)

HOLOTYPE: The specimen No. PK-019, presented in Text-fig. 6*a* and Pl. 2, Fig. 9.

TYPE LOCALITY: Korytnica, 24 km SSW of Kielce, southern slopes of the Holy Cross Mountains, Central Poland.

TYPE HORIZON: Middle Miocene (Badenian).

DERIVATION OF THE NAME: Latin *vicinalis* — neighboring, in reference to its association to the preceding species.

MATERIAL: 45 fragmentary specimens.

DIMENSIONS (*in* mm):

Coll. numbers	Dt	Dc	L	Figured in Text-fig. 6	Figured in Pl. 2
PK-019 — **holotype**	1.0	4.0	—	a	Fig. 9
PK-020	0.7	2.0	—	b	Fig. 10
PK-018	1.4	—	7.0	d	Fig. 8

DIAGNOSIS: Tube opaque, massive, spirally coiled in its posterior, and either straight or slightly curved in the anterior part; subquadrangular in section, as the tube is flattened externally; outer surface either covered solely by transverse corrugations, or sculptured by three longitudinal crests, the median one of which is the strongest; corrugations bent anteriorly when approaching the median crest; along the tube-length the peristomes are missing; the final peristomal part lacks crests and becomes circular in section.

DESCRIPTION: All descriptive features are shared with those given in the diagnosis of the species.

REMARKS: The newly established species, *Hydroides vicinalis* sp.n., differs from *H. vesicularis* sp.n. by its sculpture of longitudinal elements and of the outer surface, by its subquadrangular section, and the pattern of corrugations. The species *Hydroides vicinalis* sp.n. is close to the two present-day species, *Hydroides stoichadon* ZIBROWIUS, 1971, and *H. pseudouncinata*

PLATE 2

1-6 — *Hydroides vesicularis* sp.n.: 1 — **Holotype** (Specimen No. PK-011), 2-6 — **paratypes** (2 — No. PK-012, 3 — No. PK-013, 4 — No. PK-014, 5 — No. PK-015, 6 — No. PK-016); all × 10

7-10 — *Hydroides vicinalis* sp.n.: 7-8, 10 — **Paratypes** (7 — Specimen No. PK-017, 8 — No. PK-018; 10 — No. PK-020), 9 — **holotype** (No. PK-019); all × 15

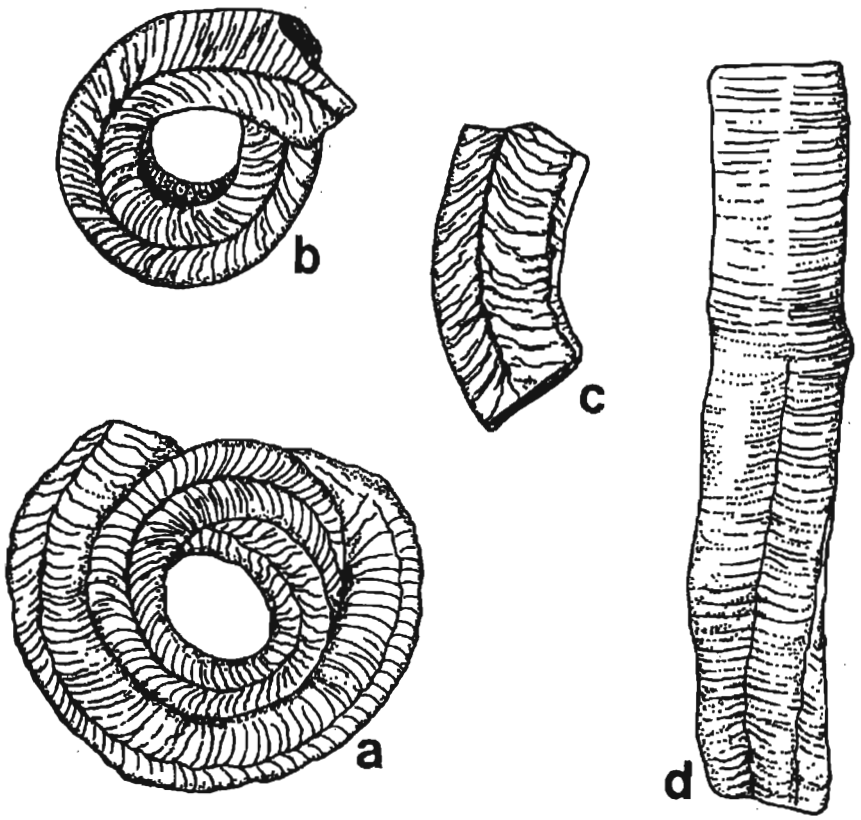


Fig. 6. *Hydroides vicinalis* sp.n.

a — Holotype (Specimen No. PK-019); b-d — paratypes (b — No. PK-020, c — No. PK-017, d — No. PK-018); all × 15

pseudouncinata ZIBROWIUS, 1971, living in the Mediterranean (*see* ZIBROWIUS 1971a, BIANCHI 1981), from which it differs by the median crest the strongest, but all the three crests and the tube wall relatively thinner, and corrugations more delicate.

Genus *Cementula* NIELSEN, 1931

Cementula rugosa sp.n.
(Text-fig. 7 and Pl. 3, Figs 6-11)

HOLOTYPE: The specimen No. PK-026, presented in Text-fig. 7*a* and Pl. 3, Fig. 6.
TYPE LOCALITY: Korytnica, 24 km SSW of Kielce, southern slopes of the Holy Cross Mountains, Central Poland.
TYPE HORIZON: Middle Miocene (Badenian).

DERIVATION OF THE NAME: Latin *rugosus* — furnished with wrinkles, wrinkled.

MATERIAL: 61 specimens.

DIMENSIONS (*in* mm):

Coll. numbers	Dt	Dc	L	Figured in Text-fig. 7	Pl. 3
PK-026 — holotype	1.3	4.0	—	a	Fig. 6
PK-028	0.8	2.8	—	b	Fig. 8
PK-030	1.6	—	3.0	—	Fig. 10
PK-031	1.0	3.0	—	c	Fig. 11

DIAGNOSIS: Tube coiled spirally in its posterior part, but more or less irregular in the anterior part; flattened alongwith the attachment surface, and truncated along its top surface which forms a flat ridge; transverse section like a bottom-flattened and top-truncated triangle; sculptured by transverse, irregular corrugations, tangentially approaching the ridge; rare alate peristomes.

DESCRIPTION: Tubes attached to the substrate, in the posterior part coiled spirally, then more or less irregular (*see* Text-fig. 7*a* and Pl. 3, Fig. 6), are flattened alongwith the attachment surface, and truncated along its top surface which forms a flat, more or less elevated ridge situated centrally (*see* Pl. 3, Fig. 11), to which irregular wrinkles approach tangentially. The anterior part distinctly enlarges, and becomes inflated (*see* Pl. 3, Figs 6-7 and 9), having been often provided with alate peristomes (*see* Pl. 3, Fig. 10).

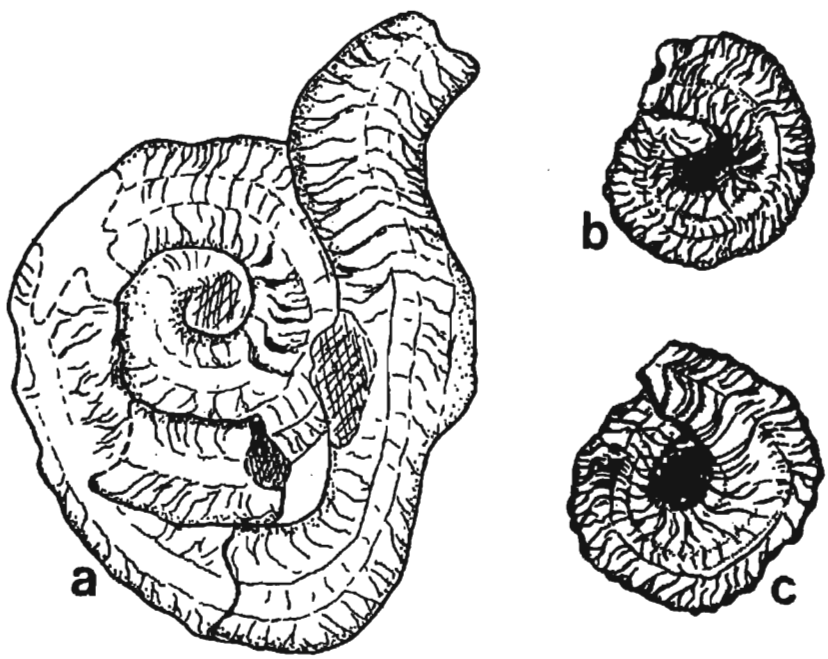
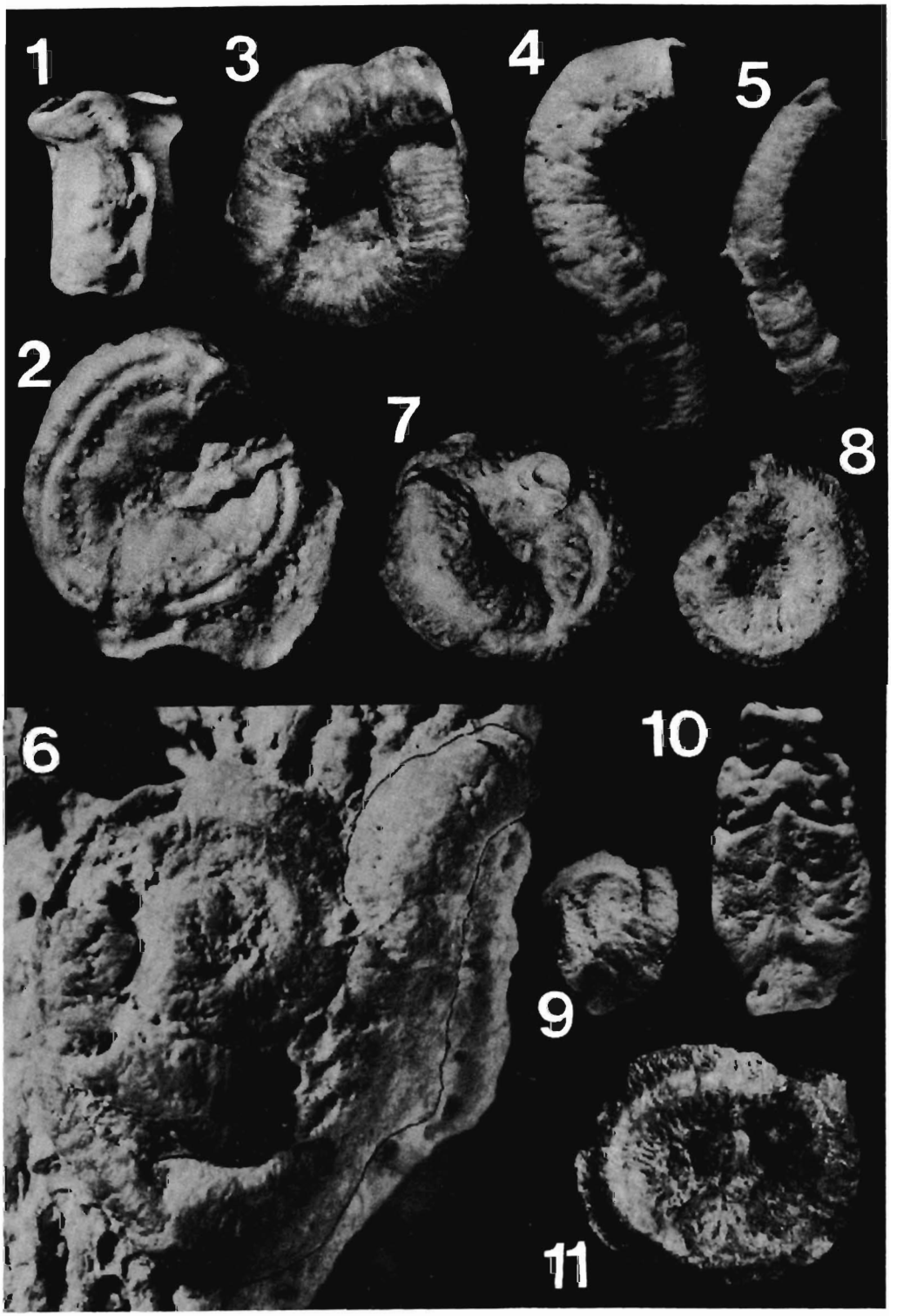


Fig. 7. *Cementula rugosa* sp.n.

a — Holotype (Specimen No. PK-026), × 15; b-c — paratypes (b — No. PK-028, c — No. PK-031), both × 10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REMARKS: The studied specimens, due to their mode of coiling and attachment to the substrate, as well as the shape of peristomes, are assigned to the genus *Cementula* NIELSEN, 1931. The new species, *Cementula rugosa* sp.n., if taking its sculpture into account, is quite similar to the species *Serpula scolopendra* BOETTGER, 1907, described from the Miocene deposits of Romania (*see* ZILCH 1934, Pl. 1, Fig. 8), from which it differs by its mode of coiling.

Cementula verrucifera sp.n.
(Text-fig. 8 and Pl. 3, Figs 1-2)

HOLOTYPE: The specimen No. PK-022, presented in Text-fig. 8*a* and Pl. 3, Fig. 2.
TYPE LOCALITY: Korytnica, 24 km SSW of Kielce, southern slopes of the Holy Cross Mountains, Central Poland.
TYPE HORIZON: Middle Miocene (Badenian).
DERIVATION OF THE NAME: Latin *verrucifera* — bearing warts.
MATERIAL: Two specimens.
DIMENSIONS (*in* mm):

Coll. numbers	Dt	Dc	L	Figured in Text-fig. 8	Figured in Pl. 3
PK-022 — **holotype**	0.8	5.0	–	a	Fig. 2
PK-021	1.3	–	2.0	b	Fig. 1

DIAGNOSIS: Tube coiled spirally, flattened alongwith the attachment surface, with the sutures between whorls coalesced; circular in transverse section; sculptured by a wide, central furrow parallelled by two rounded ridges furnished with fine granules arranged in two rows on each ridge; rare alate peristomes.

DESCRIPTION: Tubes attached to the substrate, flattened at the base, coiled spirally with the sutures between whorls coalesced. Transverse section is circular in the posterior part of the tube, and slightly quadrangular in the anterior part (*see* Text-fig. 8*b* and Pl. 3, Fig. 1). Sculpture reveals as a wide furrow, situated centrally, and two rounded ridges parallelling the furrow from both sides. These ridges are furnished with fine granules arranged in two rows on each ridge. Rare peristomes, distinctly wider than the tube, are alate.

PLATE 3

1-2 — *Cementula verrucifera* sp.n.: 1 — **Paratype** (Specimen No. PK-021, peristomal part of the tube), × 15; 2 — **holotype** (No. PK-022, complete coil), × 10

3-5 — *Serpula* sp.; 3 — Specimen No. PK-023, 4 — No. PK-024, 5 — No. PK-025; all × 15

6-11 — *Cementula rugosa* sp.n.: 6 — Holotype (Specimen No. PK-026, complete coil); 7-11 — **paratypes**: 7-8, 11 — posterior part of the tube, 9 — coil with the peristomal part, 10 — peristomal part of the tube; 7 — No. PK-027, 8 — No. PK-028, 9 — No. PK-029, 10 — No. PK-030, 11 — No. PK-031; 6, 10-11 × 15; 7-9 × 10

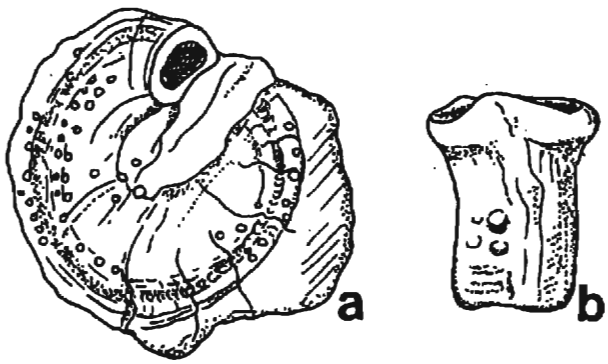


Fig. 8. *Cementula verrucifera* sp.n.

a — **Holotype** (Specimen No. PK-022), × 10; **b** — **paratype** (No. PK-021), × 15

REMARKS: The studied specimens, due to their mode of coiling and attachment to the substrate, as well as the shape of the peristomes, are assigned to the genus *Cementula* NIELSEN, 1931. The new species, *Cementula verrucifera* sp.n., differs from all the hitherto known species of the genus (*see* JÄGER 1983) by its characteristic sculpture composed of fine wart-like granules arranged alongwith the ridges.

