SVERIGES GEOLOGISKA UNDERSÖKNING

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ISBN 91-7158-163-4

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C DAVIDSONS BOKTRYCKERI AB, VÄXJÖ 1979

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ABSTRACT

Wängberg-Eriksson, Kristina, 1978: Macluritacean gastropods from the Ordovician and Silurian of Sweden. Sver. Geol. Undersök. C 758.

The present paper deals with hyperstrophic gastropods of the families Onychochilidae and Clisospiridae, superfamily Macluritacea.

The Onychochilidae is represented by the new genera *Angulospira* (type species *A. striata* n.sp.), *Tapinogyra* (type species *T. glaphyra* n.sp.) and *Bodospira* (type species *B. undulata* n.sp.). The two first mentioned genera are monotypic whereas *Bodospira* includes a second new species, *B. kallholniensis*. A new species of *Laeogyra*, *L. arvetensis*, is described and *L. gracilis* Perner is revised. All species are from the Upper Ordovician (Harjuan) Boda Limestone.

Three new species of the genus *Mimospira* of the family Clisospiridae are described *M. tenuistriata* and *M. similis* from Middle Ordovician (Viruan) strata and *M. kallholniensis* from the Upper Ordivician Boda Limestone. *Onychochilus? cochleatum* Lindström from the Silurian of Gotland and *Trochus atavus* Moberg and Segerberg from the Upper Tremadocian of Scania are revised and referred to *Mimospira*. A new genus *Undospira* is represented by the type species *U. striata* n.sp. from the Middle Ordovician (Viruan) and *U. turrita* (Koken) from the Upper Ordovician (Harjuan).

INTRODUCTION

A gastropod of the superfamily Macluritacea has a sinistrally coiled shell when oriented with the apex upwards but the soft parts are supposed to have been dextrally organized (Knight *et al.* 1960, p. I 186). This condition is currently termed hyperstrophic. Two families have been included in the Macluritacea: Onychochilidae and Macluritidae. In the present paper members of the family Clisospiridae are also regarded as macluritaceans (see also Horný 1964 and Peel 1975).

The following representatives of the Onychochilidae and Clisospiridae have previously been described from the Balto-Scandian region (see also Table 2):

Lindström 1884: *Onychochilus physa, O. reticulatum* and *O.? cochleatum*, all from the Silurian of Gotland.

Koken 1897: *Platyceras gracile*, Upper Ordovician Boda Limestone, Dalarna; *Clisospira rugosa*, Upper Ordovician Red Jonstorp Formation, Östergötland, and *C. ingrica*, Lower Ordovician (B_{III}), Leningrad district. The first two species were not illustrated whereas the description of *C. ingrica* included a drawing.

Moberg and Segerberg 1906: *Trochus atavus*, Upper Tremadocian, Scania.

Koken and Perner 1925: *Laeogyra gracilis* (= *Platyceras gracile* Koken 1897), *Helicotis rugifera* Koken (incompletely known; based on one fragmentary specimen which seems to be lost. The box in the collections of the Sveriges Geologiska Undersökning which originally contained the holotype, at present contains

another specimen which according to Knight (1941, p. 144): "is a steinkern of some young euomphalid"), Lower Ordovician "Lower Grey Orthoceratite Limestone", Småland; *Mimospira (? Clisospira) turrita,* Upper Ordovician (Harjuan) Red Jonstorp Formation (Red *Tretaspis* Beds), Östergötland; *Clisospira christianiae,* Upper Ordovician (5a), Ringerike, Norway, and *C. borkholmiensis,* Upper Ordovician Porkuni Stage (F_{II}), Estonia; *C. rugosa* and *C. ingrica* are redescribed and figured.

Öpik 1930: *Clisospira* aff. *rugosa* Koken and *C. reinwaldti* Öpik from the Middle Ordovician (Viruan) Kukruse Stage (C), Estonia.

In the present paper the following new genera and species are described: *Bodospira undulata* n.g., n.sp., *B. kallholniensis* n.g., n.sp., *Angulospira striata* n.g., n.sp., *Tapinogyra glaphyra* n.g., n.sp., *Laeogyra arvetensis* n.sp., and *Mimospira kallholniensis* n.sp., all from the Upper Ordovician (Harjuan) Boda Limestone, Dalarna; *Mimospira tenuistriata* n.sp. and *M. similis* n.sp., Middle Ordovician (Viruan) of Dalarna (Furudal and Lowermost Dalby Limestone), Västergötland (Gullhögen Fm. and Lowermost Dalby Limestone) and Öland (Källa Limestone); *Undospira striata* n.g., n.sp., Middle Ordovician (Viruan) of Dalarna (Furudal and lowermost Dalby Limestones). In addition, the following species are revised *Laeogyra gracilis* (Koken, 1925), *Mimospira cochleatum* (Lindström, 1884) and *Undospira turrita* (Koken, 1925). *Trochus atavus* Moberg and Segerberg, 1906 and *Clisospira* aff. *rugosa* Koken (Öpik 1930, p. 25, Pl. 2, fig. 11) belong to *Mimospira* but cannot be defined at species level. *Clisospira reinwaldti* Öpik (1930, p. 25, Pl. 2, fig. 12) might represent a *Laeogyra* but the holotype is too poorly preserved for even a safe generic assignment.

The material studied in the present paper belongs to the Palaeozoological Section of the Swedish Museum of Natural History (index letter: Mo), to the Museum of the Palaeontological Institute, University of Uppsala (D) and to the Palaeontological Institute, University of Lund (LO). Gastropods from the carbonate mounds of Dalarna are normally excellently preserved and this applies also to macluritaceans. Specimens from washed, weathered marl samples and mechanically crushed limestone samples of the Furudal and Dalby Limestones have a variable state of preservation, some being too fragmentary or worn to be identified. The specimens from the core of the Norra Skagen boring are partly covered by matrix and too fragile to allow preparation.

ORIENTATION OF THE GASTROPOD SHELL. – According to current practice, an ortostrophically coiled gastropod shell is depicted with the spire directed upwards. Terms such as apex for the first formed initial part of the shell and base for the lowermost part of the last whorl refer to this orientation. In the present context this terminology is utilized even for hyperstrophic shells with the spire depressed through the plane of the aperture. The more detailed implications of the hyperstrophic feature have been discussed by Linsley (1977) and Vermeij

(1971). In the Treatise (Knight *et al.* 1960) hyperstrophic shells are reproduced with the spire downwards and this is also made here. Consequently, since the illustrated specimens are normally illuminated from the top lefthand side, the base and the aperture can be more clearly seen. To avoid confusion it should be stressed, once more, that the terms apex and base still refer to the initial and last whorl respectively. This is not the case in the Treatise where the base of a hyperstrophic shell is considered to be homologous with the spire of a normal dextral shell (cf. Knight 1952, p. 38 and p. 8, Fig. 2).

DESCRIPTION OF GENERA AND SPECIES

Superfamily Macluritacea Fischer, 1885

Family Onychochilidae Koken, 1925

Genus Bodospira n.g.

TYPE SPECIES. – *Bodospira undulata* n.sp.

DIAGNOSIS. – Shell conispiral, coiled with 9 whorls; whorl profile distinctly angulated with a keel situated adapically. Ornamentation of growth lines and in the type species also of transverse ribs on abapical field of younger whorls.

REMARKS. – This genus is rather remote from the previously known genera of the Macluritacea. It is distinguished by its angulated whorl profile and ornamentation. On account of the small size, the apparently sinistral coiling, the conispiral shape and concave base, *Bodospira* is tentatively referred to the family Onychochilidae.

Bodospira undulata n.sp.

Figs. 1, 2D–G

HOLOTYPE. – Mo 150578 (Fig. 1A–C, E) from the Boda Limestone, Kallholn, Dalarna.

DIAGNOSIS. – *Bodospira* with transverse ribs on the 3–4 youngest whorls.

MATERIAL. – Eleven specimens, two of which are complete. All specimens except one are from the type locality.

DESCRIPTION. – The small conispiral shell of this gastropod is coiled with 9 whorls (Fig. 1). At least two of the initial whorls, probably including the larval shell, have a rounded profile (Fig. 1D). The profile of the ontogenetically younger

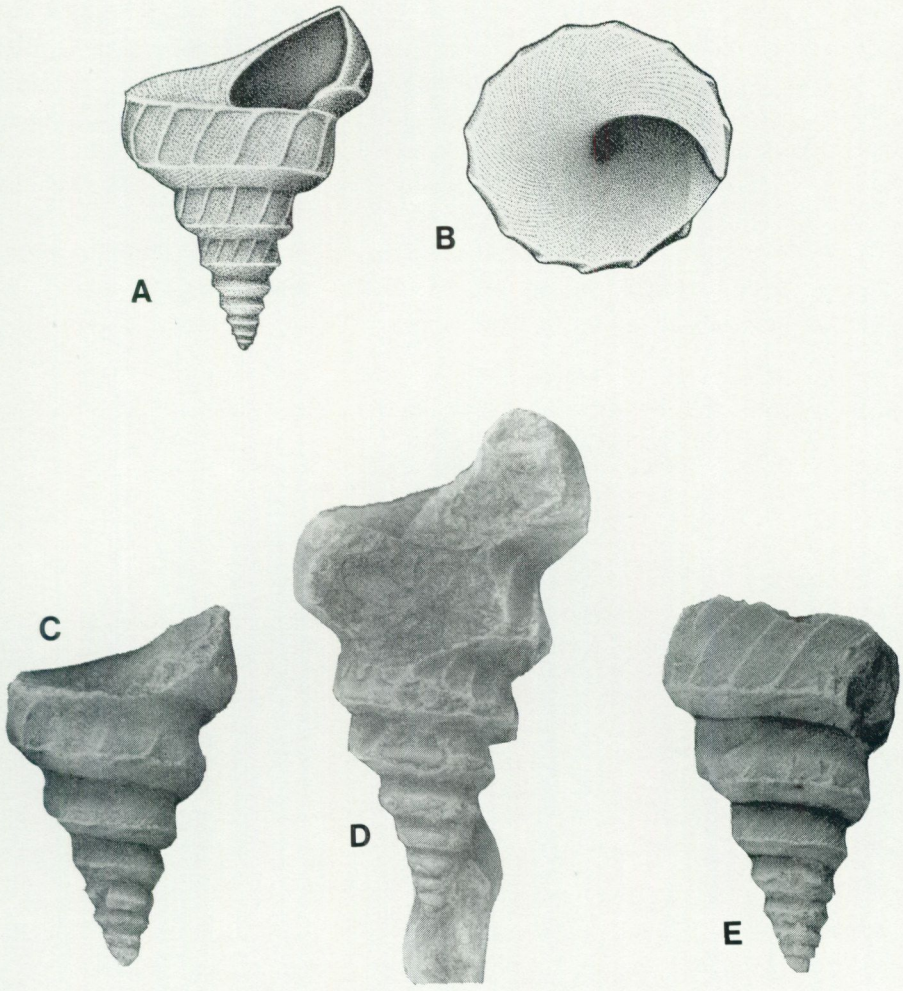

Fig. 1. *Bodospira undulata* n.sp. A–B, reconstruction of shell in apertural and basal views, respectively, based chiefly on the holotype. × 8. C and E, holotype, incomplete with last whorl missing, in apertural and abapertural views, respectively. × 10. No. Mo. 150578. D, almost complete specimen in apertural view. × 10. No. Mo. 151859. Boda Limestone, Kallholn, Siljan district.

whorls is angulated, subdividing the external face of each whorl into an adapical field directed obliquely towards the shell axis and an abapical field almost parallel to the shell axis.

