Geol. Paläont. Mitt. Innsbruck, ISSN 0378–6870, Sonderband 4, S. 83–103, 1996

IUGS UNESCO P 359

LONGOBARDIAN (LATE LADINIAN) MUELLERITORTIIDAE (RADIOLARIA) FROM THE REPUBLIC OF BOSNIA-HERCEGOWINA

Heinz Kozur & Helfried Mostler

With 2 figures and 3 plates

Abstract:
Muelleritortiidae are common in radiolarian faunas of the Longobardian *Budurovignathus mungoensis* conodont zone from the locality Varoski Creek near Fojnica south of Sarajevo. *Muelleritortis*, among them the Longobardian index species *M. cochleata* (NAKASEKO & NISHIMURA), clearly dominate over *Pentatortis* and primitive *Tritortis* species. 10 new species and subspecies are described.

Zusammenfassung:
Muelleritortiidae treten in longobardischen Radiolarien-Faunen aus der *Budurovignathus mungoensis*-Conodontenzone der Lokalität Varoski-Bach bei Fojnica südlich Sarajevo häufig auf. *Muelleritortis*, darunter die longobardische Index-Art *M. cochleata* (NAKASEKO & NISHIMURA) dominieren bei weitem gegenüber *Pentatortis* und primitiven *Tritortis*-Arten. 10 neue Arten und Unterarten werden beschrieben.

1. Introduction

Muelleritortiidae belong to the stratigraphically most important and world-wide distributed Triassic radiolarians. They are restricted to the Longobardian to Cordevolian interval, where they often clearly dominate over other radiolarians. The maximum diversity is in the middle and late Longobardian. In addition to previously described species, several new taxa of Muelleritortiidae have been found in the Longobardian of Bosnia-Hercegowina that are described in the present paper.

The material was derived from the locality Varoski Creek, about 2 km west of Fojnica at the road Mostar-Gacko (Geological Map 135 Gacko 1:50 000) south of Sarajevo (Republic Bosnia-Hercegowina). The locality data were published by MURGENOVIC & GAKOVIĆ, 1964. The material was sampled by L. KRYSTYN (Vienna). The radiolarians were derived from a micritic limestone (sample 88-272 of KRYSTYN's collection) with an intercalation of tuffitic claystones and radiolarite. The Longobardian age was determined by radiolarians of the of lower *Spongoserrula fluegeli* Subzone of the *Muelleritortis cochleata* Zone (early late Longobardian). *Budurovignathus mungoensis* (DIEBEL), the conodont index species of the middle to late Longobardian *B. mungoensis* Zone is also present, but very rare.

2. Systematic part

All figured material is frosm radiolarian-bearing micritic limestones of the locality Varoski Creek. The limestone was a floated block. Therefore it is not clear, whether it was derived from below or above the tuffitic claystones-chert intercalation. The material is deposited in the Institute of Geology and Paleontology, Innsbruck University.

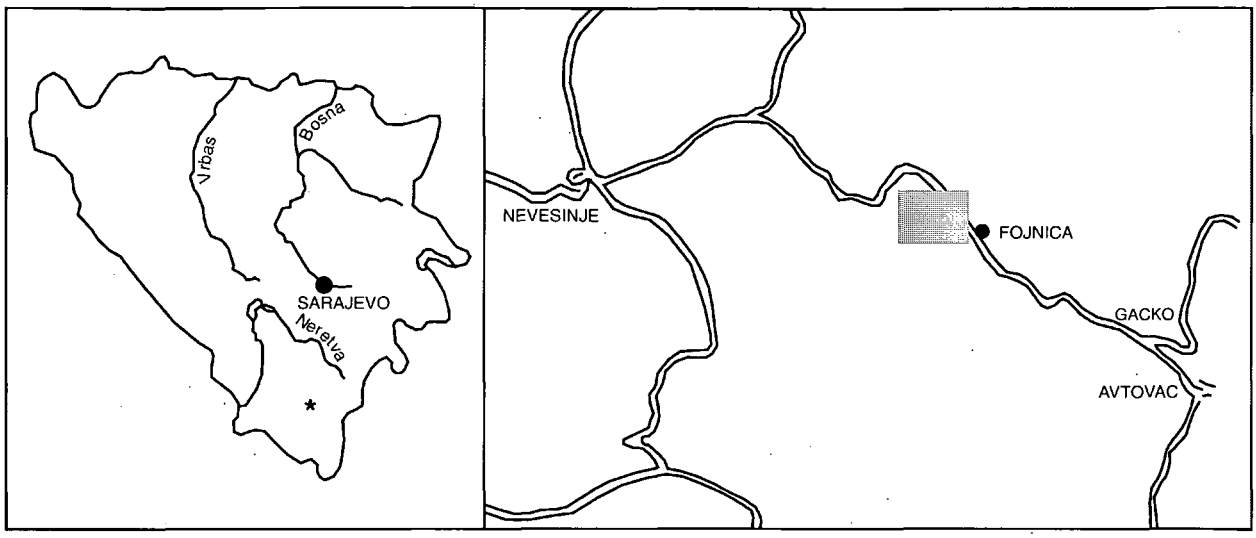


Fig. 1: Locality map. a) Geographic position of the locality (asterisk) in the Republic Bosnia-Hercegowina. b) Detailed locality map from MUDRENOVIĆ & GAKOVIĆ (1964).

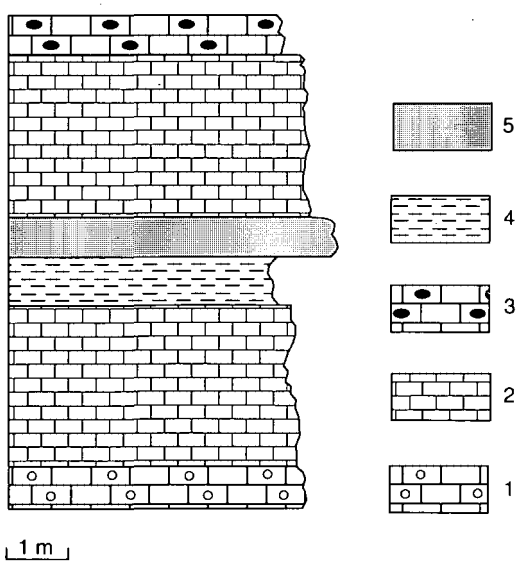


Fig. 2: Lithostratigraphic sequence with radiolarian-bearing limestone below and above a thin radiolarite-tuffit intercalation (from MUDRENOVIĆ & GAKOVIĆ, 1964). Vertical scale indicated.

1 = Calcarenite
2 = radiolarian-bearing limestone
3 = cherty limestone with *Joannites klipsteini* and *J. cymbiformis*
4 = tuffitic claystones
5 = red radiolarite

Subclass Radiolaria MÜLLER, 1858
Order Polycystina EHRENBERG, 1838
Suborder Entactinaria KOZUR & MOSTLER, 1982
Superfamily Palaeoscenidiacea RIEDEL, 1967

Family Muelleritortiidae KOZUR, 1988

Description: Thick-walled, two-layered shell spherical, subspherical or with subtriangular, triangular, subquadratic to quadratic outline in polar view (perpendicular to the equatorial plane of main spines). Inner layer with small pores. Outer layer consisting of pore frames with large, polygonal or roundish pores that differ in size and outline. The pore frames are often high and rather broad, mostly with nodes on the vertices. Sometimes the pore frames of the outer layer are low, rarely indistinct and absent near the equatorial margin of the main spine plane. Exceptionally the outer layer is very indistinct or even absent. Very rarely the co-

arse outer pore frames are partly covered by a spongy layer.

There are 2–6, mostly 3 or 4 main spines with 3 rounded, very broad ridges, which are subdivided by a deep and mostly broad distinct furrow which may be nearly as wide as the furrows between the ridges. By this the main spines appear often hexacarinate. Independent from the number of the main spines, always one of them display straight ridges, whereas the remaining 1–5 main spines displays twisted ridges. The main spines are mostly situated in the equatorial plane, but in few taxa a part of the twisted main spines runs oblique to the equatorial plane.