Genus *Metavermilia* BUSH, 1904

Metavermilia lacera (REUSS, 1860)
(Text-fig. 9 and Pl. 4, Figs 4-7)

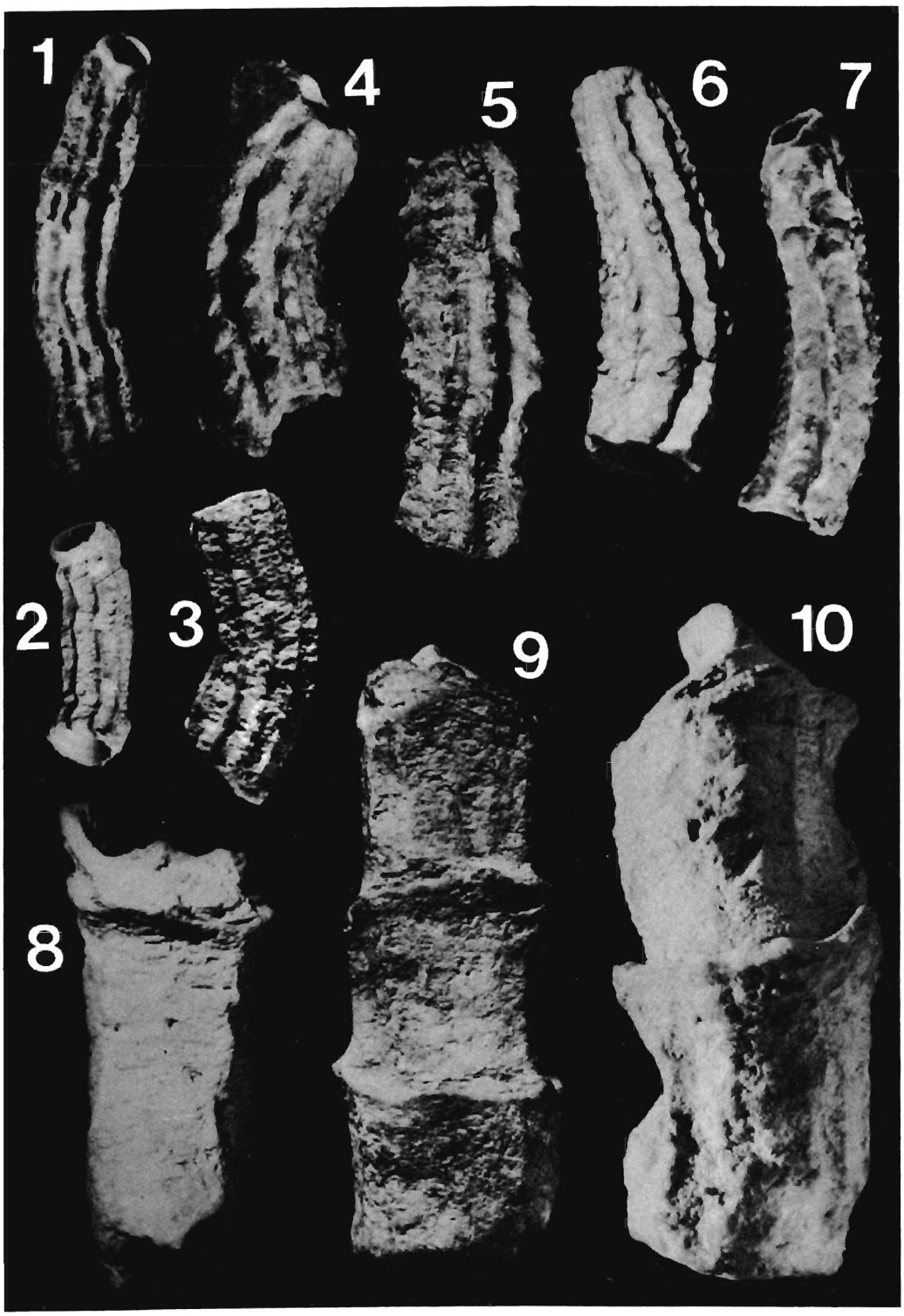
1860. *Serpula lacera* REUSS; A.E. REUSS, p. 225, Pl. 3, Fig. 10a-b.
1901. *Vermetus septemcarinatus* n.sp.; O. BOETTGER, p. 158.
1907. *Serpula septemcarinata* (BTTGR.); O. BOETTGER, p. 214.
1924. *Serpula lacera* REUSS.; M. DEMBIAŃSKA, p. 118, Pl. 2, Fig. 12.
1934. *Serpula septemcarinata* (BOETTGER); A. ZALCI, p. 196, Pl. 1, Fig. 4.
1955. *Serpula lacera* REUSS.; W.J. SCHMIDT, p. 61, Pl. 6, Fig. 14.

PLATE 4

1-3 — *Metavermilia? semicostata* (BOETTGER, 1901); 1 — Specimen No. PK-032, 2 — No. PK-033, 3 — No. PK-034; 1-2 × 10, 3 × 15

4-7 — *Metavermilia lacera* (REUSS, 1860); 4 — Specimen No. PK-035, 5 — No. PK-036, 6 — No. PK-037, 7 — No. PK-038; all × 10

8-10 — *Vermiliopsis monodiscus* ZIBROWIUS, 1968; 8 — Specimen No. PK-039, 9 — No. PK-040, 10 — No. PK-041; all × 10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MATERIAL: 270 specimens.
DIMENSIONS (*in* mm):

Coll. numbers	Dt	L	Figured in Text-fig. 9	Pl. 4
PK-035	1.8	6.0	d	Fig. 4
PK-036	2.0	5.3	a	Fig. 5
PK-037	1.6	6.0	c	Fig. 6
PK-038	1.3	6.0	b	Fig. 7

DESCRIPTION: Tubes massive, straight or slightly curved, adhering to the substrate along almost its whole length. Transverse section is polygonal. Outer surface is sculptured by 5 longitudinal keels, the three median of which are usually more pronounced and folded, while the remaining two, outer ones are much lower, and commonly composed of numerous, isolated tubercles. All the keels are superposed by distinct transverse corrugations. Peristomes are absent.

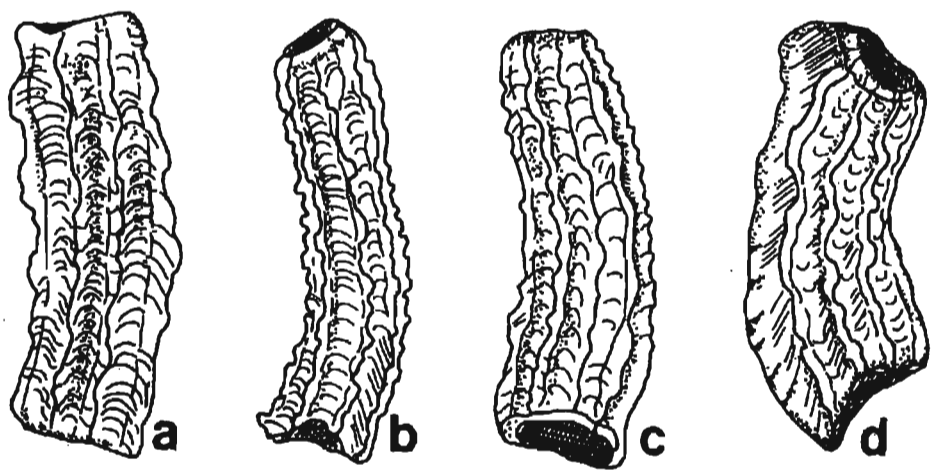

Fig. 9. *Metavermilia lacera* (REUSS, 1860)

a — Specimen No. PK-036, b — No. PK-038, c — No. PK-037, d — No. PK-035; all × 10

REMARKS: The studied specimens are concordant with the holotype of the species (*see* REUSS 1860, Pl. 3, Fig. 10a,b). To the synonymy of the species included are the specimens described by BOETTGER (1901, 1907) as "*Serpula septemcarinata*", the species formerly recorded in the Korytnica Clays by BALUK (1975, p. 15). According to the present author, this species of BOETTGER (1901) comprises the forms identical with those described by REUSS (1860), and the only difference realizes due to the counting (BOETTGER) or not counting (REUSS) two keels formed just at the attachment margin. All other features of the both species are the same.

The assessment of the discussed REUSS' species to the genus *Metavermilia* BUSH, 1904, rests on the sculpture of the tubes and their size, and a lack of peristomes. JÄGER (1983, p. 64) suggested a generic attribution of this species to *Vermiliopsis* SAINT-JOSEPH, 1894. An absence of peristomes,

so characteristic of the latter genus, involves an opinion that the more reasonable is to attribute the species *lacera* to the genus *Metavermilia* BUSH, 1904, in which similar features are displayed by various species (*see* ZIBROWIUS 1971b; BIANCHI 1981, p. 80).

Metavermilia? semicostata (BOETTGER, 1901) (Text-fig. 10 and Pl. 4, Figs 1-3)

1901. *Vermetus semicostatus* n. sp.; O. BOETTGER, p. 158.
1907. *Serpula semicostata* (BTTGR.); O. BOETTGER, p. 215.
1934. *Serpula semicostata* (BOETTGER); A. ZILCH, p. 197, Pl. 1, Fig. 7.

MATERIAL: 10 specimens.
DIMENSIONS (*in* mm):

Coll. numbers	Dt	L	Figured in Text-fig. 10	Pl. 4
PK-032	1.2	6.2	a	Fig. 1
PK-033	1.0	3.5	b	Fig. 2
PK-034	1.0	3.0	d	Fig. 3

DESCRIPTION: Tubes massive, opaque, straight or curved, partly attached to the substrate. Transverse section is circular. Sculpture consists of 5 longitudinal, smooth crests, between which the densely spaced, transverse corrugations are developed.

REMARKS: The studied specimens are concordant with the holotype of the species (*see* ZILCH 1934, Pl. 1, Fig. 7). The collected tubes are, by their size and sculpture, close to those of the

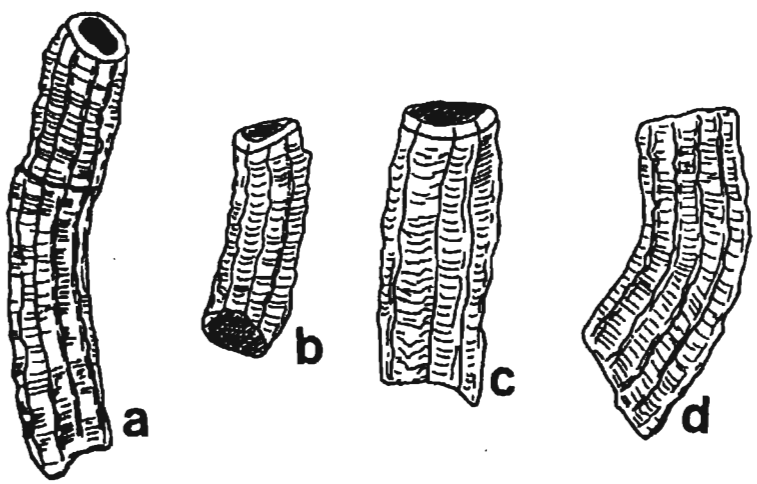

Fig. 10. *Metavermilia? semicostata* (BOETTGER, 1901)

a — Specimen No. PK-032, b — No. PK-033, both × 10; c — No. PK-097, d — No. PK-034, both × 15

present-day species of the genus *Metavermilia* BUSH, 1904. They are also comparable to those of the genus *Semivermilia* TEN HOVE, 1975, whose species display, however, the attachment base much wider than the studied specimens do. In the author's opinion, the species *semicostata* may be included, albeit with a question mark, to the genus *Metavermilia* BUSH, 1904. From the individuals of the species *Metavermilia lacera* (REUSS, 1860), the studied specimens differ by their more slender form, straight (not undulated) keels, and a distinctly lesser increase of the diameter along the tube length.

The species has hitherto been reported from the Miocene deposits of Romania (BOETTGER 1901, 1907; ZILCH 1934), as well as from the Korytnica Clays by BAŁUK (1975, p. 15).

Genus *Vermiliopsis* SAINT-JOSEPH, 1894

Vermiliopsis monodiscus ZIBROWIUS, 1968
(Text-fig. 11 and Pl. 4, Figs 8-10)

1968. *Vermiliopsis monodiscus* n.sp.; H. ZIBROWIUS, pp. 1202-1210, Text-figs A-E and Text-figs F-L.
1981. *Vermiliopsis monodiscus* ZIBROWIUS, 1968; C.N. BIANCHI, pp. 78-79, Text-fig. 28 and Fig. 7k.

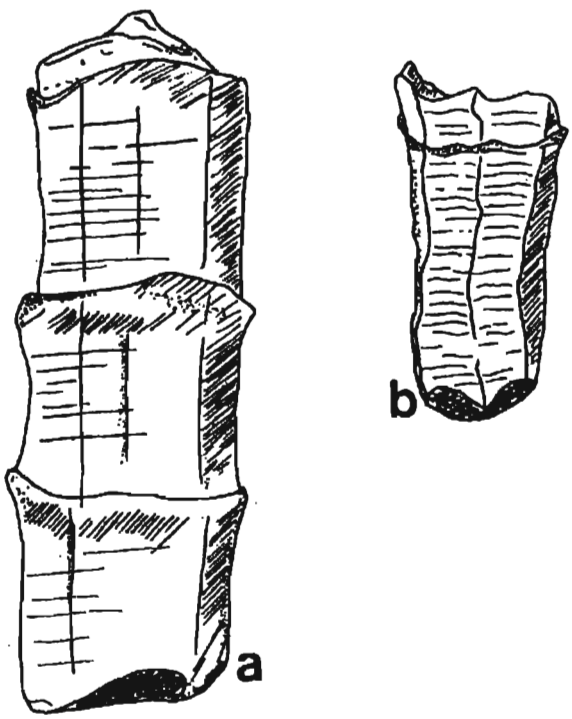

Fig. 11. *Vermiliopsis monodiscus* ZIBROWIUS, 1968

a — Specimen No. PK-040, × 6; b — No. PK-039, × 10

MATERIAL: 9 specimens.
DIMENSIONS (*in* mm):

Coll. numbers	Dt	L	Figured in Text-fig. 11	Figured in Pl. 4
PK-039	3.0	7.0	b	Fig. 8
PK-040	2.8	9.0	a	Fig. 9
PK-041	4.0	10.0	—	Fig. 10

DESCRIPTION: Tubes massive, slightly curved, of a quadrangular transverse section, attached to the substrate alongwith its whole length. Sculpture consists of three, widely distributed crests which are smooth and weakly pronounced, superposed by transverse corrugations. Peristomes are rare, trumpet-like.

REMARKS: The studied specimens are concordant with those of the present-day species *Vermiliopsis monodiscus* ZIBROWIUS, 1968, living in the Mediterranean (*see* ZIBROWIUS 1968b, Text-fig. A-E). Such forms have not hitherto been reported from the fossil state.

Vermiliopsis quinquesignata (REUSS, 1860)
(Text-fig. 12 and Pl. 5, Figs 1-9)

1860. *Serpula quinquesignata* m. n.sp.; A.E. REUSS, p. 224, Pl. 3, Fig. 6.
1901. *Vermetus* (*Bivonlopsis*) aff. *adcolimax* SACCO; O. BOETTGER, p. 159.
1907. *Serpula quinquesignata* Rss; O. BOETTGER, p. 214.
1934. *Serpula quinquesignata* REUSS; A. ZILCH, p. 197, Pl. 1, Fig. 6.
1951. *Vermilia quinquesignata* Reuss *kienbergi* n. subsp.; W.J. SCHMIDT, p. 82, Text-fig. 8.
1955. *Vermilia quinquesignata* (REUSS); W.J. SCHMIDT, p. 68, Pl. 7, Figs 9-10.
1955. *Vermilia quinquesignata kienbergi* W.J. SCHMIDT; W.J. SCHMIDT, p. 68, Pl. 7, Fig. 11.

MATERIAL: 260 specimens.
DIMENSIONS (*in* mm):

Coll. numbers	Dt	Dc	L	Figured in Text-fig. 12	Figured in Pl. 5
PK-042	1.4	—	4.3	d	Fig. 1
PK-043	2.3	—	6.7	i	Fig. 2
PK-046	1.5	3.5	—	e	Fig. 5
PK-047	1.3	2.7	—	f	Fig. 6
PK-050	2.0	—	44.0	—	Fig. 9

DESCRIPTION: Tubes massive, attached to the substrate alongwith their major parts. The fragmented material includes both the curved, as well as either spirally or irregularly coiled parts of the tubes. Their transverse section is circular, flattened at the attachment surface. Sculpture consists of 5 longitudinal crests, developed variably, as in some specimens they are wide and almost join each other (such specimens bear their sculpture the closest to that of the holotype), and in the others they are narrow and distinctly separated. All the keels are superposed by transverse, ring-shaped swellings corresponding to successive peristomes. Between these swellings there occur finer corrugations which cross the crests with a checkered pattern. The peristomes are ring-like.