Distinct growth lines are found on the external face of all whorls except the initial ones. In addition, the abapical field of the 3–4 youngest whorls has more or less distinct, delicate, transverse ridges, running conformably to the growth lines (Figs. 1, 2D, F). Nearest to the unornamented part of the shell these ridges are delicate and more or less obscure. However, they increase gradually

in height and thickness on the successive younger whorls. The width of the interspace between the individual ridges is rather constant on one and the same shell but may vary considerably between shells (Fig. 2 D, F). The base, the most abapical face of the last whorl, descends rather steeply (in apical direction) from the periphery towards the axis of the shell (Figs. 1B, 2E, G). There is no evidence of an umbilicus; nor could any umbilicus be detected in thin sections. The apertural margin could be restored with reasonable certainty on the basis of its preserved parts and with the guidance of the growth lines. The inner lip forms a uniformly curved arch meeting the outer lip, which runs obliquely backwards from the last suture, at an acute angle at the most abapical point of the shell.

DIMENSIONS. – The holotype is approximately 6.0 mm high and 4.0 mm wide.

OCCURRENCE. – Boda Limestone; Dalarna: Kallholn and Arvet.

Bodospira kallholniensis n. sp.

Figs. 2A–C, 3A–B

HOLOTYPE. – Mo 152326 (Figs. 2A–B, 3A–B) from the Boda Limestone, Kallholn, Dalarna.

DIAGNOSIS. – Large *Bodospira* with ornamentation of growth lines alone.

MATERIAL. – One almost complete specimen, a second specimen lacking the last whorl, and some few fragmentary specimens. All specimens are from the type locality.

DESCRIPTION. – The shell of this gastropod is coiled with 9 whorls (Figs. 2A–B, 3A). As in *B. undulata,* the initial whorls have a rounded profile, whereas the profile of the ontogenetically younger whorls is angulated. This angulation subdivides the external face of each of the latter whorls into an adapical field directed obliquely towards the shell axis and an abapical field almost parallel to the shell axis.

The ornamentation consists exclusively of irregular growth lines which are fairly coarse in places on the younger whorls (Fig. 2B). Transverse ornamental ridges similar to those in *B. undulata* are absent.

The base, the most abapical face of the last whorl, descends (in an apical direction) fairly steeply from the periphery towards the axis of the shell (Fig. 3B). There is no umbilicus. The somewhat thickened inner lip is almost completely preserved in the holotype and is uniformly arched throughout, just as in *B. undulata.* As demonstrated by the growth lines, the outer lip runs obliquely backwards from the last suture; it meets the inner lip at an acute angle.

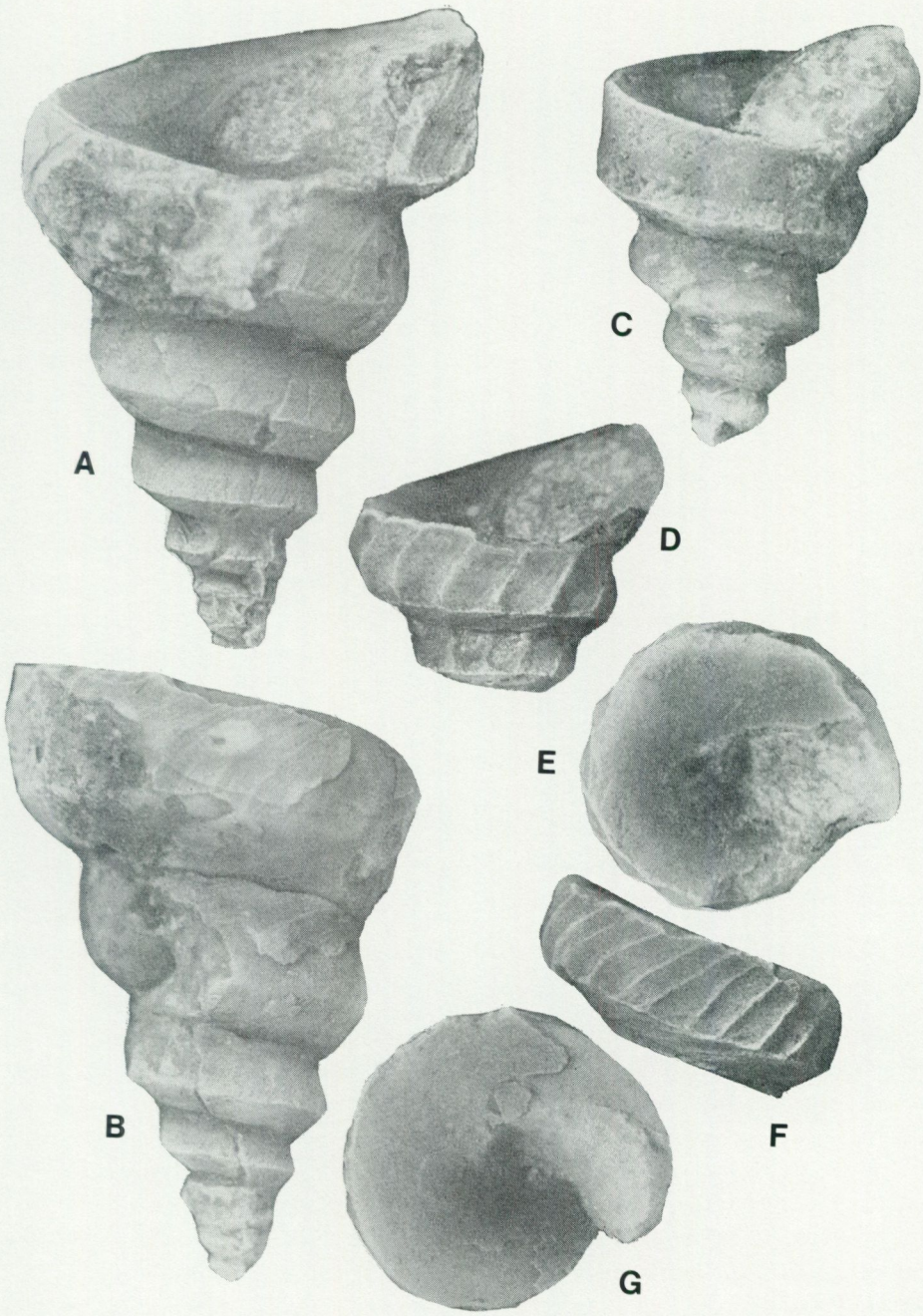

Fig. 2. *Bodospira kallholniensis* n.sp. A–B, holotype in apertural and abapertural views, respectively. × 10. No. Mo. 152326. C, specimen with last whorl missing. × 10. No. Mo. 152325. Boda Limestone, Kallholn, Siljan district.

Bodospira undulata n.sp. D–E, shell in apertural and basal views, respectively. × 10. No. Mo. 125152. Boda Limestone, Unskarsheden, Siljan district. F–G, shell in abapertural and basal views, respectively. × 10. No. Mo. 125266. Boda Limestone, Kallholn, Siljan district.

DIMENSIONS. – The holotype is 9.0 mm high and 6.0 mm wide.

REMARKS. – *B. kallholniensis* is about twice as large as *B. undulata* and lacks the transverse ribs characteristic of the type species.

Genus Angulospira n.g.

TYPE SPECIES. – *Angulospira striata* n.sp.

DIAGNOSIS. – Shell high-spired, conispiral, coiled with 9 whorls; whorl profile sharply angulated, with a distinct keel at about the mid-height of the whorl. Ornamentation of growth lines and on abapical field of younger whorls also of delicate transverse ridges.

REMARKS. – This genus appears to be closely related to *Bodospira* which has a similar kind of ornamentation. Both genera have an angulated but otherwise somewhat different whorl profile. In *Angulospira* the distinct keel separating the ad- and abapical fields of the whorl face has a mid-whorl position while in *Bodospira* this keel is situated more adapically. The shell of *Angulospira,* is considerably more high-spired and slender than that of *Bodospira. Angulospira* is at present a monotypic genus.

Angulospira striata n.sp.

Figs. 3E–F, 4A–C

HOLOTYPE. – Mo 150579 (Figs. 3E–F,4A) from the Boda Limestone, Kallholn, Dalarna.

MATERIAL. – Five incomplete specimens and some fragments, all from the type locality.

DESCRIPTION. – The high-spired, conispiral shell is coiled with 9 whorls (Fig. 3E). As in *Bodospira,* about two of the initial whorls have a uniformly rounded profile, whereas the profile of the ontogenetically younger whorls is angulate. Because of this angulation the external faces of the younger whorls are subdivided into an adapical and an abapical field both directed obliquely towards the shell axis and separated from each other by a pronounced keel.