The inner structure is known only from *Muelleritortis*. It consists of a modified pentactine spicular system situated perpendicularly to the equatorial plane. The 3–4 apical spines are connected with the outer shell, but do not continue beyond the shell. The 4 basal spines are connected with the 4 main spines. Between the 4 basal spines arches are present which are also connected with the ridges of the main spines. Between these arches a coarse lattice is present which built up a loose medullary shell. Antapical this medullary shell is connected by a bunch of at least 4 spines with the outer shell. Further connecting spines between the medullary shell and the outer shell may be present. All these spines do not continue beyond the outer shell. Often the lattice of the medullary shell is not preserved. In this case only the apical and basal spines and the arches between the latter ones are present. If also the arches are broken away and only the apical and basal spines are preserved, the spicular system is similar to a strongly asymmetrical hexastylacean spicular system.

Occurrence: Longobardian to Cordevolian. Very common in the Tethys, but also present in the Circum-Pacific realm (Japan, Philippines and western Canada).

Assigned genera:

Muelleritortis KOZUR, 1988
Ditortis KOZUR, 1988
Pentatortis KOZUR, 1988
Tritortis KOZUR, 1988

Remarks: The Muelleritortiidae KOZUR, 1988, evolved from the Sepsagonidae KOZUR& MOSTLER, 1981, that have the same inner structure and a similar structure of the two-layered cortical shell. However, in the Sepsagonidae are all main spines are either twisted or untwisted. The combination of one untwisted with 1-5 twisted main spines is unique and characteristic for the Muelleritortiidae. Despite the different morphology, mainly caused by the different number and arrangement of the main spines (2–6), the combination of one untwisted and 1–5 twisted main spines indicates that the Muelleritortiidae are a closely related group.

Genus *Muelleritortis* KOZUR, 1988

Type species: *Emiluvia* (?) *cochleata* NAKASEKO & NISHIMURA, 1979

Description: With the character of the family. Cortical shell spherical, subspherical or in polar view with subquadratic to quadratic outline. Four main spines, mostly in cross-like arrangement. Exceptionally the three twisted main spines may be in subpolar arrangement. The untwisted main spine is often longer than the twisted main spines.

Assigned taxa:

Muelleritortis cochleata cochleata NAKASEKO & NISHIMURA, 1979
Muelleritortis cochleata minoense NAKASEKO & NISHIMURA, 1979
Synonym: *Muelleritortis cochleata hungarica* DOSZT & LY, 1991
Muelleritortis cochleata koeveskalensis KOZUR, 1988
Muelleritortis cochleata tumidospina KOZUR, 1988
Muelleritortis longispinosa KOZUR, 1988
Muelleritortis pulchra pulchra KOZUR, 1988
Muelleritortis pulchra rotunda n. subsp.
Muelleritortis bosniensis n. sp.
Muelleritortis expansa n. sp.
Muelleritortis quadrata quadrata n. sp.
Muelleritortis quadrata parvispina n. subsp.
Muelleritortis ? firma (GORIČAN in GORIČAN & BUSER, 1990)
Synonym: *Muelleritortis nobilis* DOSZT & LY, 1991

Occurrence: Rare in the early Longobardian (only forms with untwisted or very slightly twisted main spines). Common in the middle and late Longobardian, very rare in the basal Cordevolian. Tethys, Philippines, Japan, British Columbia.

Remarks: The other Muelleritortiidae are distinguished by the number of arrangement of main spines (2 polar main spines in *Ditortis*, 3 main spines in triangular or subpolar arrangement in *Tritortis*, 5-6 main spines in *Pentatortis*).

In *Muelleritortis* ? *firma* (GORIČAN in GORIČAN & BUSER, 1990) all 4 main spines are untwisted. However, in some specimens (e.g. GORIČAN & BUSER, 1990, pl. 6, fig. 5) 3 main spines are very slightly twisted, the fourth one is untwisted. Similar or identical forms with one untwisted and 3 very slightly twisted main spines occur in the early Longobardian *Budurovignathus hungaricus* conodont zone of Hungary and in the lower subzone (*Pterospongus alatus* Subzone) of the Muelleritortiidae Zone of Hungary and Southern Alps. They may represent the long-ranging forerunner of typical *Muelleritortis* with one straight and 3 strongly twisted main spines.

Muelleritortis cochleata (NAKASEKO & NISHIMURA, 1979)

(Pl. 1, Figs. 6, 7, 9, 10; Pl. 2, Figs. 1, 4, 8; l. 3, Figs. 1, 3)

1979 *Emiluvia* (?) *cochleata* NAKASEKO and NISHIMURA, n. sp. – NAKASEKO & NISHIMURA, p. 70, Pl. 3, Figs. 2–4, 6

1979 *Staurocontium minoense* NAKASEKO and NISHIMURA, n. sp., pars – NAKASEKO & NISHIMURA, p. 71, Pl. 2, Figs. 7, 9, 10; non! Pl. 12, Fig. 4

1984 *Plafkerium* sp. – DE WEVER, Pl. 3, Fig. 10

1986 *Emiluvia* (?) aff. *cochleata* NAKASEKO & NISHIMURA-BRAGIN, Pl. 2, Fig. 8

1988 *Muelleritortis cochleata cochleata* (NAKASEKO & NISHIMURA, 1979) – KOZUR, p. 53, Pl. 1, figs. 1–8; Pl. 2, Figs. 1, 2; Pl. 3, Fig. 1

1988 *Muelleritortis cochleata koeveskalensis* n. subsp. – KOZUR, p. 53–54, Pl. 3, Fig. 3

1988 *Muelleritortis cochleata tumidospina* n. subsp. - KOZUR, p. 54, Pl. 3, Fig. 2

1988 *"Emiluvia" cochleata* NAKASEKO ; NISHIMURA-BRAGIN, PL. 2, Fig. 8

1989 *Plafkerium cochleata* (NAKASEKO & NISHIMURA) – DOSZT & LY, Pl. 2, Figs. 1-3

1990 *Plafkerium* sp. -GORICAN & BUSER, p. 153, Pl. 6, Fig. 9

1991 *Muelleritortis cochleata cochleata* (NAKASEKO et NISHIMURA) – DOSZT & LY, Pl. 5, Fig. 1

1991 *Muelleritortis cochleata tumidospina* KOZUR – DOSZT & LY, Pl. 4, Fig. 5

1991 *Muelleritortis cochleata hungarica* n. ssp. – DOSZT & LY, p. 344, Pl. 5, Figs. 2, 3

1991 *Plafkerium cochleatum* (NAKASEKO & NISHIMURA, 1979) – BRAGIN, p. 80, Pl. 4, Figs. 10, 12; Pl. 5, Fig. 10, Pl. 10, Fig. 6

1992 *Plafkerium* spp., pars – YEH, p. 61, only the specimens on Pl. 7, Figs. 12, 13; Pl. 9, Fig. 16

1993 *Emiluvia* ? *cochleata* NAKASEKO & NISHIMURA – SASHIDA et al.,p. 93, Figs. 8–5, 6, 8, 15, 16

1994 *Muelleritortis cochleata hungarica* DOSZT & LY – DOSZT & LY, Pl. 3, Fig. 4

1994 *Muelleritortis cochleata* (NAKASEKO & NISHIMURA) – DOSZT & LY, Pl. 3, Fig. 5

Description: With the character of the genus. Cortical shell spherical or subspherical, in polar view circular to quadratic with the corners between the main spines. In the latter type a shallow depression is present in the equatorial plane of the main spines. Outer pore frames very strong, with big, very distinct nodes on the vertices. All main spines are distally pointed and prolongated in a needle-like short spine. The untwisted main spine is distinctly longer than the 3 twisted main spines. The main spines are mostly parallel-sided in their proximal part and taper slowly in their distal part. More rarely, the main spines are distally expanded, before they are tapering. Central furrow of the ridges on the main spine mostly deep and broad, partly strongly reduced and shallow.

Occurrence: Very common in the middle to late Longobardian *Budurovignathus mungoensis* conodont zone. Tethys, Japan, Philippines, British Columbia.