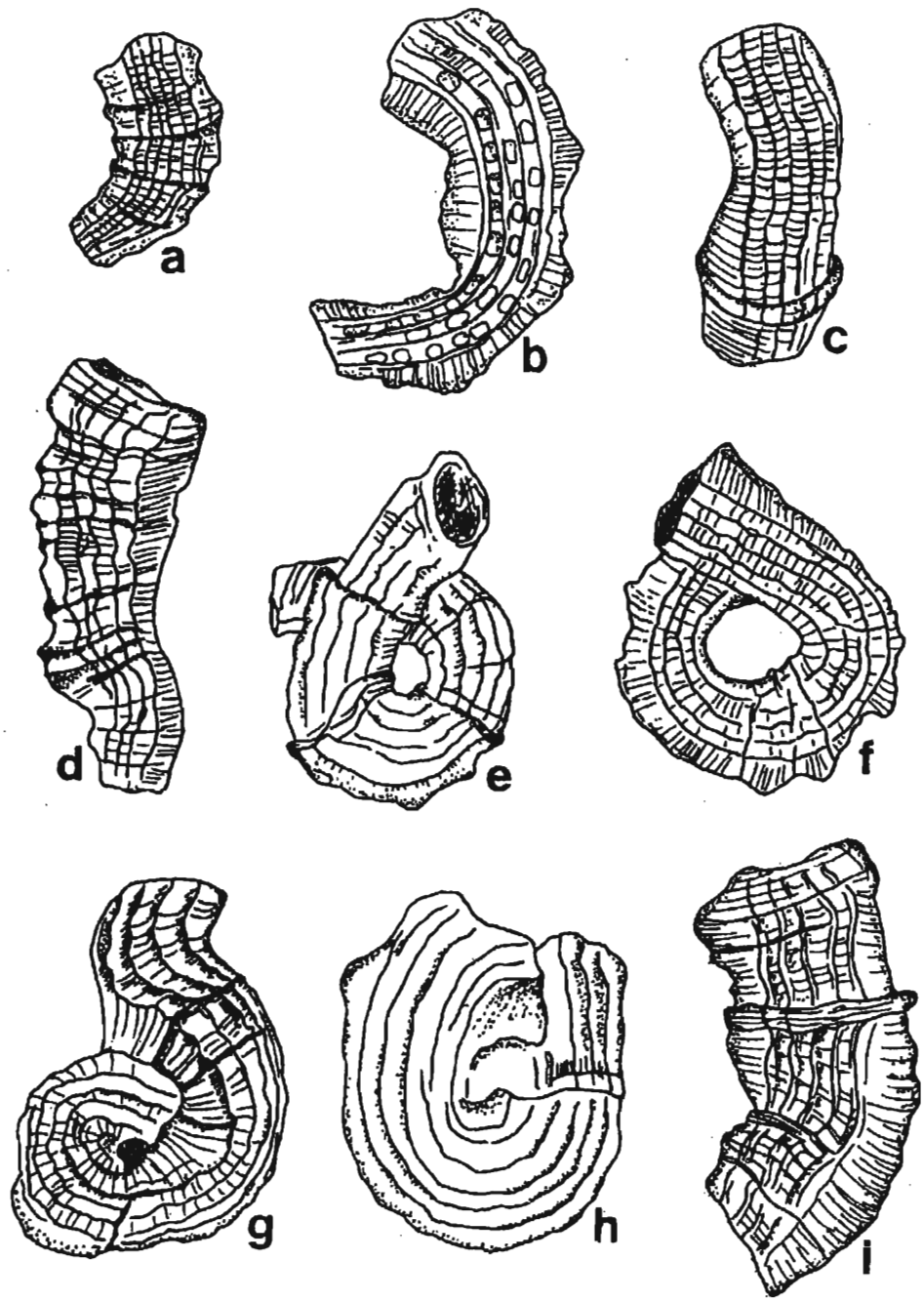

Fig. 12. *Vermiliopsis quinquesignata* (REUSS, 1860)

a — Specimen No. PK-098, b — No. PK-044, c — No. PK-045, d — No. PK-042, e — No. PK-046, f — No. PK-047, g — No. PK-048, h — No. PK-049, i — No. PK-043; a-b,e,h × 10; c-d,f-g × 15

REMARKS: The studied specimens are concordant with the holotype of the species (*see* REUSS 1860, Pl. 3, Fig. 6), although a relatively rich material from the Korytnica Clays displays a much greater variability of the tube sculpture. Between the extremes there occur intermediate forms what justifies to regard all of them as conspecific. This also allows to include into the synonymy of the species the forms distinguished by SCHMIDT (1951) as "*Vermilia quinquesignata* REUSS *kienbergi* n. subsp.".

It is noteworthy, that the species *Vermiliopsis quinquesignata* REUSS, 1860, is of a great similarity to the present-day species *Vermiliopsis labiata* (O.G. COSTA, 1861) living in the Mediterranean (*see* BIANCHI 1981, Fig. 27). When comparing the Korytnica specimens with the present-day forms (ZIBROWIUS' Collection) it is evident that the studied specimens display a more pronounced sculpture and the keels more densely spaced. The species has formerly been reported from the Korytnica Clays by BALUK (1975, p. 15).

Vermiliopsis sp.
(Text-fig. 13 and Pl. 6, Figs 5-8)

MATERIAL: 74 specimens.
DIMENSIONS (*in* mm):

Coll. numbers	Dt	L	Figured in Text-fig. 13	Pl. 6
PK-055	1.4	4.5	b	Fig. 5
PK-056	2.0	5.2	d	Fig. 6
PK-057	3.8	11.0	a	Fig. 7
PK-058	3.0	6.0	c	Fig. 8

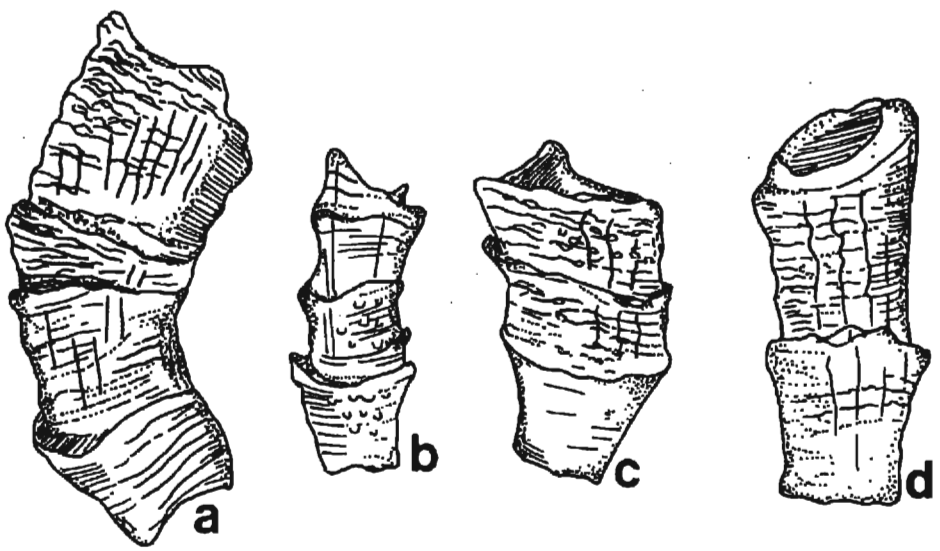

Fig. 13. *Vermiliopsis* sp.

a — Specimen No. PK-057, b — No. PK-055, c — No. PK-058, d — No. PK-056; a,c × 6; b,d × 10

DESCRIPTION: Tubes massive, slightly curved, attached to the substrate alongwith almost their whole length. Transverse section is circular. The sculpture is very delicate, developed as numerous granules arranged in transverse streaks and, locally, as longitudinal striae numbering of 7; all these elements are superposed by transverse corrugations. Peristomes are trumpet-like, relatively densely spaced.

REMARKS: The collected material comprises only fragmented tubes, what does not allow to estimate the overall shape of the tubes. The preserved fragments of tubes, due to their size, shape and sculpture, are the closest to the two present-day species, *Vermiliopsis infundibulum* (PHILIPPI, 1844) and *V. monodiscus* ZIBROWIUS, 1968, living in the Mediterranean (*see* ZIBROWIUS 1968a,b; BIANCHI 1981, Figs 7p and 25). The Korytnica specimens differ from *V. infundibulum* by their more granulated outer surface, and from *V. monodiscus* by the number of keels and their density. A lack of well preserved specimens suggests to determine the Korytnica material to the genus level only.

Genus *Semivermilia* TEN HOVE, 1975

Semivermilia sp.
(Text-fig. 14 and Pl. 6, Figs 3-4)

MATERIAL: Two specimens.
DIMENSIONS (*in* mm):

Coll. numbers	Dt	L	Figured in Text-fig. 14	Pl. 6
PK-053	0.8	3.5	a, b	Fig. 3
PK-054	0.8	3.0	c	Fig. 4

DESCRIPTION: Tubes small, opaque, curved, attached to the substrate alongwith its total length. Transverse section is subtriangular. Sculpture consists of three rounded ridges, the median one of which is the widest and most pronounced, and furnished with three narrow crests; of the latter crests, one is situated centrally, and two other run along both sides of the median ridge.

REMARKS: The studied specimens, by their sculpture and size, are close to those of the present-day species *Semivermilia pomatostegoides* (ZIBROWIUS, 1969) living in the Mediterranean (*see* BIANCHI 1981, p. 91, Fig. 34). The collected specimens differ, however, by the development of

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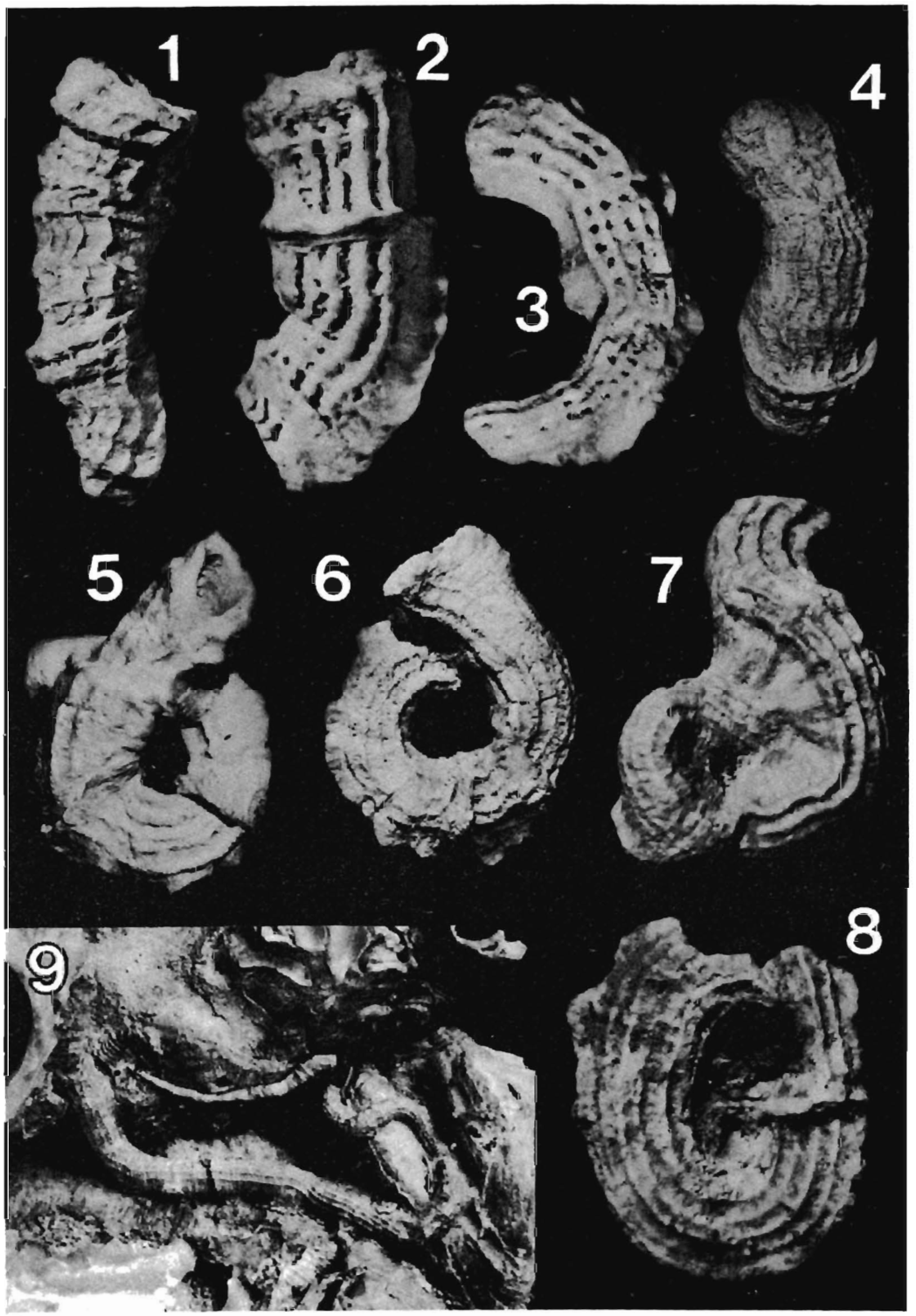
PLATE 5

1-9 — *Vermiliopsis quinquesignata* (REUSS, 1860); 1-4 — Anterior part of the tube; 5-8 — Posterior part of the tube; 9 — Wholly preserved tube on the shell of the vermetid gastropod *Lemintina arenaria* (LINNAEUS); 1 — Specimen No. PK-042, 2 — No. PK-043, 3 — No. PK-044, 4 — No. PK-045, 5 — No. PK-046, 6 — No. PK-047, 7 — No. PK-048, 8 — No. PK-049, 9 — No. PK-050; 1, 4, 6-7 × 15; 2-3, 5, 8 × 10; 9 × 4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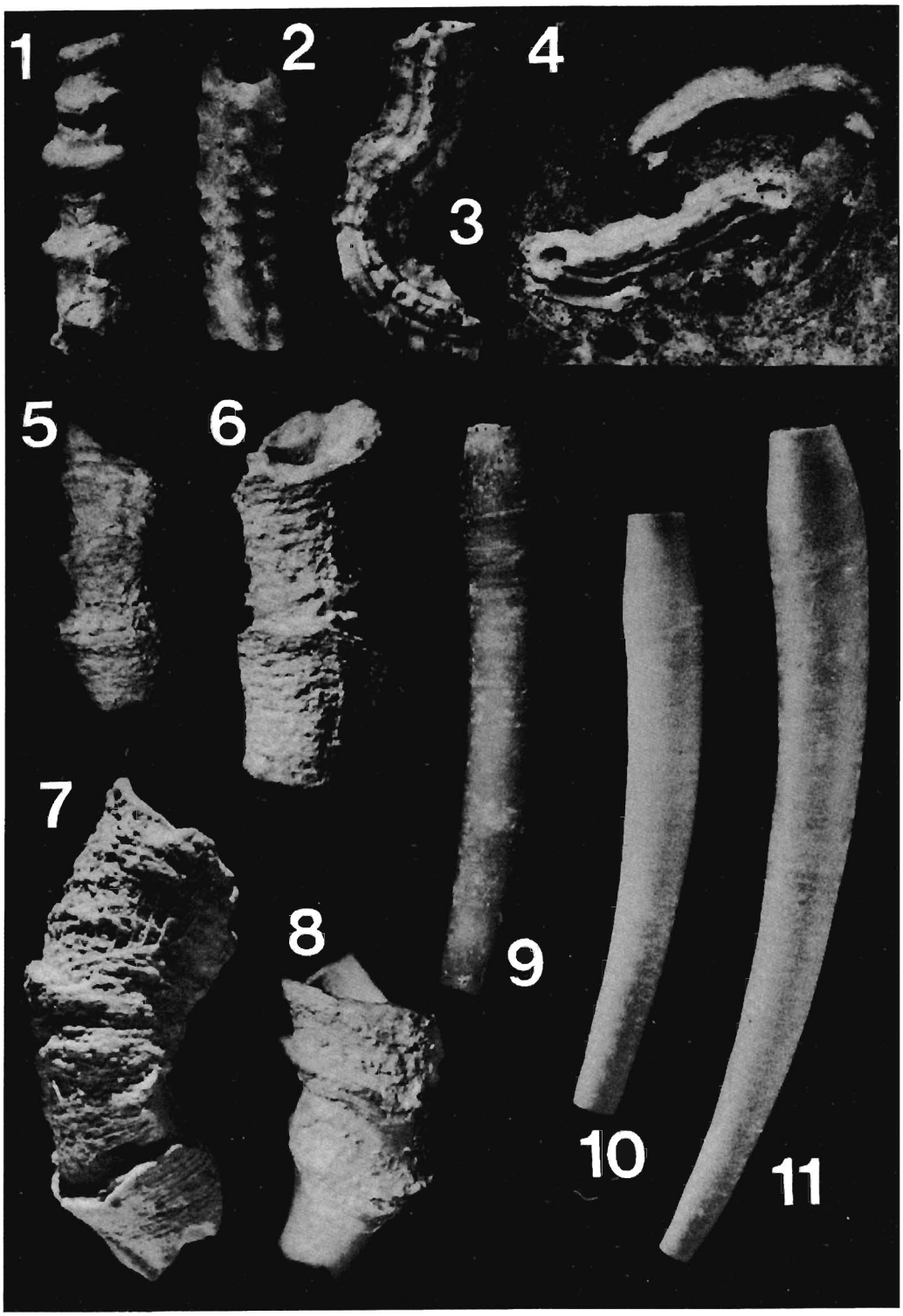
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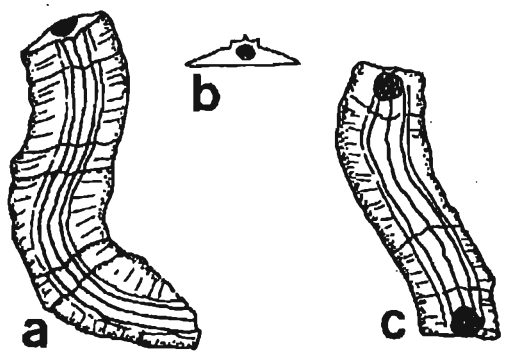

Fig. 14. *Semivermilia* sp.

a, c — Whole tubes, b — section of the tube; a-b — Specimen No. PK-053, c — No. PK-054; all × 15

three crests on the median ridge. An inferior material collected justifies its recognition to the genus level only.

Genus *Filogranula* Langerhans, 1884

Filogranula sp.
(Text-fig. 15 and Pl. 6, Fig. 1)

MATERIAL: Three specimens (anterior parts of tubes).
DIMENSIONS (*in* mm):

Coll. numbers	Dt	L	Figured in Text-fig. 15	Figured in Pl. 6
PK-051	0.7	3.2		Fig. 1

PLATE 6

1 — *Filogranula* sp.; Specimen No. PK-051, × 15

2 — *Vepreculina* sp.; Specimen No. PK-052, × 20

3-4 — *Semivermilia* sp.; 3 — Specimen No. PK-053, 4 — No. PK-054, both × 15

5-8 — *Vermiliopsis* sp.; 5 — Specimen No. PK-055, 6 — No. PK-056, both × 10; 7 — No. PK-057, 8 — No. PK-058, both × 6

9-11 — *Ditrupa cornea* (Linnaeus, 1767); 9 — Specimen No. PK-059, 10 — No. PK-060, 11 — No. PK-061; all × 10

DESCRIPTION: Tubes small, opaque, straight or slightly curved, circular in section. Outer surface furnished with numerous, thick, ring-like swellings that correspond to successive peristomes.