The initial whorl has a smooth external face, but the corresponding faces of the second to fifth whorls are ornamented with variably spaced transverse ridges showing variation in their degree of coarseness (Figs. 3E, 4A). These ridges occur only in the juvenile whorls of the shell, then gradually disappear as the angulation of the whorl profile and the ornamentation of the adult whorls become more conspicuous. The latter ornamentation in addition to rather indistinct

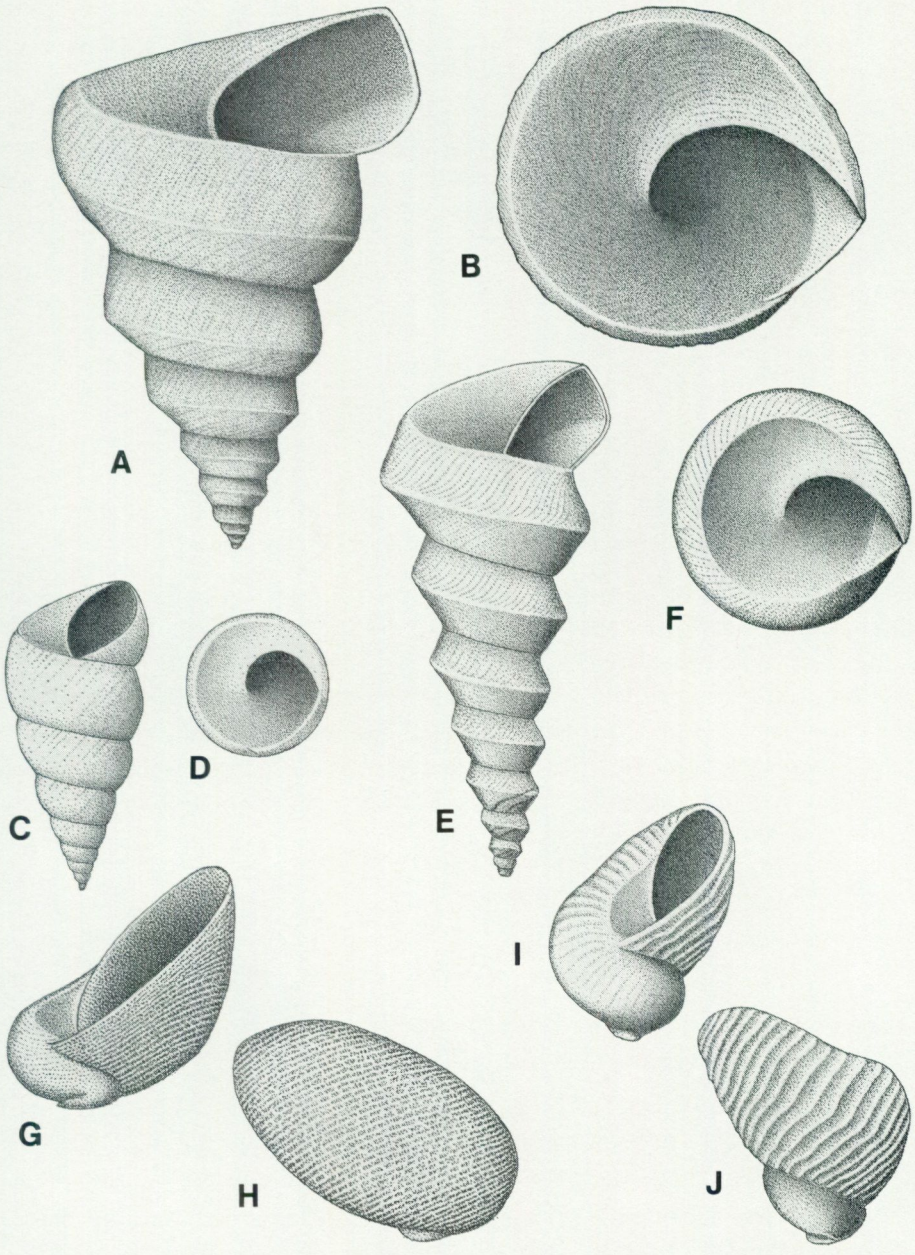

Fig. 3. *Bodospira kallholniensis* n.sp. A–B, reconstruction of holotype in apertural and basal views respectively. × 8.

Tapinogyra glaphyra n.sp. C–D, reconstruction of holotype in apertural and basal views respectively. × 8.

Angulospira striata n.sp. E–F, reconstruction of holotype in apertural and basal views respectively. × 14.

Laeogyra gracilis Perner, 1925. G–H, reconstruction of holotype in apertural and abapertural views, respectively. × 8.

Laeogyra arvetensis n.sp. I–J, reconstruction of holotype in apertural and abapertural views, respectively. × 8.

growth lines consists of delicate closely set transverse ridges on the abapical field of the 3–4 youngest whorls (Figs. 3E, 4A–C). These ridges become more distinct towards the shell aperture.

As in *Bodospira,* the basal, most abapical face descends steeply from the periphery towards the axis of the shell. There is no umbilicus. The growth lines demonstrate that the inner lip of the apertural margin formed a uniformly curved arch. The outer lip runs obliquely backwards from the last suture meeting the inner lip at an acute angle.

DIMENSIONS. – The holotype is approximately 4.0 mm high and 1.5 mm wide.

Genus Tapinogyra n.g.

TYPE SPECIES. – *Tapinogyra glaphyra* n.sp.

DIAGNOSIS. – Shell high-spired, conispiral, coiled with 8 whorls of uniformly rounded profile. No ornamentation except indistinct growth lines.

REMARKS. – *Tapinogyra* resembles *Bodospira, Angulospira* and *Mimospira* in the shape of the base and aperture but differs in the rounded whorl profile and in the absence of ornamentation. With regard to its high-spired shell, uniformly rounded whorl profile and shallow sutures *Tapinogyra* is reminiscent of the Devonian genus *Sinistracirsa.* However, the latter genus is clearly distinguished from *Tapinogyra* by its larger size, more complicated aperture and the nature of its ornamentation which consists of both transverse ridges and growth lines. *Tapinogyra* is at present monotypic.

Tapinogyra glaphyra n.sp.

Figs. 3C–D, 4F–G

HOLOTYPE. – Mo 150582 (Figs. 3C–D, 4F–G) from the Boda Limestone, Kallholn, Dalarna (the only available specimen).

DESCRIPTION. – The high-spired, conispiral shell of this gastropod is coiled with 8 whorls (Figs. 3C, 4F–G). The profile of all the whorls is gently rounded and the sutures are comparatively shallow. The external whorl face is smooth without undulations, ridges or ribs but shows indistinct growth lines in places. The basal abapical face of the last whorl descends fairly steeply from the periphery towards the axis of the shell. There is no umbilicus. The preserved parts of the apertural margin indicate that, as in *Mimospira,* the thin inner lip is uniformly curved. The outer lip extends obliquely backwards.

DIMENSIONS. – The holotype is approximately 5.0 mm high and 2.0 mm wide.

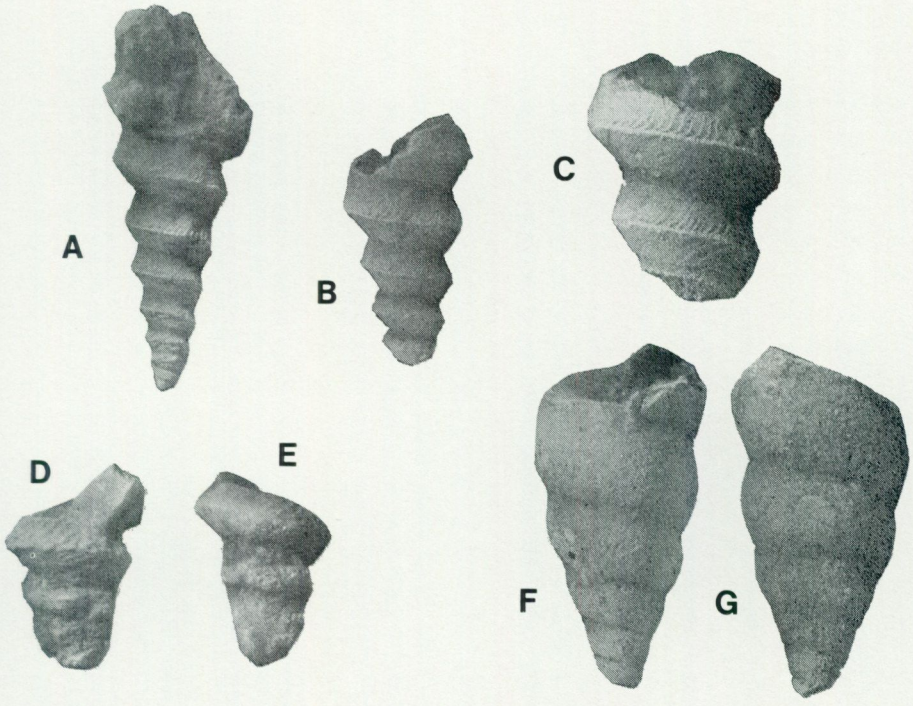

Fig. 4. *Angulospira striata* n.sp. A, holotype. × 10. No. Mo. 150579. B, fragmentary shell. × 10. No. Mo. 150580. C, fragmentary shell. × 14. No. Mo. 150581. Boda Limestone, Kallholn, Siljan district.

Angulospira? sp. indet. D–E. × 10. No. Mo. 39450 (Lindström 1884, Pl. 18, fig. 54). Hemse Beds, Sandarve, Gotland.

Tapinogyra glaphyra n.sp. F–G, holotype in apertural and abapertural views respectively. × 10. No. Mo. 150582. Boda Limestone, Kallholn, Siljan district.

Genus Laeogyra Perner, 1903

TYPE SPECIES. – *Laeogyra bohemica* Perner, 1903.

Laeogyra arvetensis n.sp.

Figs. 3I—J, 5A—D

HOLOTYPE. – Mo 150583 (Figs. 3I–J, 5A–B) from the Boda Limestone, Arvet Dalarna.

DIAGNOSIS. – A comparatively small *Laeogyra* where the ontogenetically youngest whorl is ornamented with transverse undulations.

MATERIAL. – One fairly complete specimen and some imperfect specimens which show the initial whorl and the ornamentation.

DESCRIPTION. – The small, conispiral shell is coiled with 2 whorls (Figs. 3I–J, 5A–B), except for a small, almost uncurved, initial portion with a blunt apical termination (Fig. 5D). The whorls increase rapidly in diameter and the sutures are sharply incised. The external face of the initial whorl is practically smooth except nearest its transition into the second whorl where there is an ornamentation of transverse undulations (Figs. 3J, 5B–C). These undulations gradually become more pronounced and are most conspicuous on the youngest whorl. There are approximately five undulations per mm and the undulations are practically of the same breadth as the interspaces. Individual undulations are not continuous but are separated into four anteriorly convex parts by three intervening depressions. On the shell as a whole, these depressions form three spiral grooves intersecting the undulations. The base is narrow and deeply concave, resembling a false umbilicus. The inner lip of the apertural margin could not be clearly observed in any of the specimens investigated. The outer lip runs obliquely backwards from the last suture. The completely recrystallized shell seems to be very thin.

DIMENSIONS. – The holotype is 4.0 mm high and 3.0 mm wide.

REMARKS. – Besides *L. arvetensis* two other species of *Laeogyra* are now known. *L. bohemica* Perner, 1903, the type species, is from the Ordovician ($d\gamma$) of Bohemia and *L. gracilis* Perner, 1925 from the Boda Limestone, Dalarna. *Laeogyra gracilis* was first described without figure by Koken (1897) as *Platyceras gracile* and then redescribed and figured by Perner (1925, p. 235, Pl. 38, figs. 29–31) as *Laeogyra gracilis*. *L. gracilis* is revised below, based upon the type specimen. *Laeogyra arvetensis* has several characters in common with both *L. bohemica* and *L. gracilis* and is apparently closely akin to these. It differs from *L. bohemica* above all by its considerably smaller size and from *L. gracilis* by the latter's reticulate ornamentation. *L.? reinwaldti* (Öpik 1930) see p. 18.