Remarks: Several subspecies can be discriminated. In *M. cochleata cochleata* (NAKASEKO & NISHIMURA, 1979) (Pl. 1, Fig. 9, Pl. 3, Fig. 1) the cortical shell is spherical, its outline in polar view is round, the main spines are distally not or only indistinctly widened.

Muelleritortis cochleata minoensis (NAKASEKO & NISHIMURA, 1979) (Pl. 1, Figs. 6, 10) has the same character of the main spines, but the cortical shell is quadratic in polar view, with the corners between the main spines. A slight depression of the cortical shell is present in the equatorial plane between the main spines. The median groove on at least some main spine ridges is indistinct, but this feature is rather variable in several *Muelleritortis* species and has no taxonomic importance.

In *Muelleritortis cochleata koeveskalensis* KOZUR, 1988 (Pl. 1, Fig. 7; Pl. 2, Figs. 1, 8; Pl. 3, Fig. 3) the twisted main spines are distinctly expanded before the pointed distal end. The outline of the cortical shell in polar view is subquadratic with the corners between the main spines. Between the main spines the shell is slightly depressed in the equatorial plane.

Muelleritortis cochleata tumidospina KOZUR, 1988 is discussed below.

Muelleritortis cf. *cochleata koeveskalensis* KOZUR, 1988

(Pl. 2, Fig. 4)

1990 *Plafkerium* sp. – GORICAN & BUSER, p. 153, Pl. 6, Fig. 9

Remarks: All 4 main spines have the same length. In contrast, in typical *Muelleritortis cochleata koeveskalensis* KOZUR, 1988 (Pl. 1, Fig. 7; Pl. 2, Figs. 1, 8; Pl. 3, Fig. 3), the untwisted main spine is distinctly longer than the twisted ones. The taxonomic importance of this difference is not clear. In all other features M. cochleata koeveskalensis and *M.* cf. *cochleata koeveskalensis* are identical. Similarly, also in *Muelleritortis* cf. *cochleata cochleata* (NAKASEKO & NISHIMURA, 1979) (Pl. 3, Fig. 1) the untwisted spine has about the same length as the twisted ones. Also this form is in all other features identical with typical *M. cochleata cochleata*, in which the untwisted main spine is distinctly longer than the twisted ones. Therefore probably the relative length of the untwisted main spines compared with the twisted main spines is taxonomically not important within *M. cochleata.* However, this feature has to be investigated in stratigraphic sequences. In the slightly older material from the basal *Budurovignathus mungoensis* Zone of Köveskál (Hungary), numerous specimens of *M. cochleata cochleata* occur and in all specimens the untwisted main spine is considerably longer than the twisted ones. In the material from Varoski Creek, however, in most specimens of *M. cochleata cochleata* the untwisted main spine has either about the same length as or it is not very much longer than the twisted main spines.

Muelleritortis cochleata tumidospina KOZUR, 1988

1986 *Emiluvia* (?) aff. *cochleata* NAKASEKO & NISHIMURA – BRAGIN, Pl. 2, Fig. 8

1988 *Muelleritortis cochleata tumidospina* n. subsp. – KOZUR, p. 54, Pl. 3, Fig. 2

1991 *Muelleritortis cochleata tumidospina* KOZUR – DOSZT & LY, Pl. 4, Fig. 5

1991 *Plafkerium cochleatum* (NAKASEKO & NISHIMURA, 1979), pars – BRAGIN, p. 80, Pl. 4, Fig. 10, non! Fig. 12; non! Pl. 5, Fig. 10; non! Pl. 10, Fig. 6

1992 *Plafkerium* spp., pars – YEH, p. 61, only the specimen on Pl. 7, Fig. 13

Occurrence: Middle Longobardian (lower *Budurovignathus mungoensis* conodont zone) of Hungary, Philippines and Russian Far East.

Remarks: The main spines are broader than in *Muelleritortis cochleata cochleata* (NAKASEKO & NISHIMURA, 1979). The pore frames of the outer layer display smaller nodes than in *M. cochleata cochleata.* The pores of the outer layer differ very much in size and shape within one specimen. The outline of the cortical shell in polar view is subcircular to subquadratic with slight extensions in direction of the main spines. By the latter three

features some similarities to the *Muelleritortis quadrata* group can be observed.

Muelleritortis bosniensis n. sp.
(Pl. 2, Figs. 7, 11)

Derivation of name: According to the occurrence in the Republic of Bosnia-Hercegowina.
Holotype: The specimen on Pl. 2, Fig. 11; rep.-no. KOMO 1994 III-9
Material: 12 specimens.
Diagnosis: Cortical shell globular, very large, covered in the equatorial region or in most of the cortical shell with a spongy layer. Below this spongy layer the typical two-layered structure is present. The outer of these layers has high pore frames with large roundish pores and nodes on the vertices. The 4 main spines are cross-like arranged. The untwisted main spine is longer to much longer than the twisted ones. All main spines are parallel-sided or insignificantly widened in distal direction. Distal ends of all main spines pointed. Median groove of the ridges on the main spines very broad and deep. On the untwisted main spine the median groove and the furrows between the ridges have about the same width and depth (secondarily hexacarinate).
Measurements:
Diameter of the cortical shell: 160–212 µm
Length of the untwisted main spine: 96–163 µm
Length of the twisted main spines: 60–80 µm
Occurrence: Early late Longobardian of the type locality.
Remarks: By the large globular cortical shell, in which the two layers are partly to nearly totally covered by an spongy layer, *Muelleritortis bosniensis* n. sp. is well distinguished from all other *Muelleritortis* species.

Muelleritortis expansa n. sp.
(Pl. 1, Figs. 1–5, 8?)

? 1983 *Emiluvia* ? *cochleata* NAKASEKO & NISHIMURA – NISHIZONO & MURATA, Pl. 2, Fig. 7

Derivatio nominis: According to the widened distal part of the main spines.
Holotype: The specimen on Pl. 1, Fig. 2; rep.-no. KOMO 1994 III-2
Material: More than 100 specimens.
Diagnosis: With the character of the genus. Cortical shell in polar view quadratic to subquadratic with the corners in direction of the main spines. Outer pore frames moderately high, with irregular large and small pores. Nodes on the vertices absent or very small. The 4 very broad main spines are arranged cross-like and have all the same length. The 3 twisted main spines are distally expanded, their distal ends are round, blunt, rarely rounded pointed, without terminal spine. The untwisted main spine is distally slightly expanded, rarely parallel-sided. Its distal end is round to rounded pointed. A rather strong and long terminal spine is always present. The ridges of all 4 main spines display a very broad and deep median groove producing secondarily hexacarinate character of the main spines.
Measurements
Diameter of cortical shell: 117–133 µm
Length of main spines: 100–133 µm
Occurrence: Middle to late Longobardian of the Tethys and Japan.
Remarks: In *Muelleritortis cochleata* (NAKASEKO & NISHIMURA, 1979) the untwisted main spine is in general distinctly longer than the twisted ones. The shell is either circular to subcircular in polar view or, if it is quadratic in polar view, the corners are situated between the main spines and not in their direction.

The twisted main spines of *Muelleritortis quadrata* n. sp. are distally not or only a little widened. The pore frames of the outer layer of the cortical shell are lower, often indistinct, in the equatorial part mostly missing.

Muelleritortis quadrata n. sp.
(Pl. 2, Figs. 2, 5; Pl. 3; Figs. 2, 6)

Derivation of name: According to the quadratic outline of the cortical shell in polar view.

Holotype: The specimen on Pl. 2, figs. 2; rep.-no. KOMO 1994 III-5

Diagnosis: With the character of the genus. Cortical shell with quadratic outline in polar view, corners in direction of the main spines. Pore frame of outer layer often indistinct, rarely absent, in the equatorial part always very low or absent. No nodes on the vertices. Pores of the outer layer very irregular in size and shape. The 4 main spines are moderately broad, all about of the same length. They are distally slightly widened, but display a pointed distal end, in the untwisted main spine a tiny terminal spine may be present. The median groove of the 3 ridges of the main spine is deep and broad.

Measurements: See under the subspecies.

Occurrence: Common in the early late Longobardian at the type locality.