Fig. 15. *Filogranula* sp.

Anterior part of the tube (Specimen No. PK-051), × 15

REMARKS: The studied specimens, due to their size and characteristic ring-like peristomes, are the closest to those of the present-day species *Filogranula annulata* (O.G. Costa, 1861) living in the Mediterranean (*see* Zibrowius 1972; Bianchi 1981, p. 97, Fig. 37).

An inferior number of the collected material and its incomplete nature (basal parts of tubes are missing) do not allow for a specific recognition.

? Genus *Janita* Saint-Joseph, 1894

? *Janita* sp.
(Text-fig. 16 and Pl. 7, Figs 9-11)

MATERIAL: Five specimens.
DIMENSIONS (*in* mm):

Coll. numbers	Dt	L	Figured in Text-fig. 16	Figured in Pl. 7
PK-070	0.6	2.0	b	Fig. 9
PK-071	1.0	2.0	a	Fig. 10
PK-072	1.0	8.0	c	Fig. 11

DESCRIPTION: Tubes small, massive, opaque, attached to the substrate alongwith its whole length. Transverse section is triangular. Outer surface is sculptured by 5 rather indistinct crests, crossed by delicate transverse corrugations.

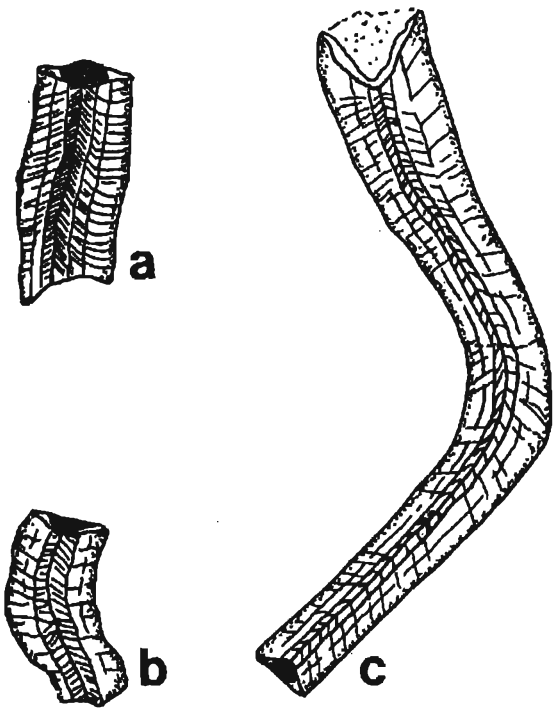

Fig. 16. ?*Janita* sp.

a — Specimen No. PK-071, b — No. PK-070, c — No. PK-072; all × 15

REMARKS: The studied specimens, due to their size and sculpture, fit almost well into features of the ancient forms referred to the genus *Janita* SAINT-JOSEPH, 1894 (*see* JÄGER 1983, p. 71), the present-day representatives of which bear, however, distinct and usually tattered keels (*see* BIANCHI 1981, pp. 101-103). An inferior number of the collected material and its poor state of preservation justify its recognition to the supposed genus only.

Genus *Vepreculina* REGENHARDT, 1961

Vepreculina sp.
(Text-fig. 17 and Pl. 6, Fig. 2)

MATERIAL: One fragment of the tube.
DIMENSIONS (*in* mm):

Coll. numbers	Dt	L	Figured in Text-fig. 17	Figured in Pl. 6
PK-052	0.5	2.0		Fig. 2

Fig. 17. *Vepreculina* sp.

Fragment of the tube (Specimen No. PK-052), × 20

DESCRIPTION: Tube small, originally attached to the substrate. Transverse section is pentagonal. Outer surface is sculptured by 3 crests furnished with relatively massive nodes.

REMARKS: The studied specimen, due to its size and sculpture, fits well into diagnostic features of the genus *Vepreculina* REGENHARDT, 1961 (*see* JÄGER 1983, p. 73); its specific recognition requires to study a more complete material.

Genus *Placostegus* PHILIPPI, 1844

Placostegus echinatus sp.n.
(Text-fig. 18 and Pl. 7, Figs 1-8)

HOLOTYPE: The specimen No. PK-065, presented in Text-fig. 18*a-b* and Pl. 7, Fig. 4*a-4b*.

TYPE LOCALITY: Korytnica, 24 km SSW of Kielce, southern slopes of the Holy Cross Mountains, Central Poland.

TYPE HORIZON: Middle Miocene (Badenian).

DERIVATION OF THE NAME: Latin *echinatus* — bearing prickles.

MATERIAL: 300 specimens.

DIMENSIONS (*in* mm):

Coll. numbers	Dt	Dc	L	Figured in Text-fig. 18	Figured in Pl. 7
PK-065 — **holotype**	0.9	3.4	—	a, b	Fig. 4a-4b
PK-063	1.2	—	5.7	c	Fig. 2
PK-064	1.2	—	6.0	d	Fig. 3
PK-068	1.2	—	5.0	e	Fig. 7

DIAGNOSIS: Posterior part of tube coiled loop-like, anterior part erected freely; transverse section subtriangular, outer surface sculptured by the weakly developed median keel, furnished with sharp, pronounced prickles, distributed at equal intervals.

DESCRIPTION: Tubes are usually opaque, but some are translucent, with outer surface glassy. Posterior parts of the tubes are coiled spirally or loop-like, while anterior ones are straight up-right. Transverse section is subtriangular. Outer surface is sculptured by a weekly developed median keel, furnished with sharp prickles, distributed at equal intervals. Peristome is provided with three teeth.

REMARKS: The newly established species, *Placostegus echinatus* sp.n., is close to the two present-day species, *P. tridentatus* (FABRICIUS, 1779) and *P. crystallinus* ZIBROWIUS, 1968, which are known *i.a.* from the Mediterranean (*see* ZIBROWIUS 1968a, BIANCHI 1981). It differs, however, by its less distinct keel, by more pronounced and regularly distributed projections that acquire a character of prickles rather than denticles, as well as by the more regular mode of coiling of the tube in its posterior part.

The majority of the studied specimens are opaque, and only some of them (*see* Pl. 7, Fig. 3) are transparent. The mode of the tube coiling in its posterior part ranges from spiral to a loop-shaped. It is to note, that both the tube transparency and its coiling (opaqueness and spiral coiling) have been regarded by REGENHARDT (1961) as distinctive for the extinct genus *Eoplacostegus* REGENHARDT, 1961. The investigated material from the Korytnica Clays indicates clearly that these both features are variably demonstrated within one species, and thus they cannot be used as diagnostic at the genus rank, what

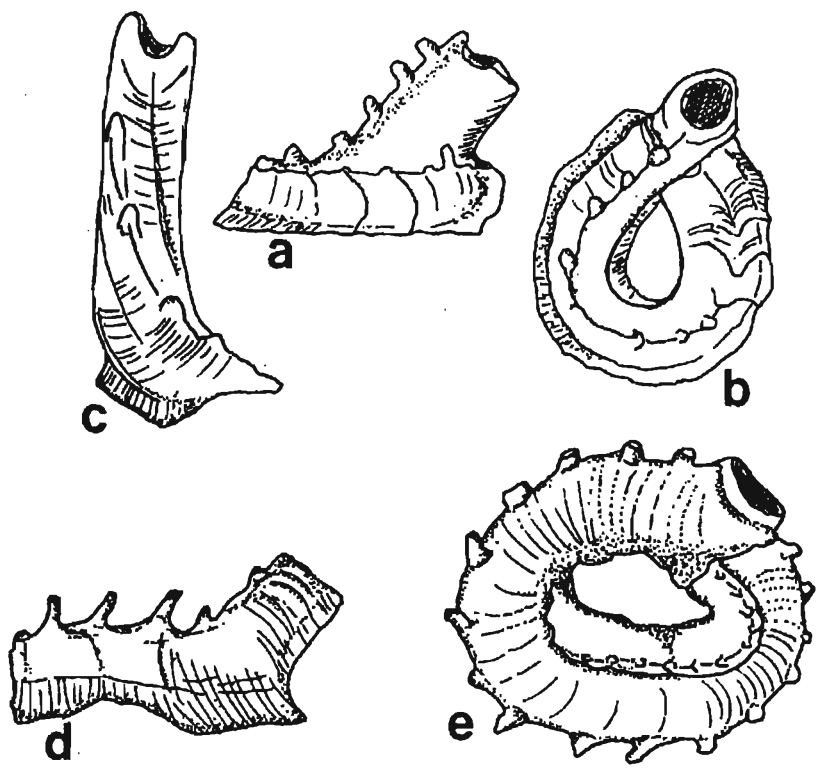

Fig. 18. *Placostegus echinatus* sp.n.

a-b — Holotype: a — lateral view of the tube, **b** — top view of the tube (**a-b** — Specimen No. PK-065), **c-e — paratypes** (**c** — No. PK-063, **d** — No. PK-064, **e** — No. PK-068); all × 10

has recently been stated also by JÄGER (1993, p. 98), and formerly announced by LOMMERZHEIM (1979, p. 163).

From the Middle Miocene (Badenian) deposits of Austria, SCHMIDT (1950) described the species "*Pomatocerus dentatus*" which, in the present author's opinion, belongs to the genus *Placostegus* PHILIPPI, 1844. That species differs from *P. echinatus* sp. n. by its strong corrugation of the tube surface, and by the less pronounced denticle-like projections, distributed on the keel irregularly. Another ancient species from Austria and Italy, *Placostegus polymorphus* ROVERETO, 1895, has also less distinct denticles, and a greater number of keels (*cf.* ROVERETO 1895; SCHMIDT 1955, 1969).

Genus *Ditrupa* BERKELEY, 1835

Ditrupa cornea (LINNAEUS, 1767) (Text-fig. 19 and Pl. 6, Figs 9-11)

1924. *Ditrupa cornea* L.; M. DEMBIŃSKA, p. 122, Pl. 2, Figs 1, 1a, and 1b.
1955. *Ditrupa cornea* (LINNAEUS); W.J. SCHMIDT, p. 42, Pl. 4, Figs 1-7.

MATERIAL: 400 specimens.
DIMENSIONS (*in* mm):

Coll. numbers	Dt_{max}	L	Figured in Text-fig. 19	Figured in Pl. 6
PK-059	1.2	8.5	a	Fig. 9
PK-060	1.3	9.4	b	Fig. 10
PK-061	1.5	12.5	c	Fig. 11

DESCRIPTION: Tubes free, slightly arched, increasing in the diameter during the growth, and clavately swollen at the peristome.

REMARKS: This cosmopolitic Linnean species, established upon the forms from Atlantic shores of Africa, and commonly reported from the Tertiary (Paleocene-Pliocene) deposits of Europe, has over the century been regarded as a scaphopod (*see e.g.* EICHWALD 1830, 1853; PUSCH 1837; HÖRNES 1856; REUSS 1867) and it is often referenced to live at present times in the Mediterranean (*e.g.* DEMBIŃSKA 1924, p. 123; SCHMIDT 1955, p. 45 *and* 1969, p.13). The latter statement does not seem to be verified: according to BIANCHI (1981, pp. 123-125) only the species *Ditrupa arietina* (O.F. MÜLLER, 1776) is known therein (*see also* BANSE 1963).

To the truth, some authors (*see* TEN HOVE & SMITH 1990, p. 101) object the validity of the holotype of this Linnean species, *Ditrupa cornea* (LINNAEUS, 1767), and of all 19*th*-century reports attributed to this species, and they suggest that the widely distributed in the Atlantic bioprovince *Ditrupa arietina* (O.F. MÜLLER, 1776) is the only, really existing species, having been recently coupled (TEN HOVE & SMITH 1990) with *Ditrupa gracillima* GRUBE, 1878, of the Indo-Pacific bioprovince.

If the above suggestion is right, then a special study is required of all ancient forms referred in paleontological monographs to as *Ditrupa cornea* (LINNAEUS, 1767) and/or as other, morphologically very similar and certainly closely related species established in the middle of this century by MEZNERICS (1944) and SCHMIDT (1955).

Within the ancient material, more detailed studies on the *Ditrupa* populations were performed upon the Miocene materials from Hungary, Romania (Kostej, Lapugy, and Bujtur), and Slovakia (Dévényújfalu = Devinska Nova Ves) by MEZNERICS (1944) who recognized the presence of the two species, *Ditrupa cornea* (LINNAEUS, 1767) and *Ditrupa transsilvanica* MEZNERICS, 1944 (*see also* SCHMIDT 1955, 1969; BOHN-HAVAS 1981). These two species, as it is judged from the morphology of tubes, may be a good counterpart of the present-day pair of species, *Ditrupa arietina* (O.F. MÜLLER, 1776) and *Ditrupa gracillima* GRUBE, 1878.

This discussed *Ditrupa*, under the specific name "*cornea*" was first recorded to occur in the Korytnica Basin by DEMBIŃSKA (1924), while the subsequent authors have always noted it as common (KOWALEWSKI 1930, p. 71; BAŁUK 1975, p. 15), both within the Korytnica Clays and the overlying marly sands and red-algal (lithothamian) limestones (GUTOWSKI 1984). The species occurs also in other localities of the Middle Miocene (Badenian) deposits in the Holy Cross Mountains (Pińczów: DEMBIŃSKA 1924; Rybnica and others: KOWALEWSKI 1930), where it locally is even gregarious (Różanka near Chmielnik: RADWAŃSKI 1969, p. 72).

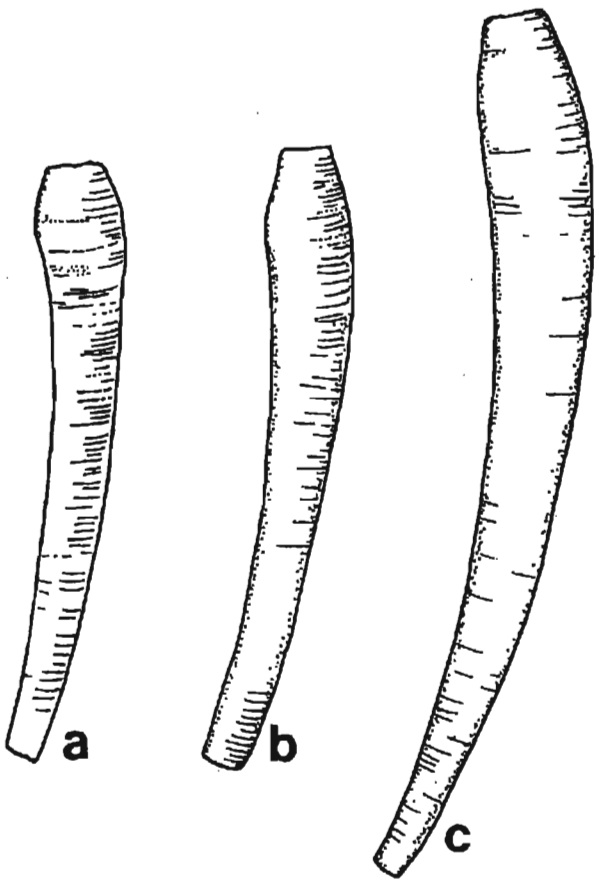

Fig. 19. *Ditrupa cornea* (LINNAEUS, 1767)

a — Specimen No. PK-059, b — No. PK-060, c — No. PK-061; all × 10

Family **Spirorbidae** PILLAI, 1970
Genus *Spirorbis* DAUDIN, 1800

Spirorbis circuliferus sp.n.
(Text-fig. 20 and Pl. 8, Figs 1-2)

HOLOTYPE: The specimen No. PK-073, presented in Text-fig. 20*a* and Pl. 8, Fig. 1*a*-1*b*.
TYPE LOCALITY: Korytnica, 24 km SSW of Kielce, southern slopes of the Holy Cross Mountains, Central Poland.
TYPE HORIZON: Middle Miocene (Badenian).
DERIVATION OF THE NAME: Latin *circulus* — a hoop, and *ferre* — to bear, in reference to the tube sculpture.
MATERIAL: Three specimens.
DIMENSIONS (in mm):

Coll. numbers	Dt	Dc	Figured in Text-fig. 20	Pl. 8
PK-073 — holotype	0.3	1.1	a	Fig. 1a-1b
PK-074	0.3	1.2	b	Fig. 2

DIAGNOSIS: Tube dextrally coiled, trochospiral, massive, opaque, sculptured by pronounced hoop-like swellings.

DESCRIPTION: The morphological features are almost totally comprised by the diagnosis of the species. Peristomes are circular.