Laeogyra gracilis Perner, 1925

Figs. 3G–H, 5E–H

1897 *Platyceras gracile* Koken, p. 196.
1925 *Laeogyra gracilis* Perner, p. 234. Pl. 38, figs. 29–31.
1964 *Pervertina gracilis* Horný, p. 212.

HOLOTYPE BY MONOTYPY. – Mo 7265 (Figs. 3G–H, 5E–H) from the Boda Limestone, Östbjörka, Dalarna.

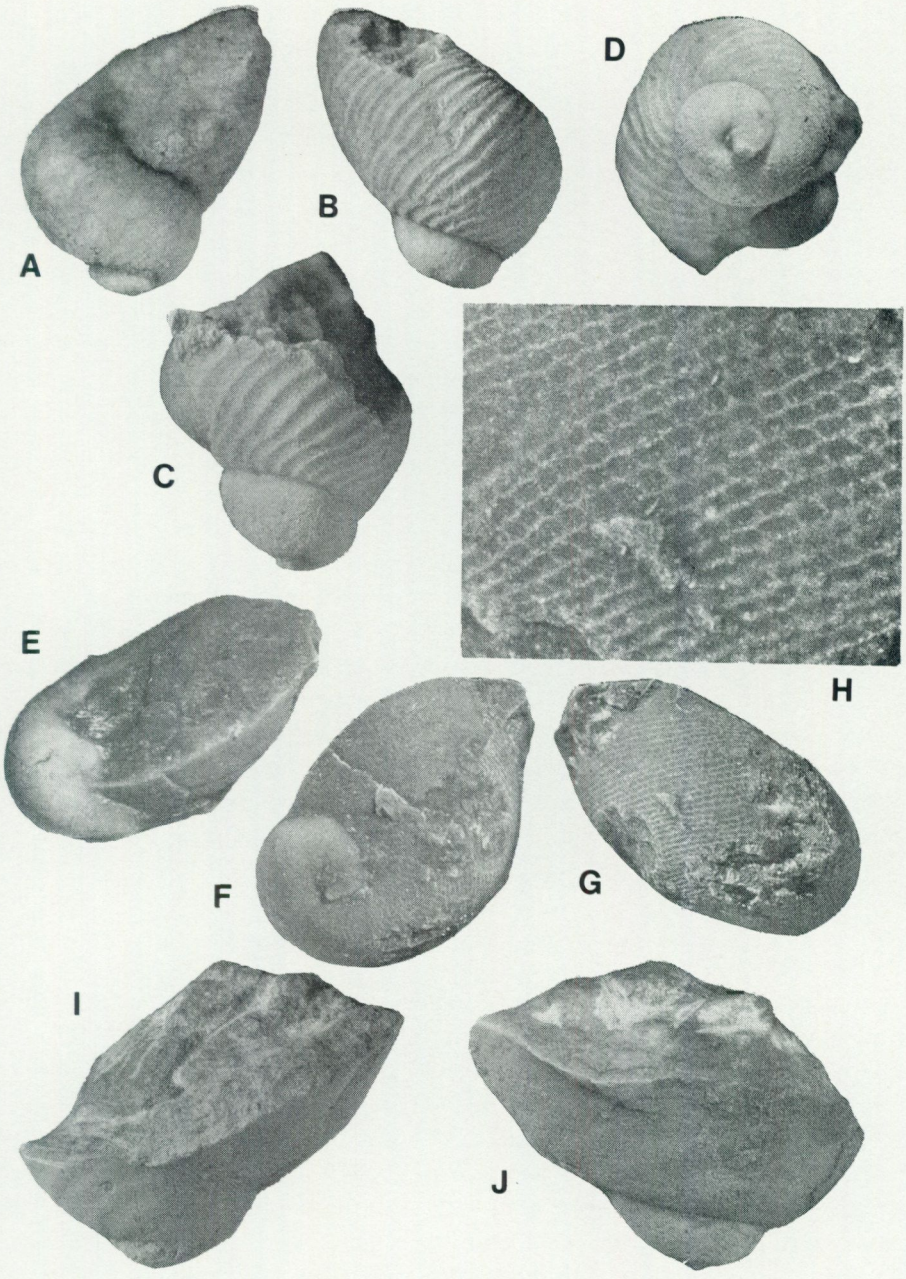

Fig. 5. *Laeogyra arvetensis* n.sp. A–B, holotype in apertural and abapertural views, respectively. × 10. No. Mo. 150583. C–D, specimen in abapertural and apical views, respectively. × 10. No. Mo. 150584. Boda Limestone, Arvet, Siljan district.

Laeogyra gracilis Perner, 1925. E–F, and G, holotype in apertural, basal and abapertural views respectively. × 8. H, ornamentation on abapertural part of holotype. × 25. No. Mo. 7265. Boda Limestone, Östbjörka, Siljan district.

Laeogyra? reinwaldti (Öpik, 1930). I–J, holotype in apertural and abapertural views, respectively. × 2.5 (Öpik 1930, Pl. 2, fig. 12). Lower part of Kukruse Stage, quarry at southern lighthouse, Tallinn.

DIAGNOSIS. – A rather small species of *Laeogyra* with a distinct regular reticulate ornamentation.

DESCRIPTION. – The small shell is coiled with one and a half whorls (Figs. 3G, 5E–F) which increase rapidly in diameter. The initial portion of the earliest whorl has, as in *L. arvetensis,* a smooth external face. The reticulate ornamentation appears gradually to become most distinct on the younger whorl face. It consists of delicate transverse ridges connected by very thin thread-like elevations in such a way that the ornamentation assumes an almost honeycomb-like pattern (Fig. 5H).

The base which cannot be clearly observed seems to be deeply concave in *L. arvetensis*. The outer lip of the apertural margin runs obliquely backwards from the last suture. The inner lip is hidden by matrix.

DIMENSIONS. – The holotype is 5.0 mm high and 6.0 mm wide.

REMARKS. – The holotype is the only known specimen from the Boda Limestone (Ashgillian). In Bohemia additional specimens have been found in layers of latest Ashgillian age. Referring to these latter specimens Horný (1964) designated *Platyceras gracile* as the type species of a new monotypic genus *Pervertina* distinguished from *Laeogyra* by its sharply reticulate ornamentation. However, in this case the ornamentation alone scarcely seems sufficient to motivate establishing a new genus. With respect to the fundamental characters of the shell the species is very close to the other species referred to *Laeogyra.* For this reason *Pervertina* is here considered as a junior synonym of *Laeogyra. L. gracilis* differs from the other species of *Laeogyra* by its distinctive ornamentation.

Family Clisospiridae Miller, 1889

Three genera, *Clisospira, Mimospira* and the new genus *Undospira,* are tentatively placed in this family. Since the shell base and aperture of *Clisospira* are still imperfectly known, the relationship between *Clisospira* and *Mimospira* remains obscure.

The holotype of *C. rugosa* (Koken, 1925; Fig. 6G–H in the present paper) is the only Swedish material of *Clisospira* available to the writer. This specimen resembles *C. curiosa* (Billings, 1865), the type species of *Clisospira,* where both the whorl profile and the presence of a flange are concerned. On the other hand its ornamentation is not reticulate as that in *C. curiosa,* but consists of transverse ribs, just as in certain Bohemian *Clisospira* species and in species of *Mimospira.* Moreover, these transverse ridges are remarkable from the point of view that they appear to continue across the sutures without any interruptions (Perner *in* Barrande 1911, p. 266, Fig. 313).

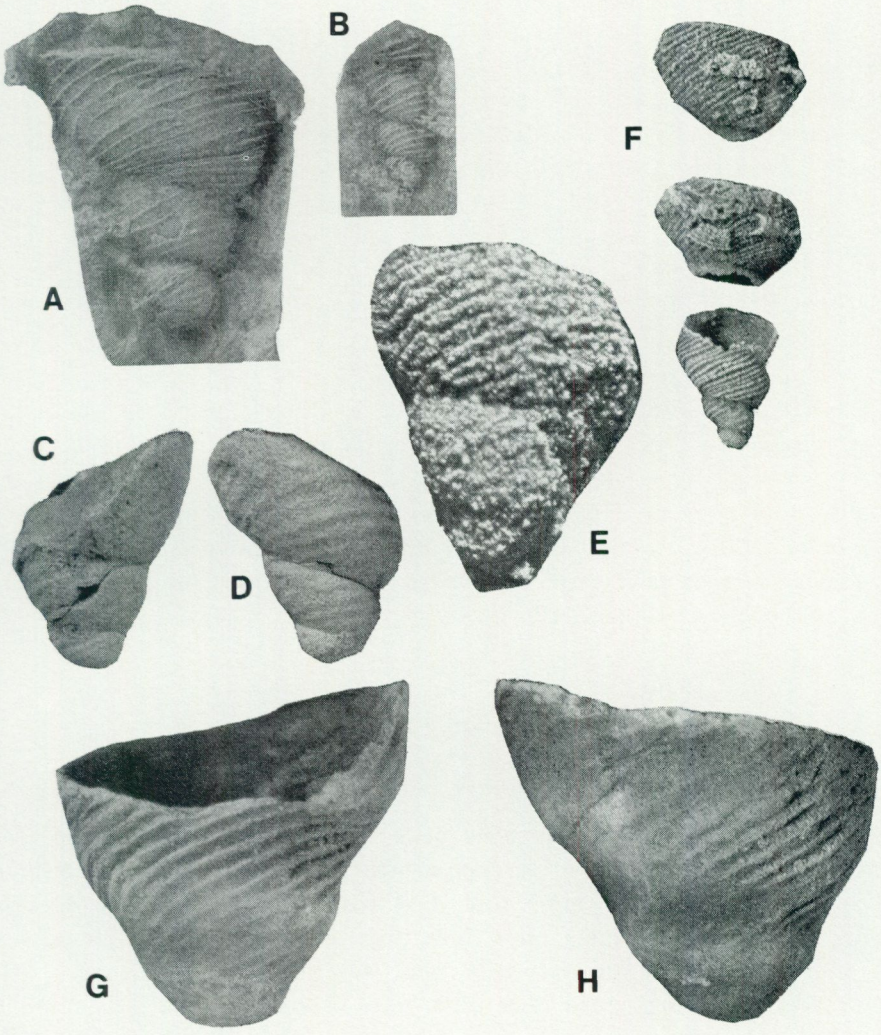

Fig. 6. *Mimospira helmhackeri* Perner, 1900. A–B, latex casts of external moulds. × 5. Ordovician, Kváň, Bohemia.

Mimospira sp. indet. (*Cliospira* aff. *rugosa* Koken; Öpik 1930, Pl. 2, fig. 11). C–D shell in apertural and abapertural views, respectively. × 3. Kukruse Stage, Kohtla, Estonia.

Mimospira atava (Moberg and Segerberg, 1906). E, latex cast of external mould. × 24. LO 1802 T. Upper Tremadocian, Fågelsång, Scania.