Remarks: By the low, often indistinct, rarely even absent outer layer, this species is well distinguished from other *Muelleritortis* species.

Muelleritortis expansa n. sp. is additionally distinguished by broader main spines that have a distinct distal widening at least in the twisted main spines, but often also the untwisted one. The twisted main spines display a round, blunt, rarely rounded pointed distal end. The untwisted main spine ends in a large terminal spine.

In *Muelleritortis* cf. *quadrata* the cortical shell has a subquadratic outline in polar view. The pore frames of the outer layer are unreduced, in the polar part moderately high, in the equatorial region lower, but also distinct.

According to distinct difference in the length of the main spines two subspecies can be discriminated which are described below.

Muelleritortis quadrata quadrata n. subsp.

(Pl. 2, Fig. 2; Pl. 3, Fig. 6)

Derivation of name and holotype: See species.

Diagnosis: With the character of the species. Main spines relatively long. The torsion of the 3 twisted main spines is rather weak. Pore frames of the outer layer very low and indistinct, present only in the polar region. In few specimens the other layer is totally absent.

Measurements:
Diameter of cortical shell (measured between the parallel sides): 160–173 µm
Length of the main spines: 150–160 µm

Occurrence: As for the species.

Remarks: *Muelleritortis quadrata parvispina* n. subsp. displays shorter main spines, the pores frames of the outer layer are in the polar region always distinct and only in the equatorial region indistinct or missing.

Muelleritortis ? *firma* (GORIČAN in GORIČAN & BUSER, 1990) displays four untwisted main spines or three spines may be very little twisted. The cortical shell has a subquadratic outline in polar view and the pore frames of the outer layer are high with distinct nodes on the vertices.

Muelleritortis quadrata parvispina n. subsp.

(Pl. 2, Fig. 5; Pl. 3, Fig. 2)

Derivation of name: According to the short main spines.

Holotype: The specimen on Pl. 3, Fig. 2; rep.-no. KOMO 1994 III-8

Diagnosis: With the character of the species. Pore frames of the outer layer in the polar region of the cortical shell distinct, in the equatorial region either indistinct or missing.

Measurements:
Diameter of cortical shell (measured between the parallel sides): 172–180 µm
Length of main spines: 93–127 µm

Remarks: *Muelleritortis quadrata quadrata* n. subsp. has longer main spines and the pore frames of the outer layer on the cortical shell are in general very low and often indistinct.

Muelleritortis pulchra rotunda n. subsp.

(Pl. 1, Fig. 11)

Derivation of name: According to rounded distal end of the twisted main spines.

Holotype: The specimen on Pl. 1, Fig. 11; rep.-no. KOMO 1994 III-4
Material: 4 specimens.
Diagnosis: With the character of the genus. Cortical shell subglobular with subcircular outline in polar view. Pore frames of the outer layer low to moderately high, with large, irregular pores. Nodes on the vertices absent or small. The 4 main spines are not cross-like arranged. The twisted main spine opposite to the untwisted one is situated somewhat oblique to the axis of the untwisted main spine. The other two twisted main spines are situated at an angle of about 60° to the third untwisted main spine. The untwisted main spine is considerably longer than the 3 twisted ones, nearly parallel-sided with pointed posterior end. Median groove of the ridges on the main spines deep and very broad (secondarily hexacarinate main spines).
Measurements:
Diameter of cortical shell: 116–130 µm
Length of the untwisted main spine: 126–137 µm
Length of the twisted main spines: 79–106 µm
Occurrence: Early late Longobardian at the type locality.
Remarks: In *Muelleritortis pulchra pulchra* KOZUR, 1988 the pore frames of the outer layer are very high with big nodes on the vertices. The size difference between the untwisted main spine and the twisted ones is larger, the twisted main spines have a pointed distal end and they are situated near each other around the opposite side of the untwisted main spine.

In all other *Muelleritortis* species the 4 main spines are cross-like arranged.

Muelleritortis sp.
(Pl. 2, Fig. 6)

Remarks: Only one specimen of a *Muelleritortis* with large globular shell and relatively short, broad main spines is present. The pore frames are very high, with round nodes on the vertices. In the equatorial area the pore frames are somewhat lower, but also high. One of the twisted main spines lies perpendicularly to the polar axis, the other one lies obliquely to this axis.

Genus *Pentatortis* KOZUR, 1988

Type species: *Pentatortis longobardica* KOZUR, 1988

Pentatortis longobardica KOZUR, 1988
(Pl. 2, Fig. 10)

Occurrence: Miuddle Longobardian to early late Longobardian of Hungary and Bosnia-Hercegowina.
Remarks: *Pentatortis longobardica* KOZUR, 1988 is characterized by three twisted main spines in a plane perpendicular or oblique to the axis of the untwisted main spine. The fourth twisted main spine lies either opposite to the untwisted main spine or somewhat oblique to its axis. The derivation of this species from *Muelleritortis* with 4 cross-like arranged main spines is rather clear. In *Muelleritortis* one twisted main spine lies either opposite to the untwisted main spine or somewhat oblique to its axis. The two other twisted main spines are situated in a plane perpendicular or somewhat oblique to the axis of the untwisted main spine. In *Pentatortis longobardica* an additional twisted main spine lies in latter plane. The arrangement of the main spines in *Pentatortis krystyni* n. sp. is different (see below).

Pentatortis krystyni n. sp.
(Pl. 2, Fig. 9)

Derivation of name: In honour of Prof. L. KRYSTYN, Vienna.
Holotype: The specimen on Pl. 2, Fig. 9; rep.-no. KOMO 1994 III-10
Material: 7 specimens.
Diagnosis: Cortical shell globular. Outer pore

frames high with roundish, mostly large pores, at the base of the main spines somewhat elongated in their directions. Vertices of the pore frames with nodes. The 5 main spines are broad, in distal direction a little widened, with pointed or roundish pointed distal end. They are about of the same length or the untwisted main spine is a little longer than the twisted ones. Median groove of the main spines wide and deep. Especially the untwisted main spine is secondary hexacarinate. The untwisted main spine and two of the twisted ones are situated in triangular arrangement in one plane. Two further twisted main spines are present in some distance of one of the twisted main spines.

Measurements:
Diameter of the cortical shell: 176–200 µm
Length of the untwisted main spine: 133–140 µm
Length of the twisted main spines: 112–133 µm

Occurrence: In the early late Longobardian at the type locality.

Remarks: *Pentatortis longobardica* KOZUR, 1988 is distinguished by the arrangements of the main spines (see above).

Pentatortis hexaspina n. sp.
(Pl. 3, Figs. 4, 5)

Derivation of name: According to the presence of 6 main spines.

Holotype: The specimen on Pl. 3, Fig. 4; rep.-no. KOMO 1994 III-11

Material: 5 specimens.

Diagnosis: Cortical shell globular to subglobular. Pore frames of the outer layer high, with nodes on the vertices. Pores of the outer layer differ in size and shape, most of them are large, roundish, at the base of the main spines elongated. The 6 main spines are parallel-sided or very little widened in distal direction. The untwisted main spine is longer than the twisted ones. The distal end of the untwisted main spine is pointed, the distal end of the twisted main spines is rounded, but often with a tiny terminal spine. Median groove of the main spine ridges broad and deep (secondarily hexacarinate main spines). One of the twisted main spines lies opposite to the untwisted main spine, but mostly somewhat oblique to its axis (subpolar arrangement with respect to the untwisted main spine). Three of the twisted main spines are situated in a plane, perpendicularly or somewhat oblique to the axis of the untwisted main spine. A fifth twisted main spine lies between this plane and the subpolar twisted main spine.

Measurements:
Diameter of cortical shell: 122–150 µm
Length of the untwisted main spine: 125–167 µm
Length of the twisted main spines: 65–94 µm

Occurrence: Early late Longobardian at the type locality.

Remarks: In *Pentatortis longobardica* KOZUR, 1988 only 4 twisted main spines are present situated opposite to the untwisted main spine and in a plane perpendicularly or somewhat oblique to the axis of the untwisted main spine.