REMARKS: The newly established species, *Spirorbis circuliferus* sp.n., which although is represented by a scanty material, differs distinctly from most of the spirorbid species, either fossil or extant. The only comparable species is *Spirorbis scalaria* ROVERETO, 1899, from the Middle Miocene (Langhian) deposits of Colli Torinesi in Italy, where it was reported as common (ROVERETO 1899, p. 87). This species of peculiarly shaped, sinistrally coiled tubes, has hitherto been recognized also from the Lower Miocene (Burdigalian) deposits of the Rhone Basin in France (PHILIPPE & PRIEUR 1984) where it occurs rarely having been adhered to bryozoans and cidaroid

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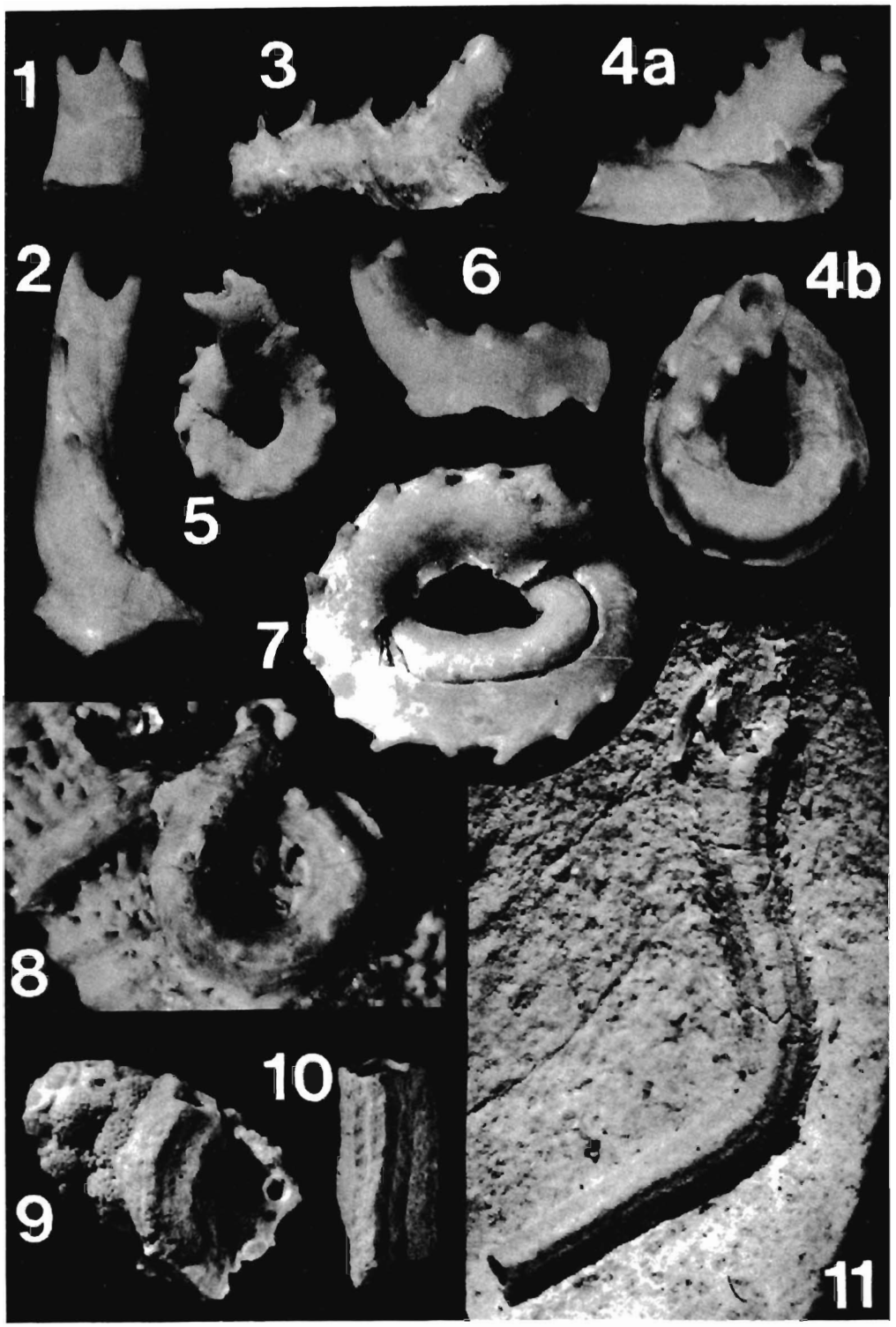
PLATE 7

1-8 — *Placostegus echinatus* sp.n.; 1-3 and 5-8 — **Paratypes:** 1 — peristomal part of the tube; 2 — erected part of the tube; 3, 6 — erecting part of the tube; 5, 7-8 — complete coil; 4 — **holotype:** 4a — lateral view of the tube; 4b — top view of the tube; 1 — Specimen No. PK-062, 2 — No. PK-063, 3 — No. PK-064, 4 — No. PK-065, 5 — No. PK-066, 6 — No. PK-067, 7 — No. PK-068, 8 — No. PK-069; all × 10

9-11 — ?*Janita* sp.; 9 — Specimen No. PK-070, 10 — No. PK-071, 11 — No. PK-072; all × 15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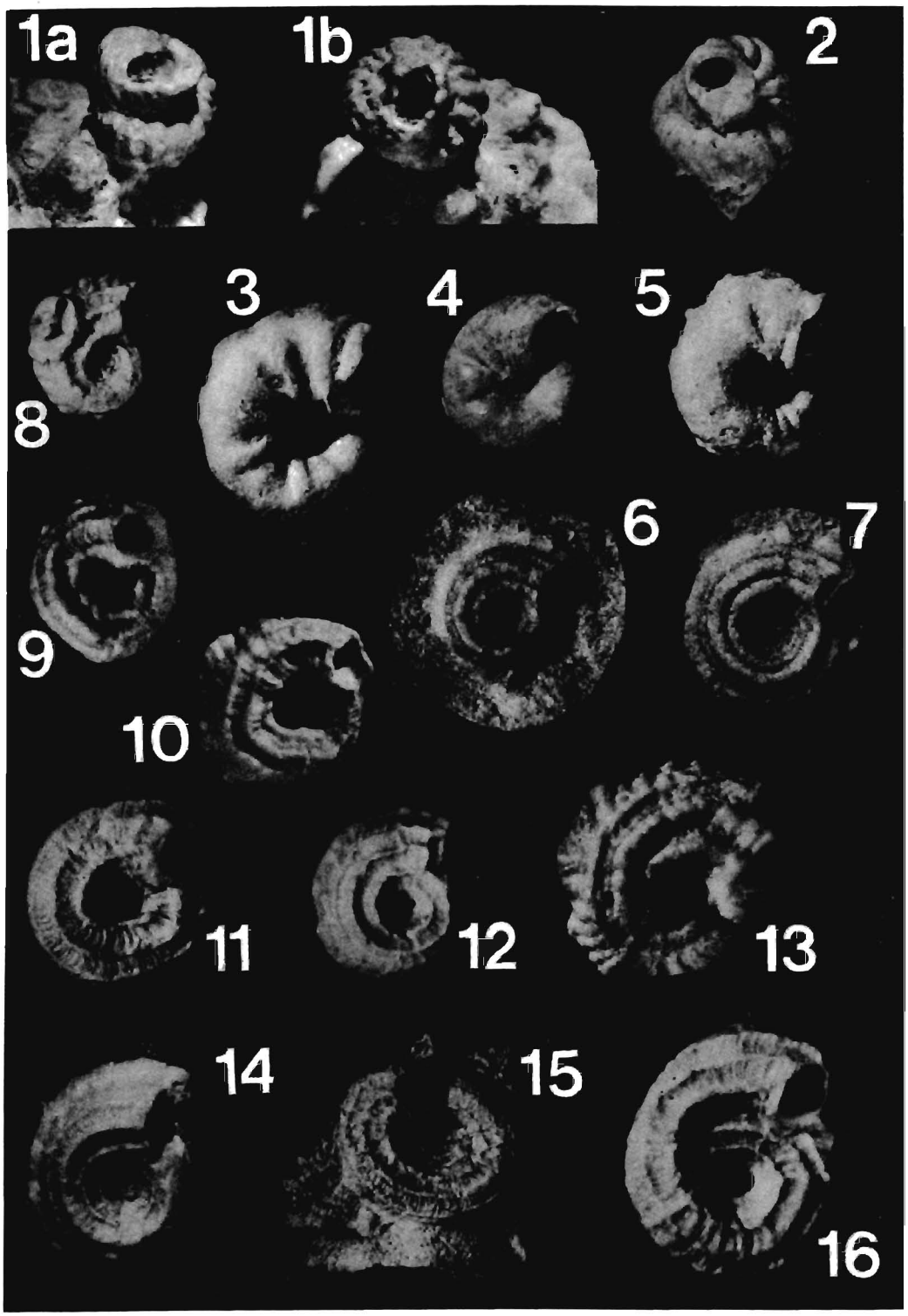
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Fig. 20. *Spirorbis circuliferus* sp.n.

a — Holotype (Specimen No. PK-073), b — paratype (No. PK-074); both × 20

spines. The newly established species, *Spirorbis circuliferus* sp.n., differs from that species by its mode of coiling (dextral against sinistral in *S. scalaria*), and by the absence of the crest along the umbilical side of the whorls.

Genus *Protolaeospira* Pixell, 1912

Protolaeospira strophostoma (Boettger, 1907) (Text-fig. 21 and Pl. 8, Figs 3-5)

1907. *Spirorbis strophostoma* n.sp.; O. Boettger, p. 217.
1934. *Spirorbis strophostoma* Boettger; A. Zilch, p. 197, Pl.1, Fig. 10.

MATERIAL: Five specimens.
DIMENSIONS (*in* mm):

Coll. numbers	Dt	Dc	Figured in Text-fig. 21	Pl. 8
PK-075	0.8	1.5	c	Fig. 3
PK-076	1.0	2.0	a	Fig. 4
PK-077	0.8	1.8	b	Fig. 5

PLATE 8

1-2 — *Spirorbis circuliferus* sp.n.: 1 — Holotype (1a — lateral view of the tube, 1b — top view of the tube), 2 — paratype; 1 — Specimen No. PK-073, 2 — No. PK-074; all × 20

3-5 — *Protolaeospira strophostoma* (Boettger, 1907); 3 — Specimen No. PK-075, 4 — No. PK-076, 5 — No. PK-077; all × 15

6-7 — *Pileolaria* sp.; 6 — Specimen No. PK-078, 7 — No. PK-079; both × 20

8-16 — *Pileolaria declivis* (Reuss, 1860); 8 — Specimen No. PK-080, 9 — No. PK-081, 10 — No. PK-082, 11 — No. PK-083, 12 — No. PK-084, 13 — No. PK-085, 14 — No. PK-086, 15 — No. PK-087, 16 — No. PK-088; 8, 15 × 15; 9-14, 16 × 20

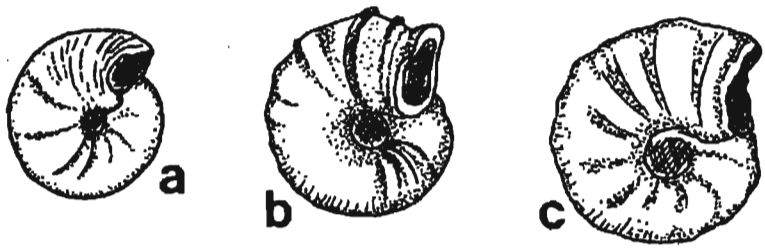

Fig. 21. *Protolaeospira strophostoma* (BOETTGER, 1907)

a — Specimen No. PK-076, b — No. PK-077, c — No. PK-075; all × 15

DESCRIPTION: Tubes sinistral, in smaller specimens translucent (*see* Pl. 8, Fig. 4) relatively massive, involute. Outer surface furnished with more or less pronounced, transverse swellings separated by furrows.

REMARKS: The collected specimens are almost fully concordant with the holotype of the species, as illustrated by ZILCH (1934, Pl. 1, Fig. 10), from which they differ in their transverse swellings distributed less regularly and developed less sharply.

The studied species, reported hitherto from Kostej in Romania only (BOETTGER 1907, ZILCH 1934), is close to the present-day species *Protolaeospira striata* (QUIÉVREUX, 1963) living in the Mediterranean and along the eastern Atlantic shores (*see* ZIBROWIUS 1968a, pp. 187-188; BAILEY 1969, pp. 368-369; BIANCHI 1981, pp. 150-152 and Pl. 1, Fig. 11). Of the Pacific species, a similar sculpture of tubes is displayed by the species *Protolaeospira eximia* (BUSH, 1904), known from the American coast (Canada to Chile) and New Zealand (*see* KNIGHT-JONES, KNIGHT-JONES & DALES 1979).

Genus *Pileolaria* CLAPARÈDE, 1868

Pileolaria declivis (REUSS, 1860)
(Text-fig. 22 and Pl. 8, Figs 8-16)

1860. *Spirorbis declivis* m. n.sp.; A.E. REUSS, p. 226, Pl. 3, Fig. 12.
non 1924. *Spirorbis declivis* REUSS; M. DEMBIŃSKA, p. 127, Pl. 2, Fig. 18.
1955. *Spirorbis* (*Laeospira*) *declivis* (REUSS); W.J. SCHMIDT, p. 80, Pl. 8, Figs 27-28.
1969. *Spirorbis* (*Laeospira*) *declivis* (REUSS), 1860; W.J. SCHMIDT, p. 37.

MATERIAL: 55 specimens.
DIMENSIONS (*in* mm):

Coll. numbers	Dt	Dc	Figured in Text-fig. 22	Figured in Pl. 8
PK-081	0.5	1.4	–	Fig. 9
PK-083	0.6	1.6	d	Fig. 11
PK-086	0.7	1.8	a	Fig. 14

DESCRIPTION: Tubes sinistral, relatively massive, attached to the substrate. Sculpture consists of 3 keels separated by wide furrows. Of these keels, two inner ones are well pronounced, while that outer one is developed more or less distinctly. Both the surface of the furrows and of the whorl sides are covered by fine corrugations.

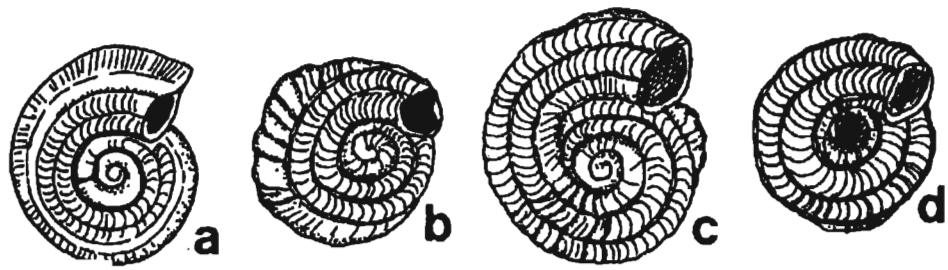

Fig. 22. *Pileolaria declivis* (REUSS, 1860)

a — Specimen No. PK-086, b — No. PK-082, c — No. PK-088, d — No. PK-083; all × 20

REMARKS: The majority of the studied specimens are concordant with the holotype of the species (*see* REUSS 1860, Pl. 3, Fig. 12a-b). A relatively rich material collected displays, however, a greater variability of its sculpture. Typical forms, furnished with two well pronounced keels and one less distinct (*see* Pl. 8, Figs 12 and 14), are almost identical with the holotype; all such forms are attached to the substrate alongwith their total coiling, and thus are flattened basally. The other extremes, with all three keels uniform (*see* Pl. 8, Figs 9 and 16), were partly attached to the tiny, more or less elongated objects (? seaweed fronds, sea fans), and thus are more circular in section. Intermediate forms (*see* Pl. 8, Fig. 10) display gradual changes between these two extremes.

The discussed variability clearly indicates that the details of the tube sculpture and its intensity in *Pileolaria declivis* (REUSS, 1860) depended on the size of the substrate to which particular individuals of this species were attached.

It is to note, that this ancient species *Pileolaria declivis* (REUSS, 1860) displays much resemblance to the present-day species *P. koehlerl* (CAULLERY & MESNIL, 1897) living in the Mediterranean (*see* BIANCHI 1981, p. 165, Fig. 62). The fossil specimens are slightly larger and massive, what does not justify its specific separateness. If the discussed forms are conspecific, their priority specific name should thus be that one used for ancient forms, i.e. *Pileolaria declivis* (REUSS, 1860).

Pileolaria inflata sp.n.
(Text-fig. 23 and Pl. 9, Figs 1-3)

HOLOTYPE: The specimen No. PK-089, presented in Text-fig. 23*a* and Pl. 9, Fig. 1.

TYPE LOCALITY: Korytnica, 24 km SSW of Kielce, southern slopes of the Holy Cross Mountains, Central Poland.

TYPE HORIZON: Middle Miocene (Badenian).

DERIVATION OF THE NAME: Latin *inflatus* — swollen, in reference to the shape of the tube.

MATERIAL: Five specimens.

DIMENSIONS: (*in* mm):

Coll. numbers	Dr	Dc	Figured in Text-fig. 23	Figured in Pl. 9
PK-089 — holotype	0.9	1.7	a	Fig. 1
PK-090	0.9	1.5	b	Fig. 2
PK-091	0.8	1.5	c	Fig. 3

DIAGNOSIS: Tube sinistral, massive, opaque, almost involute with a tendency to yield a polygonal outline, sculptured by one distinct crest placed centrally, and by transverse rugae, some of which are more pronounced; peristome circular, furnished with a denticle terminating the crest.

DESCRIPTION: The morphological features are shared with those given in the diagnosis of the species.

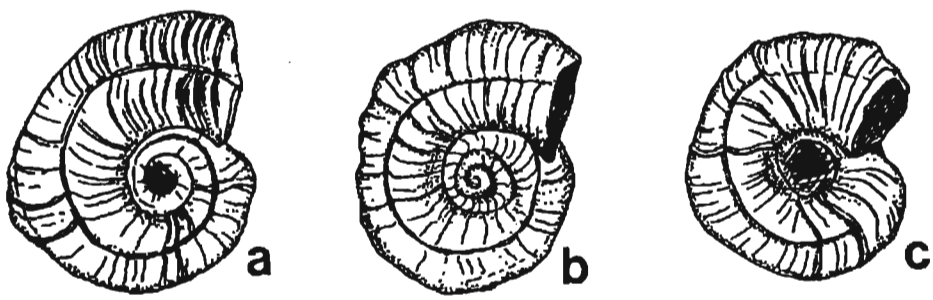

Fig. 23. *Pileolaria inflata* sp.n.

a — Holotype (Specimen No. PK-089), b-c — paratypes (b — No. PK-090, c — No. PK-091); all × 20

REMARKS: The newly established species, *Pileolaria inflata* sp.n., is similar to such present-day species as *Pileolaria pseudomilitaris* (THIRIOT-QUIÉVREUX, 1965) and *P. berkeleyana* (RIOJA, 1942), from which it differs in having one distinct crest, placed centrally, and well pronounced rugae (*compare* RIOJA 1942; THIRIOT-QUIÉVREUX 1965; BAILEY 1969; KNIGHT-JONES, KNIGHT-JONES & DALES 1979; BIANCHI 1981, pp. 160-162, Figs 7a and 60, *and* Pl. 1, Fig. 8).