Mimospira sp. indet. F, silicified specimen from Lower Edinburg Formation, Strasburg Junction, Virginia, U.S.A. × 10. No. Mo. 152573.

Clisospira rugosa Koken 1925, G–H, holotype in apertural and abapertural views, respectively. × 10. No. Mo. 10883. Red Jonstorp Formation, Rödbergsudd, Östergötland.

As far as can be seen, the base is deeply concave and the outer lip of the apertural margin is parallel with the transverse ornamental ribs. *Clisospira rugosa* is from the Upper Ordovician (Harjuan) Red Jonstorp Formation of Östergötland. In addition the following five Balto-Scandinavian species of *Clisospira* have been described (Koken 1925, Öpik 1930): *C. christianiae* Koken from the Upper Ordovician (5b, Ringerike) of Norway, *C. borkholmiensis* Koken from the Porkuni Stage (F_{II}) of Estonia, *C. ingrica* Koken from the Lower Ordovician Kunda Stage (B_{III}, Pulkova) of the Leningrad area, *C.* aff. *rugosa* Öpik and *C. reinwaldti* Öpik both from the Middle Ordovician (Viruan) Kukruse Stage (CII) of Estonia.

C. christianiae and *C. borkholmiensis* both show certain general *Clisospira*-like characters. *C. ingrica* on the other hand appears to have certain general characters in common with the genus *Mimospira*.

C. aff. *rugosa* (Fig. 6C–D) and *C. reinwaldti* (Fig. 5I–J), both preserved only as internal moulds are, in fact, undeterminable. However, it is suspected that *C.* aff. *rugosa* may turn out to belong within the genus *Mimospira*. *C. reinwaldti*, which shows traces of an ornamentation of transverse undulations and the moulds of 2–3 whorls increasing rapidly in diameter, cannot be referred to *Clisospira*. On the other hand, in the two principal characters pointed out, it resembles *Laeogyra arvetensis* and in consequence it will provisionally be designated as *Laeogyra ? reinwaldti* (Öpik).

Genus Mimospira Koken, 1925

TYPE SPECIES. – *Mimospira helmhackeri* Perner, 1900.

DIAGNOSIS. – Shell conispiral, coiled with 6 whorls which are more or less convex or even flattened in profile. Base concave without umbilicus. Inner lip of the apertural margin is uniformly arched. Outer lip extending backwards from the last suture, meeting inner lip without interruption. Ornamentation of ribs conformable with the apertural margin. Shell wall probably consisting of two layers, a very thin outer calcitic layer and an inner aragonitic layer.

REMARKS. – The generic name *Mimospira* was introduced by Koken (1925) for *Mimospira turrita* Koken and Perner (Fig. 11G–J in the present paper) from the Ordovician of Östergötland and *Onychochilus helmhackeri* Perner, 1900. *O. helmhackeri* was redescribed by Perner (1911) as *Clisospira helmhackeri* and chosen by Knight (1937) as the type species of *Mimospira*. In the present paper *Mimospira turrita* is referred to the new closely allied genus *Undospira*.

The present writer was able to examine latex casts of the two specimens of *Mimospira helmhackeri* which together with two internal moulds constituted Perner's type material. The latex casts just referred to (Fig. 6A–B) clearly show

the shape of the whorls, and *Mimospira*-like ornamentation, but nothing of the base and the apertural margin.

In the present paper *Mimospira* is defined to differ from *Clisospira* in its considerably more convex whorl profile and by the lack of the peripheral, spiral flange (cf. above). In the type species of *Mimospira,* however, the whorl profile tends to be slightly concave in the last whorl, close to the periphery. So far only one type of ornamentation is known in *Mimospira:* ribs, more or less parallel with the apertural margin.

Mimospira kallholniensis n.sp.

Fig. 7

HOLOTYPE. – Mo 151853 (Fig. 7A–D) from the Boda Limestone, Kallholn, Dalarna.

DIAGNOSIS. – A *Mimospira* with convex whorl profile, the maximum convexity situated abapically close to the sharply incised suture. Ornamentation of distinct ribs separated by rather wide interspaces.

MATERIAL. – Several specimens, four of which are fairly complete. All specimens, except a fragment from Arvet, come from the type locality.

DESCRIPTION. – The conispiral shell is coiled, with 6 whorls (Fig. 7A, C–D). The initial whorls have a uniformly rounded profile, whereas the ontogenetically younger whorls show an abapical obscure shoulder close to the sharply incised suture.

The ornamentation, which is distinct on the external faces of all the whorls except the initial one, consists of ribs arranged conformably to the apertural margin (Fig. 7A, C, F) and at acute angles (15°) to the sutures. The ribs are rounded in profile probably because of abrasion; their original shape may have been somewhat as in *M. tenuistriata* (Fig. 8F–H). The distance between the ribs increases regularly towards the aperture. The width of the ribs on the younger (adult) whorls is as a rule about one-third of the interspaces. Irregularities in the course of the ribs are frequently met with at the shoulder area close to the suture, where the ribs may change direction, diverge or fuse. (Fig. 7A, D). The basal face of the youngest whorl descends steeply from the periphery towards the axis of the shell. There is no umbilicus (Fig. 7B, E).

Parts of the apertural margin are fairly well preserved in some of the specimens (Fig. 7E–F) and the aperture could therefore be restored with reasonable certainty (Fig. 7B). The inner lip forms a continuous uniformly curved arch. The outer lip, which is also uninterrupted extends straight backwards from the last suture so as to meet the inner lip and to fuse with this.

DIMENSIONS. – The holotype is 7.0 mm high and 5.0 mm wide.

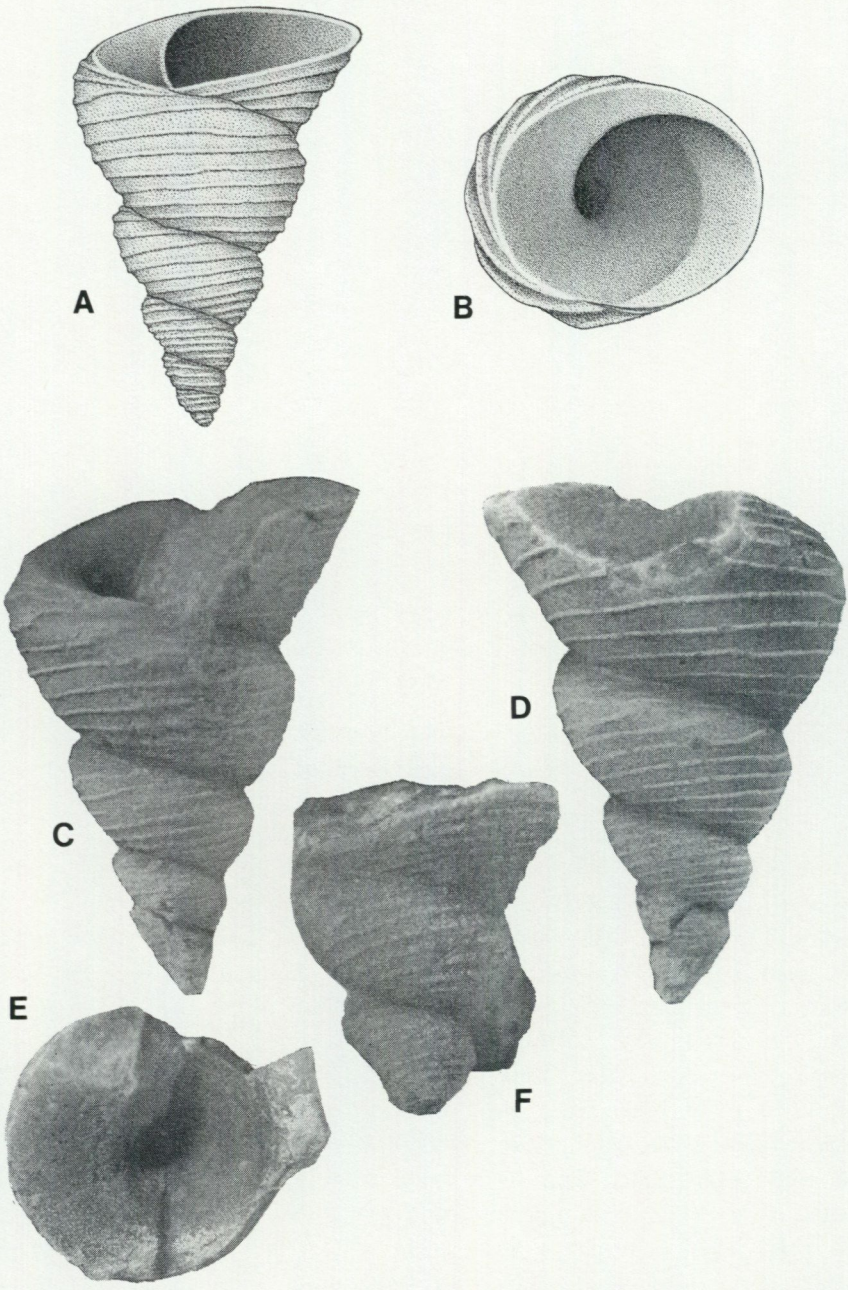

Fig. 7. *Mimospira kallholniensis* n.sp. A–B, reconstruction of holotype in apertural and basal views, respectively. × 8. C–D, holotype in apertural and abapertural views, respectively. × 10. No. Mo. 151853. E, specimen in basal view. × 10. No. Mo. 151854. F, specimen showing apertural margin. × 10. No. Mo. 150585. All specimens are from the Boda Limestone, Kallholn, Siljan district.

REMARKS. – *M. kallholniensis* is smaller than *M. helmhackeri* from which it also differs in the following two respects: (1) the condition of the sixth (youngest) whorl which is plane close to the aperture and (2) the fact that the most abapical, peripheral part of the shell lacks all indications of a flange. With respect to the shape of the whorls 1–5 and the ornamentation *M. kallholniensis* is essentially comparable to *M. helmhackeri*.

Mimospira tenuistriata n.sp.

Fig. 8A–H

HOLOTYPE. – Mo 7856 a (Fig. 8A–E) from the Lowermost Dalby Limestone, Kårgärde, Dalarna.

DIAGNOSIS. – A *Mimospira* with convex whorl profile, the maximum convexity situated mid-whorl. Ornamentation of thin distinct transverse ribs separated by narrow interspaces. Pleural angle wide (60°).

MATERIAL AND OCCURRENCE. – Numerous specimens more or less complete, from Öland: Källa Limestone (Vedby, Persnäs, Lundbyberg), Dalarna: Furudal and lowermost Dalby Limestone (Kårgärde, Fjäcka), Västergötland: Lowermost Dalby Limestone (Norra Skagen boring), Kinnekulle. All strata mentioned are of Middle Ordovician age.