Genus *Tritortis* KOZUR, 1988

Type species: *Sarla* ? *kretaensis* KOZUR & KRAHL, 1984

Tritortis kretaensis dispiralis (BRAGIN, 1986)
(Pl. 3, Fig. 11)

1986 *Sarla dispiralis* sp. nov – BRAGIN, p. 67, Fig. 12
1988 *Tritortis kretaensis subcylindrica* n. subsp. – KOZUR, p. 98–99, Pl. 4, Figs. 6, 8
1991 *Sarla dispiralis* BRAGIN, 1986, pars – BRAGIN, p. 79, Pl. 4, Fig. 11; Pl. 5, Fig. 8; non Pl. 4, Fig. 6
1991 *Sarla kretaensis robusta* n. ssp. - DOSZT & LY, p. 197, Pl. 1, Figs. 1, 2

Description: Cortical shell subglobular, in polar view with subcircular, subtriangular or triangular outline. Inner layer with small roundish pores, outer layer with high pore frames and large polygonal or roundish pores and nodes on the vertices. The 3 main spines have about the same length or the untwisted main spine is somewhat longer than

the twisted one. The sides of the main spines are parallel or there is an insignificant distal widening. The distal ends are rounded, blunt or shortly pointed, with short terminal spine. The median groove on the main spine ridges is deep and wide (secondary hexacarinate main spines).

Occurrence: Upper part of middle Longobardian to early Cordevolian of the Tethys.

Remarks: KOZUR (1988 a, b) discriminated two species within *Tritortis*, the middle Longobardian *Tritortis balatonica* KOZUR, 1988 and *Tritortis kretaensis* (KOZUR & KRAHL, 1984). The latter species was subdivided into two subspecies, *T. kretaensis kretaensis* and *T. kretaensis subcylindrica* KOZUR, 1988. *T. kretaensis kretaensis* appeared in the late Longobardian and it is the dominating form and radiolarian index species of the early Cordevolian. *T. kretaensis subcylindrica* occurs in the middle Longobardian and early Cordevolian. It is a transitional form between *T. balatonica* and *T. kretaensis*.

BRAGIN (1986, 1991) described *Sarla dispiralis* BRAGIN, 1986. He assigned to this species forms that correspond both to *T. kretaensis kretaensis* and to *T. kretaensis subcylindrica*. Therefore *Sarla dispiralis* exactly corresponds to *Tritortis kretaensis* by KOZUR (1988). The holotype of *Sarla dispiralis* corresponds to *T. kretaensis subcylindrica*. Therefore *Sarla dispiralis* BRAGIN, 1986 is a junior synonym of *Tritortis kretaensis* (KOZUR & KRAHL, 1984), whereas *T. kretaensis subcylindrica* KOZUR, 1988 is a junior synonym of *Tritortis kretaensis dispiralis* (BRAGIN, 1986). *Sarla kretaensis robusta* DOSZT & LY, 1991 is a further junior synonym of *Tritortis kretaensis dispiralis* BRAGIN, 1986.

Tritortis kretaensis kretaensis (KOZUR & KRAHL, 1984) displays in general more slender main spines that taper slowly and gradual toward the very pointed distal end. The morphological differences between both subspecies are rather gradual, but their discrimination is supported by different stratigraphic ranges. *T. kretaensis kretaensis* begins only in the late Longobardian, whereas *T. kretaensis dispiralis* begins in the upper part of the middle Longobardian. In the Cordevolian *T. kretaensis kretaensis* clearly dominates over *T. kretaensis dispiralis*. The Late Anisian-Early Ladinian age of *T. kretaensis kretaensis* established by CORDEY et al. (1988) for specimens from British Columbia cannot be confirmed. The accompanying *Spongoserrula* is in the Tethys restricted to the middle Longobardian to Cordevolian.

Whereas *T. kretaensis dispiralis* is so far only known from the Tethys, *T. kretaensis kretaensis* is common also in the Circum-Pacific realm (Philippines, Japan., British Columbia).

Tritortis balatonica KOZUR 1988 from the lower part of middle Longobardian displays a globular cortical shell.

Tritortis latispina n. sp.

(Pl. 3, Figs. 7, 8)

Derivation of name: According to the very broad main spines.

Holotype: The specimen on Pl. 3, Fig. 8; rep.-no. KOMO 1994 III-13

Material: 21 specimens.

Diagnosis: Cortical shell subglobular, in polar view with subcircular to subtriangular outline. Outer layer with high pore frames and large polygonal pores of different shape and size. Vertices with small nodes. The three main spines in triangular arrangement are very broad, mostly slightly widened in distal direction. Their distal ends are rounded or blunt, in the untwisted main spine with a distinct terminal spine. The untwisted main spine has about the same length as the twisted ones or it is a little longer. Median groove on the ridges deep, moderately wide.

Measurements:

Diameter of cortical shell: 109–140 µm

Length of the main spines (without terminal spines): 90–119 µm

Maximum width of the main spines: 65–100 µm

Occurrence: Early late Longobardian at the type locality.

Remarks: Most similar are the contemporaneous, stratigraphically oldest representatives of *Tritortis kretaensis dispiralis* (BRAGIN, 1986) which have

rather broad main spines, but not as broad as in *T. latispina* n. sp. Moreover, the terminal spine of the untwisted main spine is very small or absent in *T. kretaensis dispiralis*. Late Longobardian and Cordevolian representatives of *T. kretaensis* display by far narrower main spines.

In *Tritortis acutangulata* n. sp., which has the same form of the main spines, the two twisted main spines are situated near to each other on the opposite side of the untwisted main spine.

Tritortis acutangulata n. sp.
(Pl. 3, Figs. 9, 10)

Derivation of name: According to the arrangement of the twisted main spines at an acute angle.
Holotype: The specimen on Pl. 3, Fig. 10; rep.-no. KOMO 1994 III-15
Material: 5 specimens.
Diagnosis: Cortical shell subglobular, often a little elongated in prolongation of the untwisted main spine. Pore frames of the outer layer high, with large, polygonal pores of different shape, near the base of the main spines elongated. Vertices with small nodes. All three main spines are very broad, subcylindrical with insignificant widening in distal direction. The two twisted main spines are situated in subpolar position to the untwisted main spine. They lie near to each other at an acute angle. Distal ends of the main spines blunt or broadly rounded, in the untwisted main spine with moderately large terminal spine. The untwisted main spine is longer than the two twisted ones. Median groove on the main spine ridges deep and wide. On the untwisted main spine secondary, narrow, a short median groove is present on the wedges of the divided ridges. By this, the untwisted main spine is hexacarinate with ridges divided by a secondary median groove.
Measurements:
Diameter of cortical shell: 120–132 µm
Length of the untwisted main spine (without terminal spine): 125–146 µm
Length of the twisted main spines: 80–123
Maximum width of the main spines: 70–85 µm

Occurrence: Early late Longobardian at the type locality.

Remarks: By the arrangement of the two twisted main spines near to each other at an acute angle, this species can be easily distinguished from all other *Tritortis* species. Most similar is *Tritortis latispina* in which, however, the very broad main spines are arranged in triangular position, like in all other *Tritortis* species. *Tritortis acutangulata* may be a transitional form from *Tritortis latispina* to *Ditortis* that has two main spines (a twisted and an untwisted one) in bipolar position. In specimens of *T. acutangulata*, in which the two twisted main spines are very near to each other, the arrangement of the main spines is nearly bipolar.

Tritortis inaequispina n. sp.
(Pl. 3, Fig. 12)

Derivation of name: According to the strongly different size of the main spines.
Holotype: The specimen on Pl. 3, Fig. 12; rep.-no. KOMO 1994 III-17
Material: 2 specimens.
Diagnosis: Cortical shell globular. Outer pore frames high, with small nodes on the vertices and large polygonal or roundish polygonal pores of different shape and size. Untwisted main spine large, broad, pointed, with moderately long terminal spine. Twisted spines much smaller, short, narrow, rapidly tapering towards the pointed distal end. One twisted main spine is situated opposite to the untwisted main spine, the other one about perpendicular to it. The ridges on the untwisted main spine are subdivided by a deep, moderately broad median groove. On the twisted main spine only in the basal part an indistinct shallow median groove is present on the ridges.
Measurements:
Diameter of cortical shell: 110–120 µm
Length of the untwisted main spine (without terminal spine): 108–112 µm
Maximum width of the untwisted main spine: 60–64 µm
Length of the twisted main spines: 70–75 µm

Maximum width of the twisted main spines: 25–31 µm

Occurrence: Very rare in the early late Longobardian at the type locality.