Pileolaria korytnicensis sp.n.
(Text-fig. 24 and Pl. 9, Figs 9-11; Pl. 10, Figs 1-4)

HOLOTYPE: The specimen No. PK/GS-01, presented in Text-fig. 24*e* and Pl. 9, Fig. 9*a*.

TYPE LOCALITY: Korytnica, 24 km SSW of Kielce, southern slopes of the Holy Cross Mountains, Central Poland.

TYPE HORIZON: Middle Miocene (Badenian).

DERIVATION OF THE NAME: Neolatin *korytnicensis* — in reference to its type locality.

MATERIAL: Several tens of specimens attached to gastropod shells.

DIMENSIONS: (*in* mm):

Coll. numbers	Dt	Dc	Figured in Text-fig. 24	Figured in Pl. 9
PK/GS-01 — **holotype**	0.5	1.2	e	Fig. 9a
PK/GS-03	0.7	1.7	d	Fig. 11 left

DIAGNOSIS: Tube sinistral, opaque, coiled variably with a range from involute to gyrocone, sculptured by very fine and densely spaced transverse rugae, and possibly by one, very indistinct longitudinal crest placed centrally; all the whorls remarkably flattened, with flanges onlapping the substrate, thus hemicircular in section; interior of the tube circular, the same as the peristome, at which the tube narrows.

DESCRIPTION: The studied specimens are typically adhered to gastropod shells, in limited parts of which they may grow even gregariously (*see* Pl. 10, Figs 1-4). The mode of coiling varies, from involute to gyrocone, independently on density of spirorbid population (*see* Pl. 10, Fig. 1b), although the typical gyrocone tubes appear in places (on shells) sparsely populated by the spirorbids (*see* Pl. 9, Fig. 10). The tube sculpture consists primarily of finely shaped and densely spaced rugae, which may be so indinstinct that the tubes are almost smooth (*see* Pl. 9, Fig. 11). Some rugae may, however, be also much thicker, either alongwith the whole length of the tube (*see* Pl. 10, Fig. 4), or near the peristome (*see* Pl. 9, Fig. 9). If present, a very indistinct crest appears centrally, in the most elevated part of the tube; it is yielded by about one-third of the number of specimens. The tubes are distinctly flattened towards their sides, where their flanges may become very broad (*see* Pl. 9, Fig. 9*b*). The anterior part of the tube in specimens growing gregariously may be erect (*see* Pl. 10, Figs 1b and 2b). It is to note, that gregarious occurrences of specimens concerns the circum-apertural parts of gastropod shells, what will be discussed hereafter.

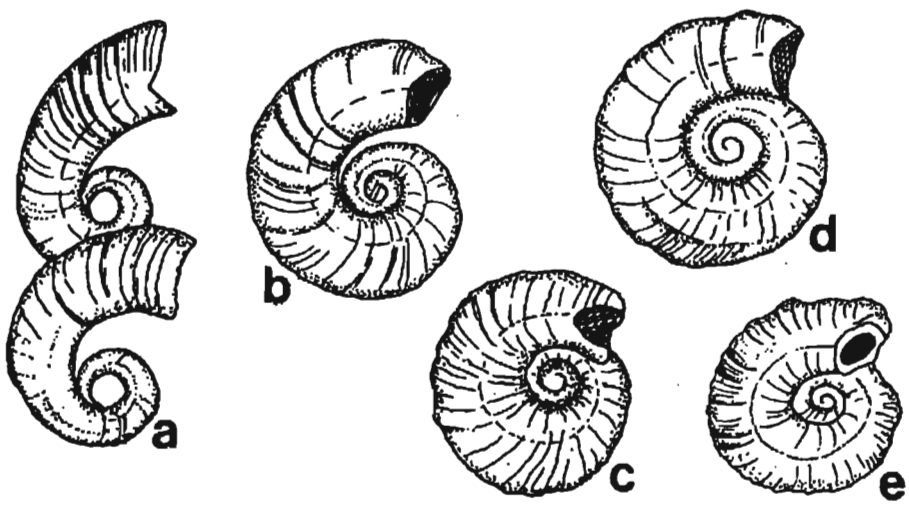

Fig. 24. *Pileolaria korytnicensis* sp.n.

a-d — Paratypes (**a** — No. PK-002, **b-d** — No. PK/GS-03); **e — holotype** (Specimen No. PK/GS-01); all × 20

REMARKS: The newly established species, *Pileolaria korytnicensis* sp.n., in many of its features is similar to the same present-day species which are afore-named in remarks to *P. inflata* sp.n., namely to *P. pseudomilitaris* (THIRIOT-QUIÉVREUX, 1965) and *P. berekeleyana* (RIOJA, 1942). It differs from the two latter species by the flatness of the tubes, and by the development of flanges which may broadly enlarge the attachment area; moreover, longitudinally one crest may appear, instead of either none or two, or more, in these present-day species (*cf.* RIOJA 1942; THIRIOT-QUIÉVREUX 1965; BAILEY 1969; KNIGHT-JONES, KNIGHT-JONES & DALES 1979; BIANCHI 1981).

The gyrocone shape of tubes that features some specimens of the newly established species is known to occur in some present-day *Pileolaria* species. In *Pileolaria grandis* PILLAI, 1970, studied by PILLAI (1970, pp. 102-106) from dead gastropod shells collected in intertidal rock pools at Hikkaduwa in Ceylon, the juveniles may spirally be coiled, but the adult forms become typically more or less straightened in a gyrocone shape. It is interpreted by PILLAI (1970, p. 102) as an irregularity in tube formation, resulted from the growth of encrusting epibionts. In *P. berkeleyana* (RIOJA, 1942) from the Pacific coast of Mexico the gyrocone specimens are characteristic of the species (*see* RIOJA 1942, pp. 144-145, Fig. 53). Such forms appear also in *P. pseudomilitaris* (THIRIOT-QUIÉVREUX, 1965), in which they are regarded as morphological variants (*see* BIANCHI 1981, pp. 160-161 and Fig. 60b; *also* p. 162 with reinterpretation of a gyrocone tube illustrated by HARRIS 1968, Fig. 3a as "*Spirorbis berkeleyanus*").

The newly established species, *Pileolaria korytnicensis* sp.n., differs from *P. inflata* sp.n. by a lack of the longitudinally developed, distinct crest, by much weaker rugae and, on the other hand, by flatness of the tubes.

To this new species belong all the forms of "*Spirorbis* sp." reported from the Korytnica Clays by BAŁUK & RADWAŃSKI (1977, p. 107 and Pl. 6, Figs 1-2).

Probably, to this species should also be referred an older report on *Spirorbis obtectus* SEGUENZA by KOWALEWSKI (1930, pp. 71 and 111) who noted its presence on, and inside, the shells of the gastropod *Ancilla glandiformis* (LAMARCK), the same as it was recognized originally by

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PLATE 9

1-3 — *Pileolaria inflata* sp.n.; 1 — **Holotype** (Specimen No. PK-089), 2-3 — **paratypes** (2 — No. PK-090, 3 — No. PK-091); all × 20

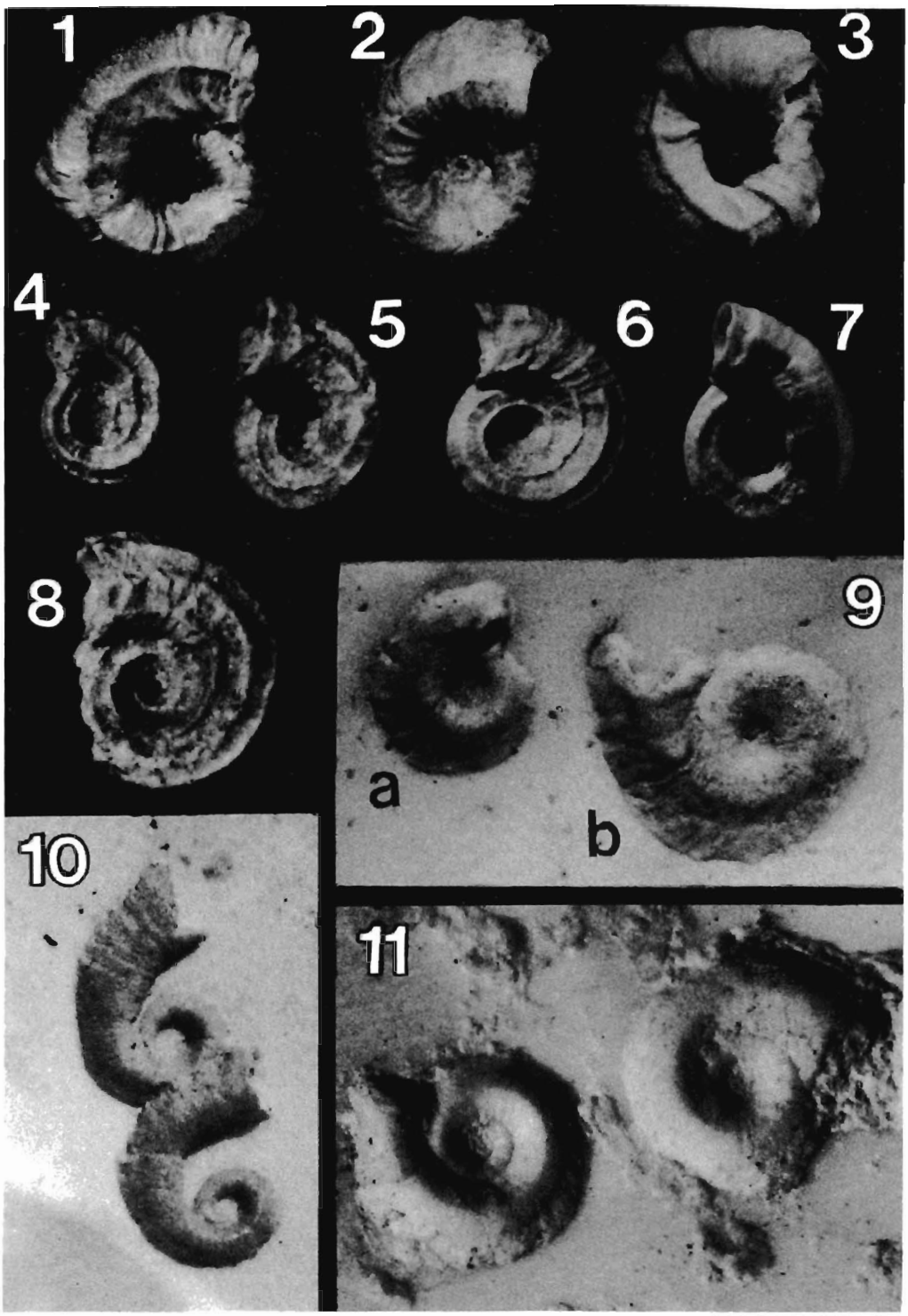
4-8 — *Janua miocaenica* sp.n.; 4-5 and 7-8 — **Paratypes**, 6 — **holotype**; 4 — Specimen No. PK-092, 5 — No. PK-093, 6 — No. PK-094, 7 — No. PK-095, 8 — No. PK-096; 4 × 25; 5-8 × 20

9-11 — *Pileolaria korytnicensis* sp.n., attached to the inner side of gastropod shells, × 20

9 — Two specimens in the shell of *Ancilla glandiformis* (LAMARCK), growing deeply in its last whorl: **a** — **holotype**, an averagely sculptured specimen, with well preserved aperture, b — **paratype**, with broad flanges; Specimen No. PK/GS-01

10 — Two specimens (**paratypes**) in another shell of *Ancilla glandiformis* (LAMARCK), growing also deeply in the last whorl; both specimens with gyrocone tubes; Specimen No. PK/GS-02

11 — Two averagely sculptured specimens (**paratypes**), more elevated, in the circum-apertural part of the shell (the same as in Pl. 10, Fig. 4) of *Natica* (*Polynices*) *redempta* MICHELOTTI; Specimen No. PK/GS-03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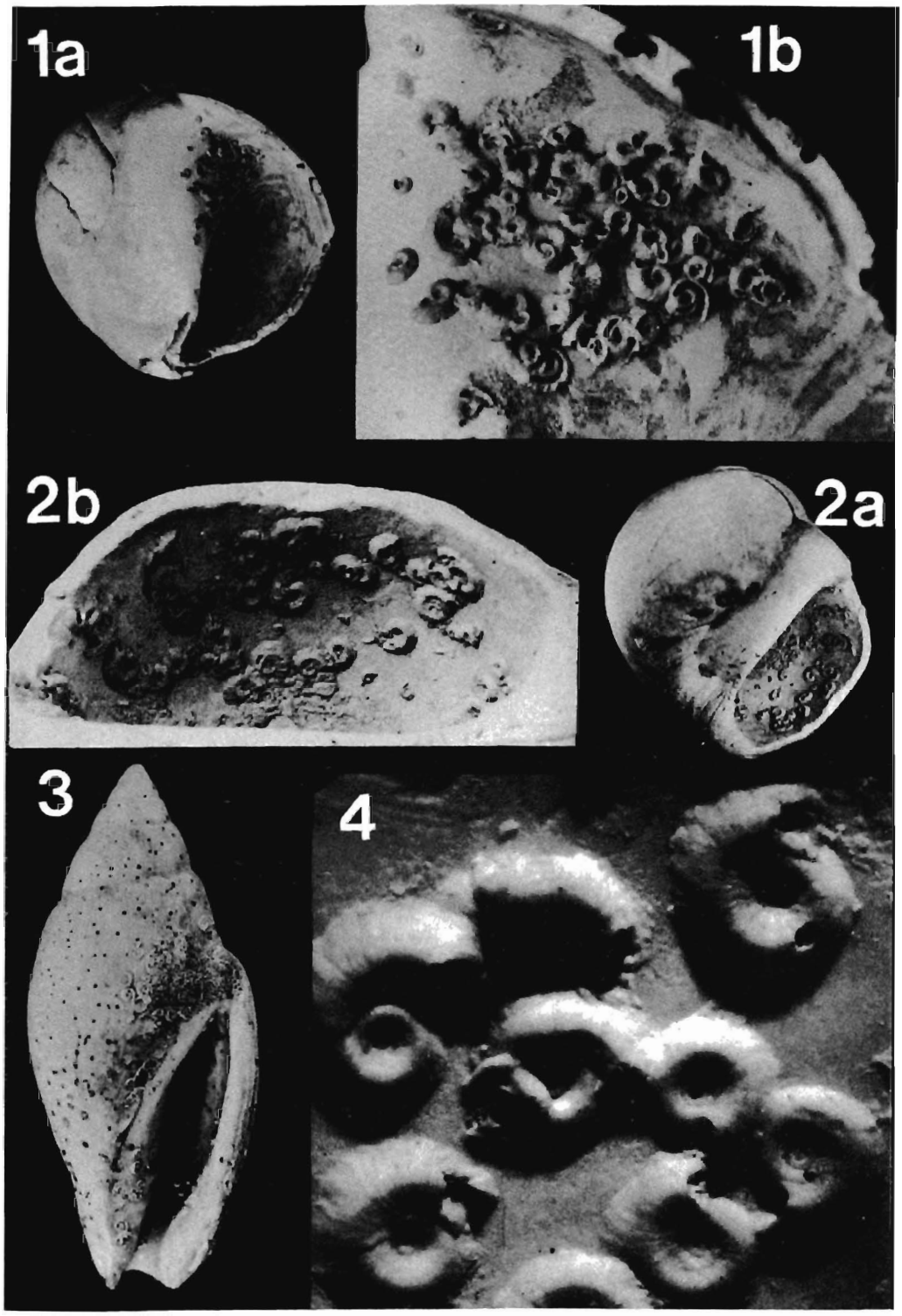
1a
1b
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2a
3
4

SEGUENZA (1880, p. 127). The discussed species, *Spirorbis obtectus* SEGUENZA, 1880, characterizes by having a crest on the adumbilical part of the whorl (*see* SEGUENZA 1880, p. 127 and Pl. 12, Fig. 13), the feature which was objected both by ROVERETO (1895, 1896, 1899, 1904), and by SCHMIDT (1955, pp. 82 and 92) who regarded this species as close to, or identical with, *Spirorbis umbilliciformis* (GOLDFUSS, 1831), erroneously ascribed by them to MÜNSTER (sic!). To that latter species, whose holotype is evidently indicated by GOLDFUSS (1831, p. 240 and Pl. 71, Fig. 7b) [and thus its re-illustration by SCHMIDT (1955, p. 82 and Pl. 8, Fig. 32), cannot be regarded as the lectotype, as recommended by SCHMIDT], referred was formerly a part of the Korytnica specimens by BALUK & RADWAŃSKI (1977, p. 107). Although the presence of *Spirorbis obtectus* SEGUENZA in the Korytnica Basin is herein not confirmed, the species itself still remains valid, as indicated recently by ZIBROWIUS (1991).