DESCRIPTION. – The conispiral shell is coiled with 6 whorls (Fig. 8A, C–E) which increase so rapidly in diameter that the pleural angle is wide. The whorl profile is rounded; sutures are shallow and indistinct.

The external faces of all the whorls, with the possible exception of the initial one are ornamented with thin transverse ribs arranged conformably to the apertural margin and separated by narrow interspaces. As can be seen from a thin section of the shell (Fig. 8F–H), these ribs are rather high and thin with a peripheral, adapically tending curvature. The distance between the ribs approximately equals the height of the ribs or is even less.

The base and the apertural margin are essentially as in *Mimospira kallholniensis*, but the base is less concave (Fig. 8B).

The shell wall is thin (Fig. 8F–H) consisting of an outer very delicate calcitic layer (0.06 mm in the last whorl) and an inner originally aragonitic layer about three times thicker (0.2 mm).

DIMENSIONS. – The holotype is 3.5 mm high and 2.5 mm wide; pleural angle wide 60°.

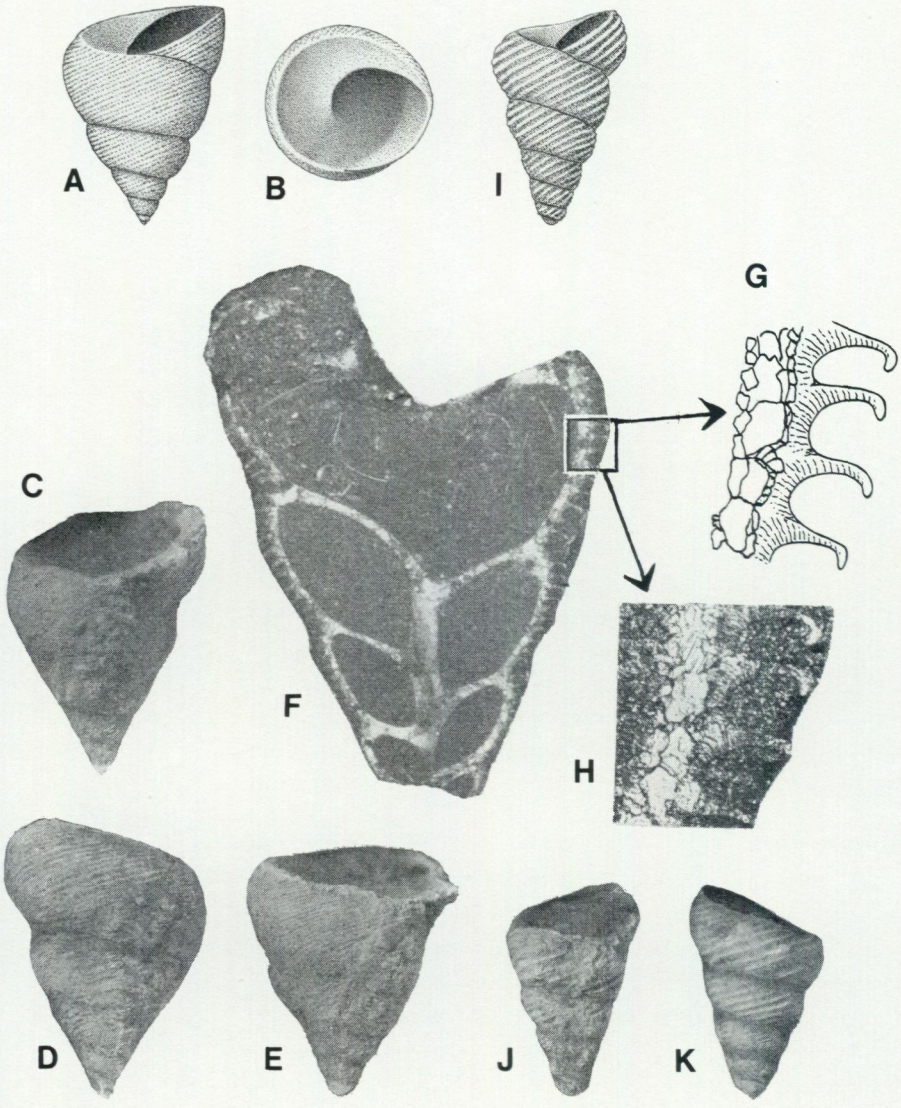

Fig. 8. *Mimospira tenuistriata* n.sp. A–B, reconstruction of holotype in apertural and basal views, respectively. × 8. C–E, holotype in apertural (C and E) and (D) abapertural views, respectively. × 10. No. Mo. 7856a. Dalby Limestone, Kårgärde, Dalarna. F, longitudinal thin section. × 20. G–H, parts of the shell wall, diagrammatic drawing and photo, respectively, showing outer layer with prismatic calcite crystals and inner recrystallized layer with drusy calcite. × 120. No. Mo. 152574.

Mimospira similis n.sp. I, reconstruction of holotype in apertural view. J–K, holotype in apertural and abapertural views, respectively. × 10. No. Mo. 13451. Källa Limestone, Källa, Öland.

Mimospira similis n.sp.

Fig. 8I–K

HOLOTYPE. – Mo 13451 (Fig. 8I–K) from the Källa Limestone close to the church of Källa, Öland.

DIAGNOSIS. – A *Mimospira* with convex whorl profile, the maximum convexity situated at mid-whorl. Ornamentation of transverse ribs separated by fairly wide interspaces. Pleural angle narrow (45°).

MATERIAL AND OCCURRENCE. – Twenty nearly complete specimens with the same occurrence as *M. tenuistriata.*

DESCRIPTION. – The conispiral shell is coiled with 6 whorls, increasing so slowly in diameter that the pleural angle is narrow (Fig. 8I—K). The whorl profile is uniformly rounded; sutures are shallow and indistinct.

The external faces of all the whorls, with the possible exception of the initial one, are ornamented with distinct transverse ribs arranged conformably to the apertural margin. The number of ribs on the individual whorls is less than in *M. tenuistriata* and the interspaces are wider (Fig. 8I, K).

The base and the apertural margin appear to be essentially as in *M. tenuistriata.*

DIMENSIONS. – The holotype is 3 mm high and 1.8 mm wide; pleural angle 45°.

REMARKS. – *Mimospira tenuistriata* apparently is closely akin to *M. similis,* differing from the latter species only in the following two respects: a wider pleural angle and a larger number of ornamental ribs. These two species are clearly distinguished from *M. kallholniensis* mainly by their considerably smaller size and more obscure sutures.

As will be discussed under Sexual Dimorphism, *M. tenuistriata* and *M. similis* may perhaps turn out to be sexual dimorphs (females and males, respectively) of one and the same species.

Mimospira cochleata (Lindström)

Figs. 9, 10

1884 *Onychochilus? cochleatum* Lindström, Pl. 18, figs. 55–57 *(non* Pl. 18, fig. 54).
1925 *Mimospira cochleatum* Koken, p. 235.

LECTOTYPE. – Mo 40515 (Figs. 9, 10A, C) from the Silurian Slite Beds, Samsugn, Gotland.

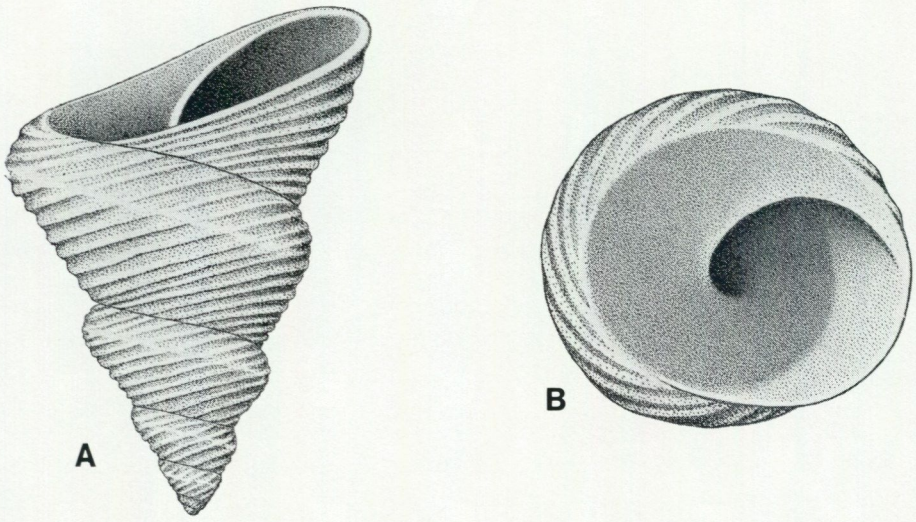

Fig. 9. *Mimospira cochleata* (Lindström, 1884) A–B, reconstruction of lectotype in apertural and basal views, respectively. × 10. No. Mo. 40515. Slite Beds, Samsugn, Gotland.

DIAGNOSIS. – A *Mimospira* in which the whorl profile is subdivided into two flattened surfaces by a distinct abapical shoulder close to the sharply incised suture. Ornamentation of ribs situated fairly closely together.

MATERIAL. – Five rather complete specimens.

DESCRIPTION. – The conispiral shell is coiled with 6 whorls (Figs. 9A, 10A, C). The initial whorls, not completely preserved in any of the studied specimens, are slightly convex in profile. The ontogenetically younger whorls are subdivided into two flattened surfaces by a distinct abapical shoulder close to the sharply incised suture.

The ornamentation is distinct on the external faces of all the whorls except the initial one. As in *M. kallholniensis* it consists of conspicuous ribs which run conformably to the apertural margin, meeting the suture at acute angels (Fig. 9A). The ribs are rounded in profile, but there is a possibility that they have undergone abrasion and were originally more sharp-edged. Abapically to the shoulder and close to the sutures the ribs are closely crowded. On the other parts of the shell the ribs and the interspaces between these are of approximately the same breadth. Moreover, the breadth of the ribs and interspaces is approximately the same on all the whorls, both the younger and older ones.

The base and the apertural margin are both essentially as in *M. kallholniensis* (Fig. 9B).

DIMENSIONS. – The lectotype is 9.0 mm high and 6.5 mm wide.