Remarks: This species seems to be a transitional form between *Tritortis* and *Ditortis*. The untwisted main spine and one of the twisted main spines are in bipolar position, like in *Ditortis*, but because of the presence of the second twisted main spine, this species is assigned to *Tritortis*.

3. Biostratigraphic evaluation

The Muelleritortiidae are dominant and easily determinable radiolarians of the Tethyan Longobardian and Cordevolian. In the Early Longobardian *Budurovignathus hungaricus* Zone Muelleritortiidae with one untwisted main spine and one to five twisted main spines are missing. There occur only forms without twisted main spines (*Muelleritortis* ? *firma* group), which may be the forerunners of *Muelleritortis cochleata*. At the base of the middle Longobardian (base of the *Budurovignathus mungoensis* conodont zone), *Muelleritortis cochleata* has its first appearance. This species dominates the entire middle and late Longobardian Muelleritortiid faunas. In the middle Longobardian, *Tritortis* is very rare, in the lower part represented by *Tritortis balatonica*, in the upper part by primitive *Tritortis kretaensis dispiralis*. Typical *Tritortis kretaensis kretaensis* began only immediately below the Ladinian-Carnian boundary. A little later, at the base of the Cordevolian, defined by the first appearance of the conodonts *Budurovignathus diebeli* (KOZUR & MOSTLER) and *Paragondolella polygnathiformis* (BUDUROV & STEFANOV), *Muelleritortis* becomes suddenly very rare and these faunas are dominated by *Tritortis kretaensis kretaensis*, the index species of the early Cordevolian *T. kretaensis* Zone.

Pentatortis with 3 species was so far only found in the middle and early late Longobardian, but this genus is rather rare. The likewise rare *Ditortis* was so far only found in the late Longobardian.

Muelleritortis cochleata and the *Tritortis kretaensis* lineage are very important for stratigraphic subdivisions. Radiolarian faunas, in which *Muelleritortis cochleata* dominates the Muelleritortiidae, belong to the middle and late Longobardian *Muelleritortis cochleata* Zone which perfectly coincides with the *Budurovignathus mungoensis* conodont zone. If *Tritortis kretaensis* dominates the Muelleritortiidae, the faunas belong to the early Cordevolian *Tritortis kretaensis* Zone. The change from a *Muelleritortis cochleata* dominated into a *Tritortis kretaensis kretaensis* dominated fauna occurs in the Dallapuszta section of Darnó-hegy (Hungary) within a very short interval of a few cemtinmetres of red radiolarites. In the upper part of the*M. cochleata* Zone, *Tritortis kretaensis dispiralis* is common.

Muelleritortis cochleata and *Tritortis kretaensis* are common in the Tethys and in the Circum-Pacific realm (Japan, Philippines, British Columbia). Other stratigraphically important Longobardian and Cordevolian forms, like advanced Oertlispongidae, are outside the Tethys missing or rare.

CORDEY et al. (1988) placed a radiolarian fauna with *Muelleritortis cochleata*, *Tritortis kretaensis kretaensis*, *Spongoserrula dosztalyi n. sp.* (= *Spongoserrula rarauana* DUMITRICĂ sensu CORDEY et al., 1988) and *Spongoserrula dehli* CORDEY et al. into the Late Anisian to Early Ladinian on the base of "*Gondolella*" *constricta* MOSHER & CLARK. However, in North America many different forms have placed into *Neogondolella constricta* and therefore this species give not too much age evidences. On the other side, in radiolarian faunas with *Tritortis kretaensis* from the Tethys, conodonts similar to *N. constricta* are absent. Unfortunately, no data are given about the relative frequency of *M. cochleata* and *T. kretaensis*. Because all figured *Tritortis kretaensis* belong to *T. kretaensis kretaensis*, the age of this radiolarian fauna is either late Longobardian or early Cordevolian. A late Longobardian to Cordevolian age is also indicated by the two *Spongoserrula* species with pointed to needle-like spines that begin only in the upper subzone (*Spongoserrula fluegeli* Subzone) of the *Muelleritortis cochleata* Zone. In the Tethys, the genus *Spongoserrula* does not occur

before the Longobardian *Budurovignathus mungoensis* conodont zone. A late Anisian to early Ladinian age can be therefore excluded, even if we have to take into consideration the stratigraphically higher position of the Anisian-Ladinian boundary in North America compared with the priority boundary at the base of the *Reitziites reitzi* Zone. *Spongoserrula*-bearing beds belong also according the North American standard to the Longobardian.

Our investigated material belongs to the lower part of the *Spongoserrula fluegeli* Subzone of the *Muelleritortis cochleata* Zone (lower part of upper *cochleata* Zone). *Tritortis balatonica*, present in the lower part of this zone, is already replaced by *T. kretaensis dispiralis* which occurs from the middle part of the *M. cochleata* Zone up to the early Cordevolian. On the other hand, *T. kretaensis kretaensis* which begins in the late Longobardian is not yet present.

The detailed subdivision of the *Muelleritortis cochleata* Zone is based on the development of advanced Oertlispongidae and will be discussed in KOZUR & MOSTLER (in press). The lower subzone (*Pterospongus alatus* Subzone) of the *M. cochleata* Zone is characterized by advanced *Falcispongus*, advanced *Baumgartneria*, very primitive *Scutispongus* of the *S. rostratus* group, and above al several *Pterospongus* species. The last *Oertlispongus inaequispinosus* DUMITRICĂ, KOZUR & MOSTLER, an important Fassanian guideform, is still present. Denticulated *Spongoserrula species* are absent.

The middle subzone (*Spongoserrula rarauana* Subzone) of the *M. cochleata* Zone is characterized by primitive *Spongoserrula* with rounded spines (*S. rarauana* group). The guideforms of the *Pterospongus alatus* Subzone are still present in decreasing frequency.

The upper subzone (*Spongoserrula fluegeli* Subzone) of the *M. cochleata* Zone is characterized by advanced *Spongoserrula* with pointed or needle-like spines (*S. fluegeli* group) and *Steigerispongus* with pointed spines. In the lower part of this subzone *Spongoserrula* of the *S. rarauana* group are still present, in the upper subzone they become very rare or are absent.

In the early Cordevolian advanced Oertlispongidae are still common (dominated by advanced *Spongoserrula* of the *S. fluegeli* group). In the late Cordevolian Oertlispongidae are very rare. Except advanced *Spongoserrula* of the *S. fluegeli* group, few *Scutispongus* and *Bogdanella* are present.

The Muelleritortiidae are better suitable for the discrimination of zones (middle and late Longobardian *M. cochleata* Zone and Cordevolian *Tritortis kretaensis* Zone) than the Oertlispongidae, because Muelleritortiidae are worldwide common forms. However, in the Tethyan Triassic, the Oertlispongiidae are most important for definition of subzones, because they underwent the most rapid morphlogic changes during the Ladinian time. Unfortunately, outside the Tethyan realm, Oertlispongidae are rare.

Acknowledgements

The investigations by H. KOZUR were sponsored by the Deutsche Forschungsgemeinschaft. The sample material was collected by Prof. L. KRYSTYN, Vienna. The SEM photos were taken by Dr. Z. BALOGH, Innsbruck. We thank these persons and the DFG for the important support.

References

BRAGIN, N. JU. (1986): Biostratigrafija triasovych otlozhenij juznogo Sachalina. – Izv. AN SSSR, ser. geol., **1986**, 4, 61–75, 2 figs., 3 pls., Moskva.

BRAGIN, N. JU. (1991): Radioljarii i nizhnemezozojskie tolshchi vostoka SSSR. – Trudy GIN SSSR, **469**, 125 pp., 22 figs., 16 pls., Moskva.