Pileolaria sp.
(Text-fig. 25 and Pl. 8, Figs 6-7)

MATERIAL: Three specimens.
DIMENSIONS (*in* mm):

Coll. numbers	Dt	Dc	Figured in Text-fig. 25	Figured in Pl. 8
PK-078	0.4	1.2	a	Fig. 6
PK-079	0.3	1.0	b	Fig. 7

DESCRIPTION: Tubes sinistral, massive, circular in section. Sclpture consists of three rounded ridges, separated by shallow furrows.

PLATE 10

1-4 — *Pileolaria korytnicensis* sp.n., growing gregariously in the circum-apertural parts of gastropod shells

1a-1b — Shell of *Natica* (*Polynices*) *redempta* MICHELOTTI, to show the spirorbids growing near its inner lip: 1a — General view, × 1.5; 1b — Close-up, × 5; Specimen No. PK/GS-04

2a-2b — Another shell of *Natica* (*Polynices*) *redempta* MICHELOTTI, to show the spirorbids growing near its outer lip; 2a — General view, × 1.5; 2b — Close-up, × 5; Specimen No. PK/GS-05

3 — Shell of *Lyria taurinia* (BONELLI), to show the spirorbids growing in its interior, near the aperture, and around the latter; those growing around the inner lip, near the posterior (anal) canal, are subsequently overgrown by bryozoans; the whole shell, prior to the spirorbid settlement, was densely bored by the sponge *Cliona vastifica* HANCOCK; Specimen No. PK/GS-06, × 1.5 (*re-illustrated from*: BALUK & RADWAŃSKI 1977, Pl. 6, Fig. 1)

4 — Shell of *Natica* (*Polynices*) *redempta* MICHELOTTI; the same as in Pl. 9, Fig. 11 (Specimen No. PK/GS-03), to show the variability of tube size, coiling and sculpture of the spirorbids growing near its aperture; × 20

Fig. 25. *Pileolaria* sp.

a — Specimen No. PK-078, b — No. PK-079; both × 20

REMARKS: The studied specimens, due to their size and sculpture, are close to those of the present-day species *Pileolaria endoumensis* (ZIBROWIUS, 1968), from which they differ (*see* ZIBROWIUS 1968a) by their circular section. An inferior material does not allow for its precise comparison, and thus the collected specimens are determined to the genus level only.

Genus *Janua* SAINT-JOSEPH, 1894

Janua miocaenica sp.n.
(Text-fig. 26 and Pl. 9, Figs 4-8)

HOLOTYPE: The specimen No. PK-094, presented in Text-fig. 26*a* and Pl. 9, Fig. 6.

TYPE LOCALITY: Korytnica, 24 km SSW of Kielce, southern slopes of the Holy Cross Mountains, Central Poland.

TYPE HORIZON: Middle Miocene (Badenian).

DERIVATION OF THE NAME: Latin *miocaenicus* — in reference to its stratigraphic age.

MATERIAL: 12 specimens.

DIMENSIONS (*in* mm):

Coll. numbers	Dt	Dt	Figured in Text-fig. 26	Figured in Pl. 9
PK-094 — holotype	0.6	1.4	a	Fig. 6
PK-093	0.7	1.0	c	Fig. 5
PK-095	0.6	1.3	d	Fig. 7

DIAGNOSIS: Tube dextral, distinctly widened anteriorly, fragile, sculptured by three distinct crests (associated with the fourth in the adult specimens) and transverse rugae, finely shaped in the posterior, and thickly grown, thus smothering the crests in the anterior part of tube; peristome widened trumpet-like, circular in outline.

DESCRIPTION: All descriptive features are shared with those given in the diagnosis of the species.

REMARKS: The newly established species is herein ascribed to the genus *Janua* SAINT-JOSEPH, 1894, not hitherto reported from the fossil state. To the studied specimens the most comparable are

those of the present-day Mediterranean population illustrated as "*Janua* sp." by BIANCHI (1981, Pl. 1, Fig. 14). From the present-day species recognizable in the Mediterranean, *Janua pagenstecheri* (QUATREFAGES, 1865) and *J. pseudocorrugata* (BUSH, 1904), the newly established species differs (*see* BIANCHI 1981, pp. 168-172) by its more pronounced sculpture and a distinctly advanced widening of the peristomal part of the tube which acquires a trumpet-like shape.

In the present-day species, some similar forms are also known in the genera *Dexiospira* CAULLERY & MESNIL, 1897, and *Neodexiospira* PILLAI, 1970, the mutual relation of which is a subject of controversy and/or more or less diversified opinions (*see* SCHMIDT 1955; PILLAI 1970; KNIGHT-JONES, KNIGHT-JONES & KAWAHARA 1975; JÄGER 1993).

Of the extinct species recently attributed to one of these genera, the most similar is the species *heliciformis* of EICHWALD (1830) which should certainly be placed within the genus *Janua*, and which differs from *Janua miocaenica* sp.n. by the more distinctly developed transverse rugae and the constant diameter of the tube, the peristomal part including, as well as by the more solid (massive) and thicker tube wall. It is to note, that the species *Janua heliciformis* (EICHWALD, 1830) has obviously been reported from the so-called Sarmatian deposits of the Parathetys basins, *i.e.* from the non-marine (brackish) sedimentary sequences of Upper Miocene age in the Ukraine, Austria, and Romania (EICHWALD 1830, 1853; ROVERETO 1895; SCHMIDT 1955, 1969).

The only exception in the stratigraphic matter was noted by DEMBIŃSKA (1924), who reported this species also from the "Tortonian" of the territories then of Poland (=Badenian, *see* RADWAŃSKA 1992, pp. 144-145), but who unfortunately intermixed *J. heliciformis* (EICHWALD, 1830) with the normal-marine species *Pileolaria declivis* of REUSS (1860).

A decade ago, the Miocene spirorbid polychaetes from the Ukraine were comprehensively studied by BELOKRYS (1984) who described a sequence of 12 species, 9 of which being new. The species *J. heliciformis* (EICHWALD, 1830) has been ascribed to the Sarmatian, while the other forms, either of Upper or of Middle Miocene age, have been distinguished as new taxa. Of these, all the forms furnished with crests, regardless their taxonomic attribution by BELOKRYS (1984), are herein regarded as conspecific with *J. heliciformis* (EICHWALD, 1830). Neither the number of the crests (ranging 2 to 4), nor the mode of attachment to the substrate fall into the features diagnostically important. It is thought to interpret all these forms as a case of phenotypic variability of that species having been an ecological response to the environmental (presumably oligohaline) conditions.

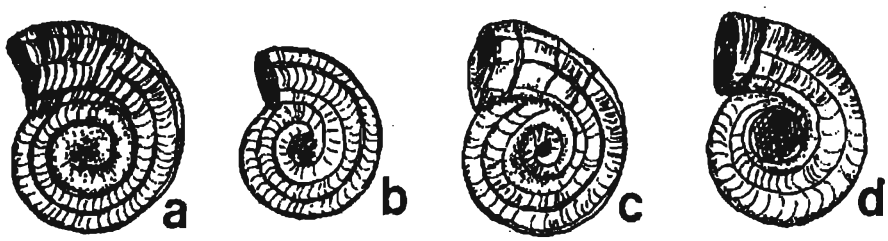

Fig. 26. *Janua miocaenica* sp.n.

a — Holotype (Specimen No. PK-094); b-d — paratypes (b — No. PK-092, c — No. PK-093, d — No. PK-095); a-c × 20, d × 25

GENERAL REMARKS ON ECOLOGY

All the studied tube-dwelling polychaetes are the suspension feeders, and thus they require a permanent mobility of water to keep their branchial crown free from clogging by sediment. The favorable bathymetric conditions of most of the present-day genera are very generally referenced as littoral, usually inter- or shallow subtidal, with the clear evidence that many genera or species of some genera are either eurybathic or confined just to bathyal depths (*see* HAYWARD 1977, BIANCHI 1981, JÄGER 1983).

Within the Korytnica Basin, the favorable environmental conditions of well ventilated, shallow sublittoral waters prevailed during the major timespan of clay sedimentation, but the tube-dwelling polychaetes have inhabited the seafloor very infrequently. Their presence enriches the spectrum of organic life in particular biotopes (*see* BAŁUK & RADWAŃSKI 1977; RADWAŃSKA 1982, 1992), but it gives little information on ecological details, since the life requirements of many present-day polychaetes are not fully recognized yet and, on the other hand, an attribution and/or relation of the studied forms to the present-day taxa are not clarified.

All the studied forms lived either freely (*Ditrupa*) or epizoically on various organic substrata. The spirorbids were often attached to the soft substrata, preferably to various plants, as it is known both in modern (*see* PILLAI 1960, 1970; HAYWARD 1977; BIANCHI 1981) and ancient (*see* JUX 1964, STRAUCH 1966) environments. Of the plants, possible was the spirorbid growth also on floating terrestrial plant detritus (leaves and/or fronds), a feature known since the Late Paleozoic time (*see* STRAUCH 1966).

A relatively common occurrence of the tube-dwelling polychaetes in the Korytnica Basin concerns only the spirorbids which profusely overgrew some gastropod shells, and what makes a separate problem discussed hereafter.

A note on the biologic relationships

In present-day environments, many tube-dwelling polychaetes are recognized to share their ecospace with other organisms, some of which are more or less confined to a definite species of the polychaete. As reviewed by BIANCHI (1981), apart from ordinary parasites (protozoans, trematodes, copepods) and predators (naticid gastropods, crabs, echinoderms, and some fish), there are revealed also some more specialized relations. To exemplify, the pyramidellid gastropods are ectoparasites to some serpulids, whose blood they suck from the branchial crown; on the other hand, some fish (e.g. *Crystallogobius*) lay their eggs in emptied tubes of *Protula* and/or other large-sized serpulids.

All these relationships (except of the naticid predatory) have little chance to be demonstrated in the fossil material. Nevertheless, they give a general impression how the tube-dwelling polychaetes might have been ecologically pressured, and their tubes used as a habitat in past environments.

The other reports offer an insight into the structures which may easily be preserved in the fossil material. Of such structures, noteworthy are peculiar borings of the nudibranch gastropod *Okadaia elegans* BABA, 1930, feeding upon two spirorbid and one serpulid species, as recorded from the Central and West Pacific (YOUNG 1969). A more complicated relationship has comprehensively been studied by SCRUTTON (1975) who recognized several species of Mesozoic and Tertiary serpulids with their tubes infested by a commensal (or even mutualistic) symbiont, the hydroid *Protulophila gestroi* ROVERETO, 1901, leaving a very distinct pattern of its polyp chambers and stolonal network within the polychaete tubes.

Although not stated in the studied material from the Korytnica Basin, all these reviewed cases allow to assume that careful examination of the fossil polychaete tubes may deliver important information on the polychaete-associated biota inhabiting the bygone biotopes.

PROBLEM OF THE HERMITTED SHELLS

Recently, WALKER (1992) has strongly insisted that the setting of the tube-dwelling polychaetes around the aperture of any gastropod shell is indicative of the presence of the hermit crab inhabiting such a shell.

Regardless the nature of the polychaete/hermit-crab relationship that is not easily interpretable under any past conditions, it is noteworthy that only very few Korytnica specimens may demonstrate such a relation. Of such specimens, one was illustrated by BAŁUK & RADWAŃSKI (1977, Pl. 3, Fig. 1 and Pl. 6, Fig. 1; re-illustrated herein as Pl. 10, Fig. 3): this is a shell of the gastropod species *Lyria taurinia* (BONELLI), heavily bored by the sponge *Cliona vastifica* HANCOCK, and encrusted in its circum-apertural part by the spirorbid *Pileolaria korytnicensis* sp.n. Similar settings of spirorbids are also present in shells of the gastropod species *Natica* (*Polynices*) *redempta* MICHELOTTI, the circum-apertural parts of which are overgrown by *Pileolaria korytnicensis* sp.n. gregariously (*see* Pl. 10, Figs 1-2 and 4). All these specimens of gastropod shells conform well with those presented by WALKER (1992, Figs 4-5) as infested by commensals to the hermit crabs. It is to note, that the discussed spirorbid species, *Pileolaria korytnicensis* sp.n., is the only one of the Korytnica spirorbids which grew on gastropod shells typically. In the majority of cases, however, only one or a few specimens of this spirorbid species are met at the aperture of shells of such gastropod species as: *Tudicla rusticula* (BASTEROT) [illustrated by BAŁUK

& RADWAŃSKI (1977, Pl. 6, Fig. 2)], *Triton affine* DESHAYES, *Ancilla glandiformis* (LAMARCK), *Conus* sp., and *Clavatula asperulata* (LAMARCK). In these findings it is usually not possible to recognize whether the spirorbids settled during the gastropod life, or upon an emptied shell. In shells of the gastropod species *Ancilla glandiformis* (LAMARCK) these spirorbids are located deeply, about a half-whorl or even more in the shell interior (*see* Pl. 9, Figs 9-10): these specimens have evidently preferred a very cryptic habitat of the emptied shell, rather disconnected with any activity of the hermit crabs.

One may also note, that of the Korytnica gastropod shells infested by diverse commensals to the hermit crabs, those carrying either spirorbid or serpulid polychaetes are extremely rare (*see* BAŁUK & RADWAŃSKI 1991, p. 7, Table 1). It thus is thought that some of the spirorbid and/or serpulid polychaetes casually could, but not had obligatorily to, be confined to the hermitted gastropod shells in the Korytnica Basin and, consequently, they may support, but they do not evidence the relationship postulated by WALKER (1992).

PROBLEMS OF INVESTIGATION OF THE MIOCENE TUBE-DWELLING POLYCHAETES

Any study of the tube-dwelling polychaetes of Miocene, or any other Neogene age, bears serious problems. These are involved by some disopportunities of various nature, as reviewed beneath.

(i). The taxonomy of the present-day polychaetes is based primarily on features of the soft parts of their bodies (*see* HOWELL 1962, FAUCHALD 1977, TEN HOVE & VAN DER HURK 1993), and the secreted tubes whose morphology yields a reasonable taxonomic potential (*see* Text-fig. 1), are either not taken into account in diagnoses, or are treated very variably already at the genus level (compare the generic diagnoses quoted by SCHMIDT 1955). Moreover, in some present-day genera (e.g. *Hydroides*) most tubes are undistinguishable at the species level (*see* ZIBROWIUS 1971a, TEN HOVE & VAN DER HURK 1993).

(ii). The Miocene and other Tertiary species, quite numerous indeed, have commonly been established in the 19th century, usually as representing the most popular genus *Serpula* which then was almost synonymized with all the tube-dwelling polychaetes. In majority, these species can hardly be assigned to the present-day polychaete genera established by the decline of the last century and in this century (*cf.* TEN HOVE & VAN DER HURK 1993, p. 26). Moreover, a major part of the ancient taxa were established upon either very poor or very inadequately illustrated material, the type of which has been lost, and thus their recognition remains often impossible to comply with the modern taxonomy.

To exemplify, within the studied material there appear doubts as to the generic assessment of the serpulid species "*lacera*" of REUSS (1860), and of all distinguished species of the spirorbids, those of EICHWALD (1830) and REUSS (1860) including.

(iii). If a similarity of some Miocene taxa to those present-day ones is evident at the genus or species level, and thus their phyletic relation and/or indentity may be recognized, some other Miocene taxa reveal such a relation not to the modern but to the still older ancient forms, primarily to those of Upper Cretaceous age, which have no counterparts in the recognized present-day forms, and thus cannot be studied uniformitarianistically.

To exemplify, a part of the studied forms may easily be assigned either to the present-day or to the extant taxa, for instance the genera *Hydroides*, *Vermiliopsis*, *Semivermilia*, *Filogranula*, *Protolaeospira*, and *Janua*, of which some have already been noted from the Miocene (*Hydroides* by SCHMIDT 1955, 1969 and HAYWARD 1977; *Vermiliopsis* by SCHMIDT 1955, 1969; *Filogranula* by JÄGER 1983), and the remainder not as yet having been known from the ancient epochs.

On the other hand, such taxa as the two new species of the genus *Cementula*, namely *C. rugosa* sp.n. and *C. verrucifera* sp.n., as well as the genera *Janita*, *Vepreculina*, and *Placostegus* bear the Cretaceous affinities, as indicated by their good counterparts present in the Middle and Late Cretaceous polychaete assemblages of Europe (*see* REGENHARDT 1961; LOMMERZHEIM 1979; JÄGER 1983, 1991, 1993).

(iv). Finally, the modern taxonomy of the present-day polychaetes originated primarily in France and Italy, that is in the European part of the Atlantic bioprovince, the Mediterranean including. It is apparent, however, that the Middle Miocene (Badenian) fauna of the Korytnica Basin and other parts of the Central Paratethys basins in Europe possesses very distinct Indo-Pacific provenences (*see* BAŁUK & RADWAŃSKI 1977, RADWAŃSKA 1992), and thus in this very bioprovince the counterparts (close relatives and/or phyletic descendants) should be expected. The recognition of the polychaete faunas of the Indo-Pacific bioprovince is, however, very poor (*see* PILLAI 1960, 1965, 1970; ZIBROWIUS 1971b), possibly with an exception of a part of the Australian and New Zealand region (*see* HAYWARD 1977).

In consequence of the above disopportunities, the knowledge on the European Miocene polychaete faunas is still inadequate (*see e.g.* JANSSEN 1972, PHILIPPE & PRIEUR 1984). Its further advance will depend on a possibility of the collecting new materials either from classical or from any new localities, and on the recognition of the present-day polychaete faunas from bioprovinces other than the eastern Atlantic and Mediterranean.

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REFERENCES

BAILEY, J.H. 1969. Spirorbinae (Polychaeta: Serpulidae) from Chios (Aegean Sea). *Zool. J. Linn. Soc.*, 48 (3), 363-385. London.