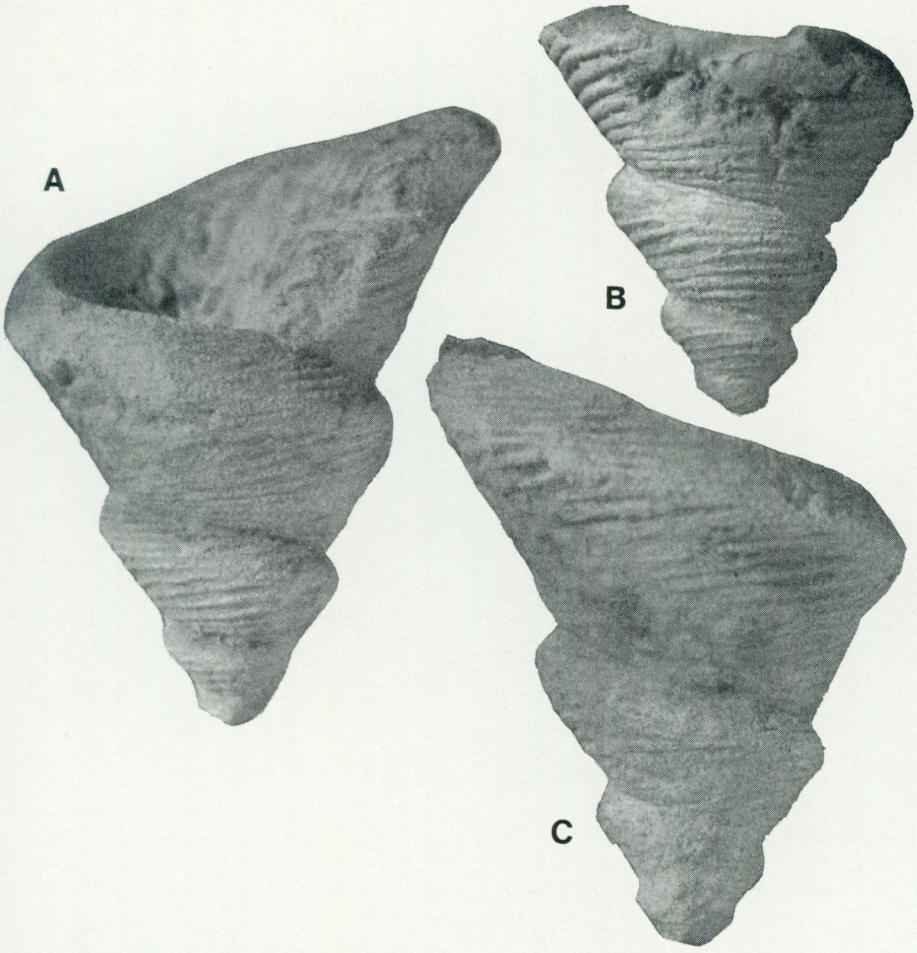

Fig. 10. *Mimospira cochleata* (Lindström, 1884) A–C, lectotype in apertural and abapertural views, respectively. × 10. B, specimen in abapertural view. × 10. No. Mo. 150586. Slite Beds, Samsugn, Gotland.

REMARKS. – *Onychochilus? cochleatum* was named and described by Lindström in 1884. This species was then discussed by Koken (1925), who tentatively placed it in the genus *Mimospira*. Lindström figured two specimens, one of which (Lindström 1884, Pl. 18, fig. 54) seems to be akin to the genus *Angulospira,* whereas the other specimen (Lindström 1884, Pl. 18, figs. 55–57) is a clear representative of the genus *Mimospira*. This illustrated specimen could not be isolated amongst the five specimens available to me. That being so, specimen Mo 40515 has been chosen as a lectotype.

As currently known, *M. cochleata* is distinguished from the Ordovician *Mimospira* species chiefly by the presence of a distinct abapical shoulder on the indi-

vidual adult whorls. It seems to be more closely akin to the Upper Ordovician *M. kallholniensis* than to the geologically somewhat older *Mimospira* species. Actually it differs from *M. kallholniensis* only in the following three characters: (1) the ontogenetically younger whorls are flattened adapically; (2) more pronounced abapical shoulder; and (3) narrower interspaces between the ribs.

Mimospira atava (Moberg & Segerberg)

Fig. 6E

1906 *Trochus atavus* Moberg & Segerberg (p. 74, Pl. 3, fig. 23).

HOLOTYPE. – LO 1802 T (Fig. 6E) from Upper Tremadocian, Fågelsång, Scania.

REMARKS. – The only available material is the holotype preserved as an external mould of approximately four whorls.

The moderately convex whorl profile, the rather distinct sutures and the ornamentation of closely placed ribs clearly shows that this gastropod belongs to the genus *Mimospira*. Because of the poor state of preservation the total number of whorls cannot be determined. Nothing of the base and aperture can be observed. Due to these circumstances no definition can be made at species level.

Genus Undospira n.g

TYPE SPECIES. – *Undospira striata* n.sp.

DIAGNOSIS. – Shell conispiral, coiled with approximately 6–10 whorls which are more or less convex in profile. Ornamentation of transverse coarse ridge-like undulations crossed by delicate striae.

REMARKS. – This genus seems to be closely related to *Mimospira* but has a different ornamentation. More precisely, the ornamentation consists of fairly coarse ridge-like undulations crossed by delicate striae, not of transverse narrow ribs as is the case in *Mimospira*.

Undospira striata n.sp.

Fig. 11A–F

HOLOTYPE. – Mo 151968 (Fig. 11A–D) from the Furudal Limestone, Kårgärde, Dalarna.

DIAGNOSIS. – Shell coiled with approximately 6 whorls, with rather coarse transverse ridge-like undulations and delicate striae.

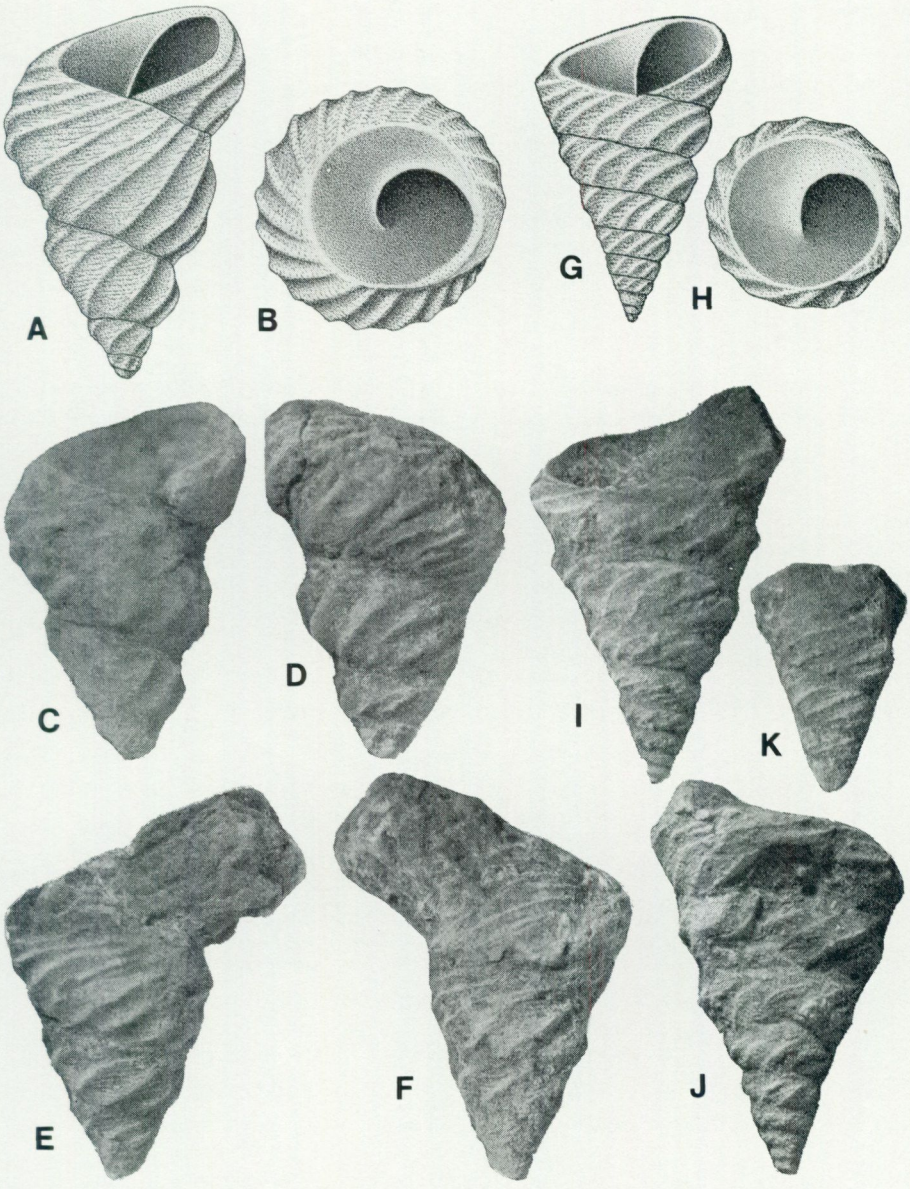

Fig. 11. *Undospira striata* n.sp. A–B, reconstruction of holotype in apertural and basal views, respectively. × 10. C–D, holotype in apertural and abapertural views, respectively. × 10. No. D 1200. Furudal Limestone, Kårgärde, Siljan district. E–F, specimen in apertural and abapertural views, respectively. × 10. No. Mo. 7856b. Furudal Limestone, Kårgärde, Siljan district.

Undospira turrita (Koken) G–H, reconstruction of holotype in apertural and basal views respectively. × 10. I–J, holotype in apertural and abapertural views respectively. ×10. No. Mo. 10886 Red Jonstorp Formation, Rödbergsudd, Östergötland.

Undospira? sp.indet. K, incomplete specimen. × 10. No. Mo. 10888. *Gigas* Limestone, Ljung, Östergötland.

MATERIAL AND OCCURRENCE. – Two specimens, the holotype and another flattened specimen in which details of the ornamentation are better preserved than in the holotype. Both specimens are from the type locality.

DESCRIPTION. – The conispiral shell of this species is coiled with approximately 6 whorls, rounded in profile (Fig. 11A, C–F); the maximum convexity is situated mid-whorl or somewhat abapically.

On the external face two ornamental elements can be distinguished: (1) transverse rather coarse, ridge-like undulations arranged conformably to the apertural margin and (2) delicate striae crossing both the ridge-like undulations and the interspaces between these.

The base and the apertural margin, fairly well preserved in the holotype, are essentially as in *Mimospira* (Fig. 11B). Thus the base (the adaxial face of the youngest whorl) descends steeply from the periphery towards the central axis of the shell. There is no umbilicus. The inner lip of the apertural margin forms a uniformly curved arch, while the outer lip runs obliquely backwards from the last suture so as to meet and to fuse with the inner lip.

DIMENSIONS. – The holotype is 5.0 mm high and 3.0 mm wide.

Undospira? turrita (Koken, 1925)

Fig. 11G–J

Mimospira (? Clisospira) turrita Koken 1925, p. 236, Pl. 40, fig. 5a, b.

HOLOTYPE. – Mo 10886 (Fig. 21A–D), described by Koken 1925, from the Red Jonstorp Formation, Rödbergsudd, Östergötland.

DIAGNOSIS. – Shell coiled with 10 comparatively low whorls, ornamented with transverse, ridge-like undulations and delicate striae.