BRAGIN, N. JÙ., OLEJNIK, L. M. & PARNJAKOV, V. P. (1998): Stratigrafija i struktura opornogo razreza gorbushinskoj svity Mezozoja Primorja. – Izv. AN SSSR, ser. geol., **1988**, 2, 23–34, 3 figs., 1 tab., 2 pls., Moskva.

CORDEY, F., DE WEVER, P., DUMITRICĂ, P., DANELIAN, T., KITO, N. & VRIELYNCK, B. (1988): Desription of some new Middle Triassic radiolarians from the Camp Cove

Formation, southern British Columbia, Canada. – Rev. Micropaléont., **31**, 1, 30–37, 3 figs., 2 pls., Paris.

DE WEVER, P. (1984): Triassic radiolarians from the Darnó area (Hungary). – Acta Geol. Hungarica, **27**, 3–4, 295–306, 2 figs., 2 tabs., 3 pls., Budapest.

DOSZTÁLY, L. (1989): Triassic radiolarians from Dallapuszta. – Máfi Évi Jel., **1988**, 193–201, 2 figs., 1 tab., 2 pls., Budapest.

DOSZTÁLY, L. (1991): Triász korú radiolariák a Balaton-Felvidékröl. – Máfi Évi Jel., **1989**, 333–355, 1 fig., 5 pls., Budapest.

DOSZTÁLY, L. (1994): The Anisian/Ladinian and Ladinian/Carnian boundaries in the Balaton Highland based on radiolarians. – Acta Geol. Hungarica, **36**, 1, 59–72, 6 figs., 4 pls., Budapest.

GORIČAN, S. & BUSER, S. (1990): Middle Triassic radiolarians from Slovenia (Yugoslavia). – Geologija, **31–32**, 133–197, 2 figs., 1 tab., 12 pls., Ljubljana.

KOZUR, H. (1988 a): Muelleritortiidae n. fam., eine charakteristische longobardische (oberladinische) Radiolarienfamilie, Teil I. – Freiberger Forsch.-H., **C 419**, 51–61, 4 pls., Leipzig.

KOZUR, H. (1988 b): Muelleritortiidae n. fam., eine charakteristische longobardische (oberladinische) Radiolarienfamilie, Teil II. – Freiberger Forsch.-H., **C 427**, 95–100, Leipzig.

KOZUR, H. & KRAHL, J. (1984): Erster Nachweis triassischer Radiolaria in der Phyllit-Gruppe auf der Insel Kreta.- N. Jb. Geol. Paläont., Mh., **1984**, 7, 400–404, 1 fig., Stuttgart.

KOZUR, H. & MOSTLER, H. (1981): Beiträge zur Erforschung der mesozoischen Radiolarien. Teil IV: Thalassosphaeracea HAECKEL, 1862, Hexastylacea HAECKEL, 1882 emend. PETRUSEVSKAJA, 1979, Sponguracea HAECKEL, 1862 emend. und weitere triassische Lithocycliacea, Trematodiscacea, Actinommacea und Nassellaria. – Geol. Paläont. Mitt. Innsbruck, Sonderband, **1**, 1–208, 69 pls., Innsbruck.

MUDRENOVIĆ, V. & GAKOVIĆ, J. (1964): Beitrag zur Kenntnis der Entwicklung der Mittel- und Obertrias im Tal der Zalomska Rijeka (östliche Herzegowina). – Geol. glasn., **10**, 140–157, 4 figs., Sarajevo.

NAKASEKO, K.& NISHIMURA, A. (1979): Upper Triassic Radiolaria from southwest Japan. – Sci. Rep., Col. Educ. Osaka Univ., **28,** 2, 61–109, 1 fig., 1 tab., 12 pls., Osaka.

NIZHIZONO, Y. & MURATA, M. (1983): Preliminary studies on the sedimentary facies an radiolarian biostratigraphy of Paleozoic and Mesozoic sediments, exposed along the mid-stream of the Kuma River, Kyushu, Japan. – Kumamoto J. Sci., Geol., **12**, 2, 1–40, 18 figs., 3 tabs., 6 pls.

YEH, K.-Y. (1992): Triassic Radiolaria from Uson Island, Philippines. – Bull. Nat. Mus. Natural Hist., **3**, 51–91, 5 figs., 9 pls., Taichung.

Authors' addresses:
Dr. sc. Heinz Kozur, Rézsü u. 83, H-1029 Budapest, Hungary; Univ.-Prof. Dr. Helfried Mostler, Institute of Geology and Paleontology, University of Innsbruck, Innrain 52, A-6020 Innsbruck, Austria.

Explanation of Plates

All figured radiolarians are from a micritic limestone of the locality Varoski Creek near Fojnica, south of Sarajevo (Republic Bosnia-Hercegowina). They belong to the lower *Spongoserrula fluegeli* Subzone of the *Muelleritortis cochleata* Zone (early late Longobardian).

Plate 1

Figs. 1–5: *Muelleritortis expansa* n. sp., Fig. 2: holotype, rep.-no. KOMO 1994 III-2; Figs. 1, 3-5: paratypes, rep.-no. KOMO 1994 III-3; Fig. 1: x 150, Figs. 2, 3, 5: x 180; Fig. 4: x 200.

Fig. 6: *Muelleritortis cochleata minoensis* (NAKASEKO & NISHIMURA, 1979), x 210, rep.-no. KOMO 1994 III-18.

Fig. 7: *Muelleritortis cochleata koeveskalensis* KOZUR, 1988, x 180, rep.-no. KOMO 1994 III-19.

Fig. 8: Transitional form between *Muelleritortis expansa* n. sp. and *M. quadrata* n. sp., x 220, rep.-no. KOMO 1994 III-20.

Fig. 9: *Muelleritortis cochleata cochleata* (NAKASEKO & NISHIMURA, 1979), x 180, rep.-no. KOMO 1994 III-21.

Fig. 10: *Muelleritortis* cf. *cochleata minoensis* (NAKASEKO & NISHIMURA, 1979), transitional form to *M. cochleata koeveskalensis* KOZUR, 1988, x 200, rep.-no. KOMO 1994 III-22.

Fig. 11: *Muelleritortis pulchra rotunda* n. sp., holotype, x 190, rep.-no. KOMO 1994 III-4.