BAŁUK, W. 1975. Lower Tortonian gastropods from Korytnica, Poland. *Palaeontol. Polon.*, 32, 1-186. Warszawa — Kraków.

BAŁUK, W. & RADWAŃSKI, A. 1967. Miocene cirripeds domiciled in corals. *Acta Palaeontol. Polon.*, 12 (4), 457-513. Warszawa.

— & — 1977. Organic communities and facies development of the Korytnica Basin (Middle Miocene; Holy Cross Mountains, Central Poland). *Acta Geol. Polon.*, 27 (2), 85-123. Warszawa.

— & — 1979a. Additional data on the organic communities and facies development of the Korytnica Basin (Middle Miocene; Holy Cross Mountains, Central Poland). *Acta Geol. Polon.*, 29 (3), 225-238. Warszawa.

— & — 1979b. Boring ctenostomate bryozoans from the Korytnica Clays (Middle Miocene; Holy Cross Mountains, Central Poland). *Acta Geol. Polon.*, 29 (3), 243-252. Warszawa.

— & — 1979c. Polychaete-attributable faecal pellets, *Tibikola sanctacrucensis* ichnosp.n., from the Korytnica Clays (Middle Miocene; Holy Cross Mountains, Central Poland). *Acta Geol. Polon.*, 29 (3), 339-344. Warszawa.

— & — 1984. New data on the Korytnica Basin, its organic communities and ecological relationships between species (Middle Miocene; Holy Cross Mountains, Central Poland). *Acta Geol. Polon.*, 34 (3/4), 179-194. Warszawa.

— & — 1991. A new occurrence of fossil acrothoracican cirripedes: *Trypetesa polonica* sp.n. in hermitted gastropod shells from the Korytnica Basin (Middle Miocene; Holy Cross Mountains, Central Poland), and its bearing on behavioral evolution of the genus *Trypetesa*. *Acta Geol. Polon.*, 41 (1/2), 1-36. Warszawa.

BANSE, K. 1963. Klasse: Polychaeta (*Vielborster*). *In*: R. RIEDL (*Ed.*), Fauna und Flora der Adria, pp. 198-227. *Verlag Paul Parey*; Hamburg — Berlin.

BIANCHI, C.N. 1981. Policheti Serpuloidei. *Consiglio Nazionale delle Ricerche; Guide per il riconoscimento delle specie animali delle acque lagunari e costiere italiane*, 5, 1-187. Genova.

BELOKRYS, L.S. 1984. Spirorbiny pritsernomorskogo miocena. *Paleont. Zhurnal*, No. 2, 26-39. Moskva.

BOETTGER, O. 1901 *and* 1907. Zur Kenntnis der Fauna der mittelmiocänen Schichten von Kostej im Krassó-Szörenyer Komitat. *Verh. u. Mitteil. Siebenburg. Ver. Naturwiss.*, 51, pp. 1-199 *and* 55, pp. 101-217. Hermannstadt.

BOHN-HAVAS, M. 1981. Selection of *Ditrupa cornea* (L.) and forms convergent with it by scanning electron microscope. *Magyar Áll. Földtani Intézet Évi Jelentése Az 1979. Évről*, pp. 387-415. Budapest.

DEMBIŃSKA, M. 1924. Les annélides mioceniques de la Pologne. *Rozpr. i Wiad. Muzeum im. Dzieduszyckich (Acta Musaei Dzieduszyckiani)*, 9, 116-131. Lwów.

EICHWALD, E. 1830. Naturhistorische Skizze von Lithauen, Volhynien und Podolien in geognostisch-mineralogischer, botanischer und zoologischer Hinsicht entworfen. Wilna.

— 1853. Lethaea Rossica ou Paléontologie de la Russie; 3, dernière période, pp. 1-533. Stouttgart.

FAUCHALD, K. 1977. The polychaete worms: definitions and keys to the orders, families and genera. *Nat. Hist. Mus. Los Angeles County, Sci. Ser.*, 28, 1-190. Los Angeles.

FRIEDBERG, W. 1907. Młodszy miocen Galicyi zachodniej i jego fauna. *Spraw. Kom. Fizyogr. A.U. w Krakowie*, 40 (3), 1-49. Kraków.

GOLDFUSS, A. 1831 (1826-1833). *Petrefacta Germaniae*, 1, pp. 1-252 and Pls 1-71. Düsseldorf.

GUTOWSKI, J. 1984. Sedimentary environment and synecology of macrobenthic assemblages of the marly sands and red-algal limestones in the Korytnica Basin (Middle Miocene; Holy Cross Mountains, Central Poland). *Acta Geol. Polon.*, 34 (3/4), 323-340. Warszawa.

HARRIS, T. 1968. *Spirorbis* species (Polychaeta: Serpulidae) from the Bay of Naples with the description of a new species. *Pubbl. Staz. Zool. Napoli*, 36 (2), 188-207. Napoli.

HAYWARD, B.W. 1977. Lower Miocene polychaetes from the Waitakere Ranges, North Auckland, New Zealand. *J. Roy. Soc. New Zealand*, 7 (1), 5-16.

HÖRNES, M. 1856. Die fossilen Mollusken des Tertiaer-Beckens von Wien, *I.* Univalven. *Abh. Geol. Reichsanst.*, 3, 1-736. Wien.

HOWELL, B.F. 1962. Worms. *In*: R.C. MOORE (*Ed.*), Treatise on Invertebrate Paleontology, Part W (*Miscellanea*), pp. *W*144-*W*177. Lawrence, Kansas.

JÄGER, M. 1983. Serpulidae (Polychaeta sedentaria) aus der norddeutschen höheren Oberkreide — Systematik, Stratigraphie, Ökologie. *Geol. Jb., Reihe A*, 68, 1-219. Hannover.

— 1991. Serpulidae und Spirorbidae (Polychaeta sedentaria) aus dem Alb und der Oberkreide Helgolands (Norddeutschland). *Geol. Jb., Reihe A*, 120, 139-175. Hannover.

— 1993. Danian Serpulidae and Spirorbidae from NE Belgium and SE Netherlands: K/T boundary extinction, survival, and origination patterns. *Contr. Tert. Quatern. Geol.*, 29 (3/4), 73-137. Leiden.

JANSSEN, R. 1972. Beiträge zur Kenntnis der Bryozoa, Vermes, Crustacea und Echinodermata aus dem nordwestdeutschen Mittel- und Obermiozän. *Veröff. Überseemus. Bremen, Reihe A*, 4 (11), 71-108. Bremen.

JUX, U. 1964. *Chaetocladus strunensis* n.sp., eine von *Spirorbis* besiedelte Pflanze aus dem Oberen Plattenkalk von Bergisch Gladbach (Devon, Rheinisches Schiefergebirge). *Palaeontographica, Abt. B*, 114 (4-6), 118-134. Stuttgart.

KERN, J.P. 1979. The ichnofossil *Helicotaphrichnus commensalis* in the Korytnica Basin (Middle Miocene; Holy Cross Mountains, Central Poland). *Acta Geol. Polon.*, 29 (3), 239-242. Warszawa.

KNIGHT-JONES, P., KNIGHT-JONES, E.W. & KAWAHARA, T. 1975. A review of the genus *Janua*, including *Dexiospira* (Polychaeta: Spirorbinae). *Zool. J. Linn. Soc.*, 56 (2), 91-129. London.

KNIGHT-JONES, P., KNIGHT-JONES, E.W. & DALES, R.P. 1979. Spirorbidae (Polychaeta Sedentaria) from Alaska to Panama. *J. Zool., London*, 189 (4), 419-458. London.

KOWALEWSKI, K. 1930. Stratigraphie du Miocène des environs de Korytnica en comparaison avec le Tertiaire des autres territoires du Massif de S-te Croix. *Spraw. Pol. Inst. Geol. (Bull. Serv. Géol. Pol.)*, 6 (1), 1-211. Warszawa.

LOMMERZHEIM, A. 1979. Monographische Bearbeitung der Serpulidae (Polychaeta sedentaria) aus dem Cenoman (Oberkreide) am Südwestrand des Münsterländer Beckens. *Decheniana*, 132, 110-195. Bonn.

MEZNERICS, I. 1944. Ditrupa-Reste aus Ungarn. *Ann. Hist.-Nat. Mus. Nation. Hung., Pars Min. Geol. Pal.*, 37, 40-47. Budapest.

PHILIPPE, M. & PRIEUR, A. 1984. Serpulidés (Annelida, Sedentarida). *In*: La faune du faciès "Marnes bleues", Burdigalien du Bassin de Faucon-Mollans-Malaucène (Sud-Est de la France). *Nouv. Arch. Mus. Hist. Nat. Lyon*, 22, 71-73. Lyon.

PILLAI, T.G. 1960. Some marine and brackish-water Serpulid Polychaeta from Ceylon, including new genera and species. *Ceylon J. Sci. (Bio. Sci.)*, 3 (1), 1-40. Peradeniya.

— 1965. Annelida Polychaeta from the Philippines and Indonesia. *Ceylon J. Sci. (Bio. Sci.)*, 5 (2), 110-177. Peradeniya.

— 1970. Studies on a collection of spirorbids from Ceylon, together with a critical review and revision of spirorbid systematics, and an account of their phylogeny and zoogeography. *Ceylon J. Sci. (Bio. Sci.)*, 8 (2), 100-172. Peradeniya.

PUSCH, G.G. 1837. Polens Paläontologie, pp. 1-218. *E. Schweitzerbart's Verlagshandlung*; Stuttgart.

RADWAŃSKA, U. 1982. Non-mollusk fauna of the oyster shellbed at Korytnica; its facies and stratigraphical significance. [*In Polish*]. *Unpublished M.Sc. thesis*; Department of Paleontology, Institute of Geology, University of Warsaw.

— 1984. Some new fish otoliths from the Korytnica Clays (Middle Miocene; Holy Cross Mountains, Central Poland). *Acta Geol. Polon.*, 34 (3/4), 299-322. Warszawa.

— 1987. Free-living crinoids from the Korytnica Clays (Middle Miocene; Holy Cross Mountains, Central Poland). *Acta Geol. Polon.*, 37 (3/4), 113-129. Warszawa.

— 1992. Fish otoliths in the Middle Miocene (Badenian) deposits of southern Poland. *Acta Geol. Polon.*, **42** (3/4), 141-328. Warszawa.
— 1994. A new group of microfossils: Middle Miocene (Badenian) opercular caps (*calottae*) of the tube-dwelling polychaetes *Vermiliopsis* SAINT-JOSEPH, 1894. *Acta Geol. Polon.*, **44** (1/2), 83-96 [*this issue*]. Warszawa.
RADWAŃSKA, U. & RADWAŃSKI, A. 1984. A new species of inarticulate brachiopods, *Discinisca polonica* sp.n., from the Korytnica Basin (Middle Miocene; Holy Cross Mountains, Central Poland). *Acta Geol. Polon.*, **34** (3/4), 253-269. Warszawa.
RADWAŃSKI, A. 1964. Boring animals in Miocene littoral environments of southern Poland. *Bull. Acad. Polon. Sci., Sér. Sci. Géol. Géogr.*, **12** (1), 57-62. Warszawa.
— 1969. Lower Tortonian transgression onto the southern slopes of the Holy Cross Mts. *Acta Geol. Polon.*, **19** (1), 1-164. Warszawa.
— 1970. Dependence of rock-borers and burrowers on the environmental conditions within the Tortonian littoral zone of Southern Poland. *In*: T.P. CRIMES & J.C. HARPER (*Eds*), Trace Fossils (*Geol. J. Spec. Issues*, **3**), 371-390. Liverpool.
REGENHARDT, H. 1961. Serpulidae (Polychaeta sedentaria) aus der Kreide Mitteleuropas, ihre ökologische, taxionomische und stratigraphische Bewertung. *Mitt. Geol. Staatsinst. Hamburg*, **30**, 5-115. Hamburg.
REUSS, A.E. 1860. Die marinen Tertiärschichten Böhmens und ihre Versteinerungen. *Sitzungsber. d. Kaiser. Akad. d. Wiss., Math.-Naturwiss. Cl.*, **39** (2), 207-285. Wien.
— 1867. Die fossile Fauna der Steinsalzablagerung von Wieliczka in Galizien. *Sitzungsber. d. Kaiser. Akad. d. Wiss., Math.-Naturwiss. Cl.*, **55** (1), 17-182. Wien.
RIOJA, E. 1942. Estudios anelidologicos, V: Observaciones acerca de algunas especies del genero *Spirorbis* DAUDIN, de las costas mexicanas del Pacifico. *Anales Inst. Biol. Mexico*, **13** (1), 137-153. Mexico.
ROVERETO, G. 1895. Di alcuni anellidi del terziario in Austria. *Atti Soc. Ligust. Sci. Nat. e Geogr.*, **6** (2), 1-7. Genova.
— 1896. Sinonimie degli anellidi più freqentemente citati del terziario d'Italia. *Riv. Ital. Paleontol.*, **2** (12), 323-325. Bologna.
— 1899. Serpulidae del terziario e del quaternario in Italia. *Palaeontograph. Ital.*, **4**, 47-91. Pisa.
— 1904. Studi monografici sugli Anellidi fossili; *I*. Terziario. *Palaeontograph. Ital.*, **10**, 1-73. Pisa.
SCHMIDT, W.J. 1950. Neue *Serpula*-Arten aus dem Material des Naturhistorischen Museums in Wien. *Ann. Naturhist. Mus. Wien*, **57**, 159-162. Wien.
— 1951. Neue Serpulidae aus dem tertiären Wiener Becken. *Ann. Naturhist. Mus. Wien*, **58**, 77-84. Wien.
— 1955. Die tertiären Würmer Österreichs. *Denkschr. Österr. Akad. Wiss., Math.-Naturwiss. Kl.*, **109** (7), 1-121. Wien.
— 1969. Vermes. *In*: Catalogus Fossilium Austriae, Heft **Va**, 1-56. Wien.
SCRUTTON, C.T. 1975. Hydroid-serpulid symbiosis in the Mesozoic and Tertiary. *Palaeontology*, **18** (2), 255-274. London.
SEGUENZA, G. 1880. Le formazioni terziarie nella provincia di Reggio (Calabria). *Atti R. Accad. Lincei, Mem. Cl. Sci. Fis., Mat., Nat., Ser. 3*, **6**, 1-445. Roma.
STRAUCH, F. 1966. Zur Autökologie und über bemerkenswerte Funde von *Spirorbis* DAUDIN 1800 (Polychaeta sedentaria) im Oberkarbon des Saargebietes. *Paläont. Zt.*, **40** (3/4), 269-273. Stuttgart.
TEN HOVE, H.A. & SMITH, R.S. 1990. A re-description of *Ditrupa gracillima* GRUBE, 1878 (Polychaeta, Serpulidae) from the Indo-Pacific, with a discussion of the genus. *Records of the Australian Museum*, **42** (1), 101-118. Sydney.
— & VAN DEN HURK, P. 1993. A review of Recent and fossil serpulid 'reefs'; actuopalaeontology and the 'Upper Malm' serpulid limestones in NW Germany. *Geologie en Mijnbouw*, **72**, 23-67. Gravenhage.
THIRIOT-QUIÉVREUX, C. 1965. Description de *Spirorbis* (*Laeospira*) *pseudomilitaris* n.sp., polychète spirorbinae, et de sa larve. *Bull. Muséum Nation. d'Hist. Natur., Sér. 2*, **37** (3), 495-502. Paris.
WALKER, E.E. 1992. Criteria for recognizing marine hermit crabs in the fossil record using gastropod shells. *J. Paleont.*, **66** (4), 535-558. Lawrence, Kansas.
YOUNG, D.K. 1969. *Okadaia elegans*, a tube-boring nudibranch mollusc from the Central and West Pacific. *Amer. Zoologist*, **9** (3, *ed.* 2), 903-907. Utica, N.Y.
ZIBROWIUS, H. 1968a. Étude morphologique, systématique et écologique, des Serpulidae (Annelida Polychaeta) de la région de Marseille. *Rec. Trav. Station Mar. Endoume, Bull.*, **43** (59), 81-253. Marseille.
— 1968b. Description de *Vermiliopsis monodiscus* n.sp. espèce Méditerranéenne nouvelle de Serpulidae (Polychaeta Sedentaria). *Bull. Muséum Nation. d'Hist. Natur., Sér. 2*, **39** (6), 1202-1210. Paris.

— 1971a. Les espèces méditerranéennes du genre *Hydroides* (Polychaeta Serpulidae); Remarques sur le prétendu polymorphisme de *Hydroides uncinata*. *Tethys*, **2** (3), 691-746. Marseille.
— 1971b. Revision of *Metavermilia* BUSH (Polychaeta, Serpulidae), with descriptions of three new species from off Portugal, Gulf of Guinea, and western Indian Ocean. *J. Fisheries Res. Board Canada*, **28** (10), 1373-1383. Ottawa.
— 1972. Mise au point sur les espèces Méditerranéennes de *Serpulidae* (Annelida Polychaeta) décrites par Stefano delle Chiaje (1822-1829, 1841-1844) et Oronzio Gabrielle Costa (1861). *Tethys*, **4** (1), 113-126. Marseille.
— 1991. Les Polychètes Serpulidae et Spirorbidae dans "Le formazioni terziarie nella provincia di Reggio (Calabria)" par Giuseppe Seguenza (1880). *Atti Accad. Pelorit. dei Pericol., Cl. Sci. Fis. Mat. e Nat.*, **67**, Supplemento 1 (2), 151-158. Messina.
ZILCH, A. 1934. Zur Fauna des Mittel-Miocäns von Kostej (Banat): Typus-Bestimmung und Tafeln zu O. BOETTGER's Bearbeitungen. *Senckenbergiana*, **16** (4-6), 193-302. Frankfurt am Main.