MATERIAL. – The holotype, the only specimen so far known. This specimen is fairly complete and well preserved but somewhat flattened. However, its shape can be restored with reasonable certainty by comparison with *U. striata.*

DESCRIPTION. – The conispiral shell is coiled with 10 whorls which appear to be slightly rounded in profile (Fig. 11G, I–J).

The external faces of the three initial whorls are smooth, but whether or not this condition is the result of abrasion is a question which must be left unanswered. On the other hand, the external faces of the ontogenetically younger whorls possess an ornamentation similar to that of *U. striata* in that one can distinguish both (1) transverse ridge-like undulations arranged conformably to the apertural margin and (2) delicate striae across both the ridge-like undulations

and the separating interspaces. The ridge-like undulations are less coarse than those of *U. striata.*

The base and the apertural margin may be assumed to have been essentially as in *U. striata* (Fig. 11H).

DIMENSIONS. – The holotype is 5.0 mm high and 3.0 mm wide.

REMARKS. – *Undospira? turrita* differs from *U. striata* by having: (1) a greater number of whorls; (2) whorls which are wider in proportion to the height, their width/height ratio being approximately 3:1 (2:1 in *U. striata);* and (3) an ornamentation which is less coarse and consequently less conspicuous.

As may also be gathered from the above description, *Mimospira (? Clisospira) turrita* Koken (1925, p. 236, Pl. 40, fig. 5a, b) resembles most closely *Undospira striata* and that being so, it is here tentatively referred to the new genus *Undospira.* A fragmentary specimen (Fig. 11K) from the *Gigas* Limestone, Östergötland is too incomplete for definition at species level and in consequence it will be designated as *Undospira?* sp. indet.

Koken (1925) figures an incomplete gastropod shell, referred to as *Mimospira (turrita?)* not mentioned in the text. This shell which is from the division 4aα, Helgøya, Norway, and has recently been re-studied by Yochelson (1963, p. 208) who could not decide whether or not it is conspecific with *M. turrita.* On the basis of the new material treated in the present paper there is reason to believe, however, that the gastropod shell concerned belongs within *Mimospira.*

NOTES ON THE GEOLOGICAL AND GEOGRAPHICAL DISTRIBUTION OF ONYCHOCHILIDS AND CLISOSPIRIDS

As far as known, these gastropods range from the Upper Cambrian to the Middle Devonian. Outside the Balto-Scandian region they have been recorded from Bohemia, Wales, Canada, U.S.A., and China.

Several clisospirid genera have been described from the Ordovician, Silurian and Devonian of Bohemia (Barrande 1911, Horný 1964). From the Lower Ordovician of Wales (Trefor, Anglesey) an apparently sinistrally coiled gastropod has been described as *Matherella* (?) *acuticostata* Bates (1963, p. 258, Pl. 17, figs. 10–12). To judge from the illustration this species seems to be more appropriately referred to *Mimospira.* Actually it shows close similarities to the type species, *M. helmhackeri,* from the Ordovician of Bohemia. Comparatively few clisospirids have been recorded from countries outside Europe. A few *Clisospira* species have been recorded from the Ordovician of Canada, including the type species (Billings 1865:186). From the Silurian of Nova Scotia *Mimospira abbae* has been described (Peel 1975, 1977). A silicified fragmentary specimen, identified by me as a *Mimospira* (Fig. 6F), has been recovered by V. Jaanusson from

the Middle Ordovician (Champlainian) Lower Edinburg Formation of Virginia, U.S.A. The Lower Edinburg is probably contemporaneous with the Upper Dalby Formation in Sweden (Bergström 1971).

ECOLOGICAL NOTES

The Swedish macluritaceans treated in the present paper (Table 1) occur chiefly in two different lithofacies: (1) calcilutites (Källa, Furudal and lowermost Dalby Limestones, Upper Jonstorp Formation) and (2) carbonate mounds (Boda Limestone). The calcilutites formed a soft bottom of carbonate mud whereas the Boda Limestone is associated with a still incompletely understood complex of sedimentary environments where gastropods of various groups occur in abundance. *Mimospira* is the only genus common to the two facies.

In the Uhakuan and lowermost Dalbyan calcilutites *Mimospira* is frequently the dominating gastropod and numerous specimens have been washed out from marl samples. The distribution of the genus in Sweden suggests an adaptation to carbonate mud bottoms. The finds of clisospirids from other environments are restricted to one or a few specimens each and they form there a quite subordinate component of the gastropod fauna.

TABLE 1. Distribution of macluritacean gastropods in the Ordovician and Silurian of Sweden. *L* refers to the lowermost part of the division in question.

	Lower Ord. Oelandian		Middle Ordovician Viruan			Upper Ord. Harjuan		Silurian Wenlockian	Silurian Ludlovian
	Ceratopyge Beds	*Gigas* Lmst.	Källa Lmst.	Furudal Lmst.	Dalby Lmst.	Upper Jonstorp Fm.	Boda Lmst.	Slite Beds	Hemse Beds
Onychochilidae									
Angulospira striata, n.g., n.sp.	–	–	–	–	–	–	×	–	–
Angulospira sp. indet.	–	–	–	–	–	–	–	–	×
Bodospira undulata, n.g., n.sp.	–	–	–	–	–	–	×	–	–
Bodospira kallholniensis n.sp.	–	–	–	–	–	–	×	–	–
Laeogyra gracilis Koken	–	–	–	–	–	–	×	–	–
Laeogyra arvetensis n.sp.	–	–	–	–	–	–	×	–	–
Tapinogyra glaphyra n.g., n.sp.	–	–	–	–	–	–	×	–	–
Onychochilus physa Lindström	–	–	–	–	–	–	–	–	×
Onychochilus reticulatum Lindström	–	–	–	–	–	–	–	–	×
Clisospiridae									
Clisospira rugosa Koken	–	–	–	–	–	×	–	–	–
Mimospira kallholniensis n.sp.	–	–	–	–	–	–	×	–	–
Mimospira tenuistriata n.sp.	–	–	–	×	L	–	–	–	–
Mimospira similis n.sp.	–	–	×	–	L	–	–	–	–
Mimospira cochleata (Lindström)	–	–	–	–	–	–	–	×	–
Mimospira atava (Moberg & Segerberg)	+	–	–	–	–	–	–	–	–
Undospira striata n.sp.	–	–	×	L	–	–	–	–	–
Undospira turrita (Koken)	–	–	–	–	–	–	×	–	–
Undospira sp. indet.	–	×	–	–	–	–	–	–	–

SEXUAL DIMORPHISM

As is well known, the sexes of the prosobranchs generally are separate and when the sexual dimorphism is appreciable in the shells, the female shells are larger and wider than those of the males (Simroth in Bronn 1896–1907, p. 215, Cox in Knight *et. al.* 1960, p. I 128). In certain recent molluscans *(Cypraea gracilis)* differences between the two sexes are also met with in the colours (Griffiths 1960, p. 203). Out of the forms described above the two closely related species *Mimospira tenuistriata* and *M. similis* actually differ chiefly in two respects, the ornamentation and the size and proportions of the shell which is larger and broader in *M. tenuistriata* than in *M. similis* (Table 2). These two differences may very well be interpreted to reflect sexual dimorphism and, if this turns out to be so, *M. tenuistriata* and *M. similis* are conspecific. This opinion is supported to some extent by their occurrence. They occur associated and with about the same frequency. In further studies more attention should be paid to the possibility of occurrence of sexual dimorphism in several gastropod groups.

TABLE 2. Measurements in *Mimospira tenuistriata* n.sp.

No	Whorl No.	Whorl height, mm	Number of ribs along a longitudinal line
Mo 7856a	1	1.2	18–20
	2	0.8	12–15
	3	–	10
Dal. specimen	1	1.1	18
	2	0.8	10
Mo 13470	1	1.8?	18?

Measurements in *Mimospira similis* n.sp.

No	Whorl No.	Whorl height, mm	Number of ribs along a longitudinal line
Mo 13451	1	0.8	7
	2	0.5	6
Vg, specimen 1	1	0.3	–
Vg, specimen 2	1	0.8?	7
	2	0.4	6

SHELL STRUCTURE

In order to examine the clisospirid shell structure several thin sections were prepared. Most of these revealed an extensive recrystallization of the shell wall, comprising also the secondary calcite mosaic in specimens from carbonate mounds. The best state of preservation of the shell structure was found in shells from the Furudal and Dalby Limestones, particularly in specimens where the shell cavity was filled with sediment and the shell itself still was embedded in the rock. In such cases it could be clearly observed that the shell wall is com-

posed of two layers (Fig. 8F–H). The inner layer consists of an irregular calcite mosaic in which the calcite crystals vary in size and shape and show a random crystallographic orientation (para-axial mosaic, Bathurst 1964:359). The crystallographic characteristics of this mosaic indicate that the layer was originally composed of aragonite which has been replaced by coarse calcite crystals. No original structures are preserved. The thin outer layer, comprising about a quarter of shell thickness, is formed by prismatic calcite crystals which in the best preserved portions of the shell are regularly arranged and of roughly uniform size (Fig. 8G–H). The ornamentation of the shell is formed by this layer (Fig. 8F–H). Bøggild (1930:299) suggested that "if in the upper part of the shell we find a uniform structure more or less indistinctly prismatic we may conclude that we have here an original calcite". Thus it is very likely that *Mimospira* had an outer originally calcitic layer. This would also explain the good state of preservation of the ornamentation in many clisospirids because, if the ornamental structures had been originally composed of aragonite, they would be expected to have become largely obliterated during the process of replacement of aragonite by calcite. A similar preservation of the ornamentation in the onychochilids also suggests the presence of an outer prismatic calcite layer.

ACKNOWLEDGEMENTS

The author wishes to express her sincere gratitude to Prof. Erik Stensiö, Dr Valdar Jaanusson and Dr Harry Mutvei for their comprehensive advice and encouraging support during the course of this work. Excellent working facilities have been provided by Prof. Erik Jarvik and Prof. Tor Ørvig at the Palaeozoological section of the Swedish Museum of Natural History. In particular the skilful assistance of Mr Uno Samuelson (photos), Mr Bertil Blücher (drawings), Mrs Sif Samuelson, and Mrs Inger Sjöö (typing) is gratefully acknowledged. Dr John S. Peel, Copenhagen, is heartily thanked for helpful comments on a preliminary version of the manuscript. Dr A. Röömusoks, Tallinn, and Drs R. Horný and L. Marek, Praha, have kindly put material at my disposal. Dr Erik Norling and Dr Sven Laufeld at the Geological Survey of Sweden made it possible for me to conclude this work.

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PRISKLASS C

Distribueras genom
LiberKartor
162 89 VÄLLINGBY

Växjö 1979 C Davidsons Boktryckeri AB
Printed in Sweden

ISBN 91-7158-163-4