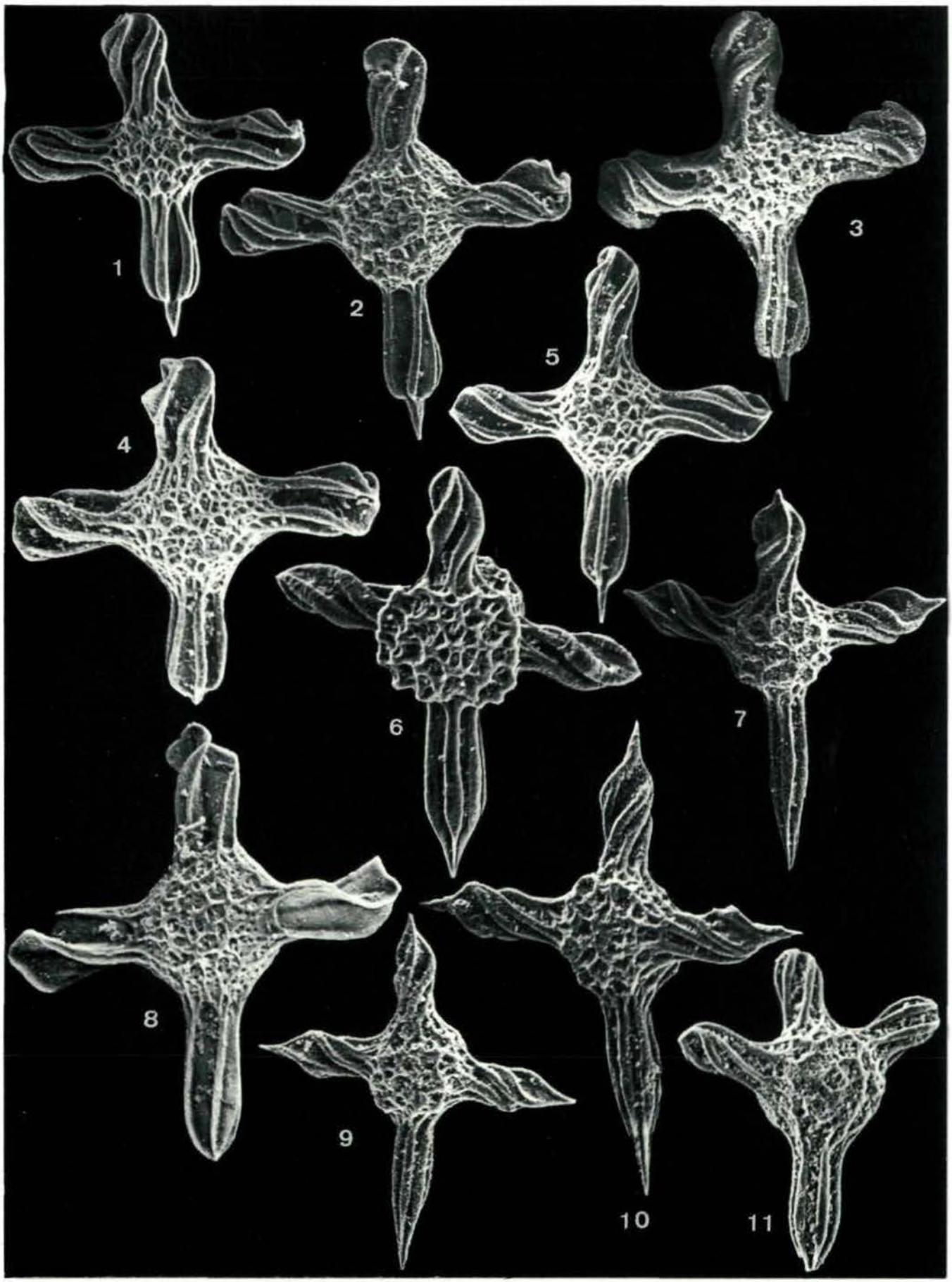

1
2
3
4
5
6
7
8
9
10
11

Plate 2

Figs. 1, 8: *Muelleritortis cochleata koeveskalensis* KOZUR, 1988, fig. 1: x 180, rep.-no. KOMO 1994 III-23, Fig. 8: x 170, rep.-no. KOMO 1994 III-24

Fig. 2: *Muelleritortis quadrata quadrata* n. subsp., holotype, x 150, rep.-no. KOMO 1994 III-5.

Fig. 3: *Muelleritortis* cf. *quadrata* n. sp., x 160, rep.-no. KOMO 1994 III-6.

Fig. 4: *Muelleritortis* cf. *cochleata koveskalensis* KOZUR, 1988, x 160, rep.-no. KOMO 1994 III-1.

Fig. 5: *Muelleritortis quadrata parvispina* n. subsp., x 150, rep.-no. KOMO 1994 III-7.

Fig. 6: *Muelleritortis* sp., x 170, rep.-no. KOMO 1994 III-25.

Figs. 7, 11: *Muelleritortis bosniensis* n. sp.; Fig. 7. paratype, x 160, rep.-no. KOMO 1994 III-26; Fig. 11: holotype, x 250, rep.-no. KOMO 1994 III-9.

Fig. 9: *Pentatortis krystyni* n. sp., holotype, x 150, rep.-no. KOMO 1994 III-10.

Fig. 10: *Pentatortis longobardica* KOZUR, 1988, x 180, rep.-no. KOMO 1994 III-27.

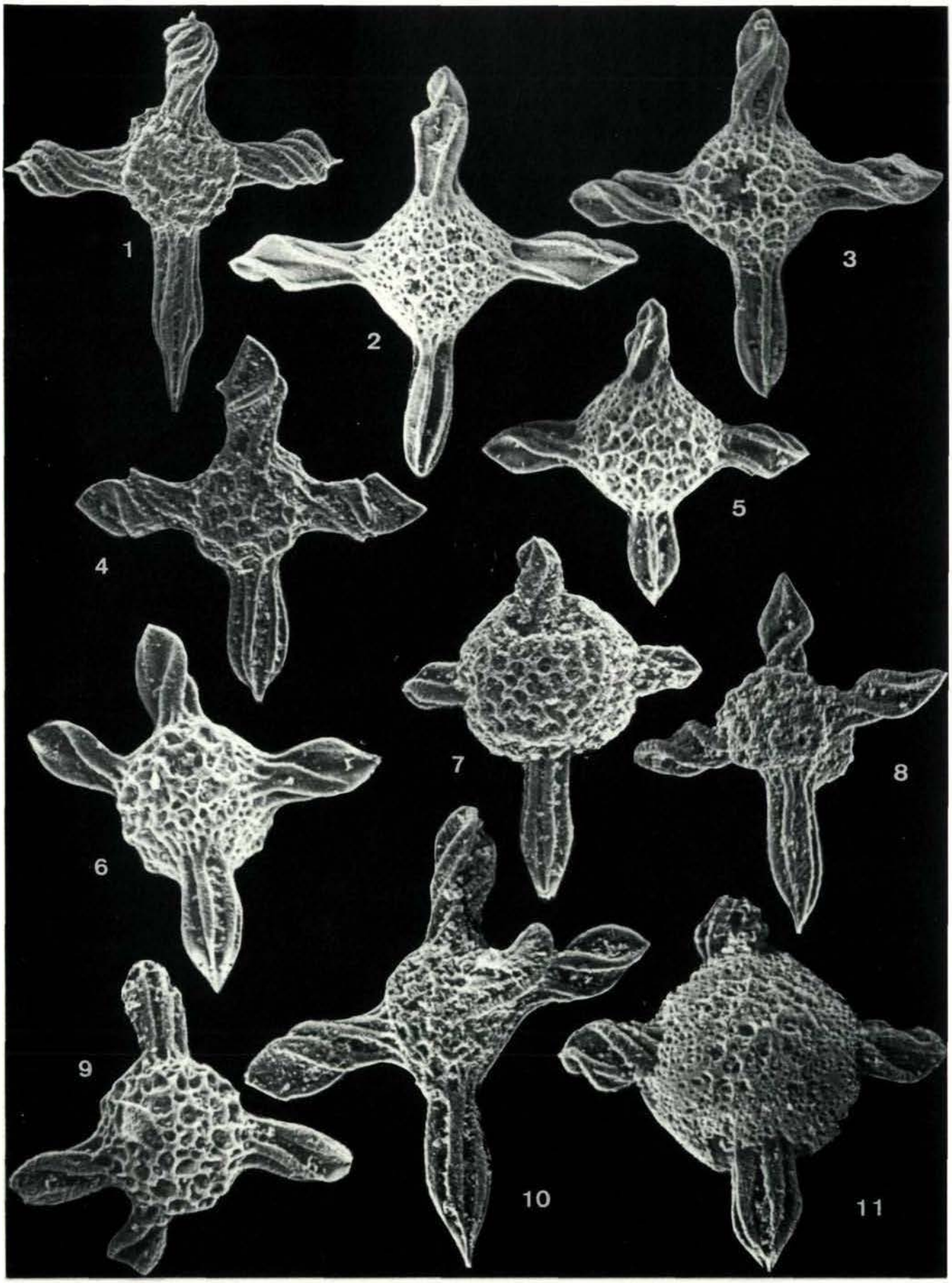

1
2
3
4
5
6
7
8
9
10
11

Plate 3

Fig. 1. *Muelleritortis* cf. *cochleata cochleata* (NAKASEKO & NISHIMURA, 1979), x 150, rep.-no. KOMO 1994 III-28.

Fig. 2: *Muelleritortis quadrata parvispina* n. subsp., holotype, x 150, rep.-no. KOMO 1994 III-8.

Fig. 3: *Muelleritortis cochleata koeveskalensis* KOZUR, 1988, x 160, rep.-no. KOMO 1994 III-29.

Figs. 4, 5: *Pentatortis hexaspina* n. sp.; Fig. 4: holotype, x 200, rep.-no. KOMO 1994 III-11; Fig. 5: x 180, rep.-no. KOMO 1994 III-30.

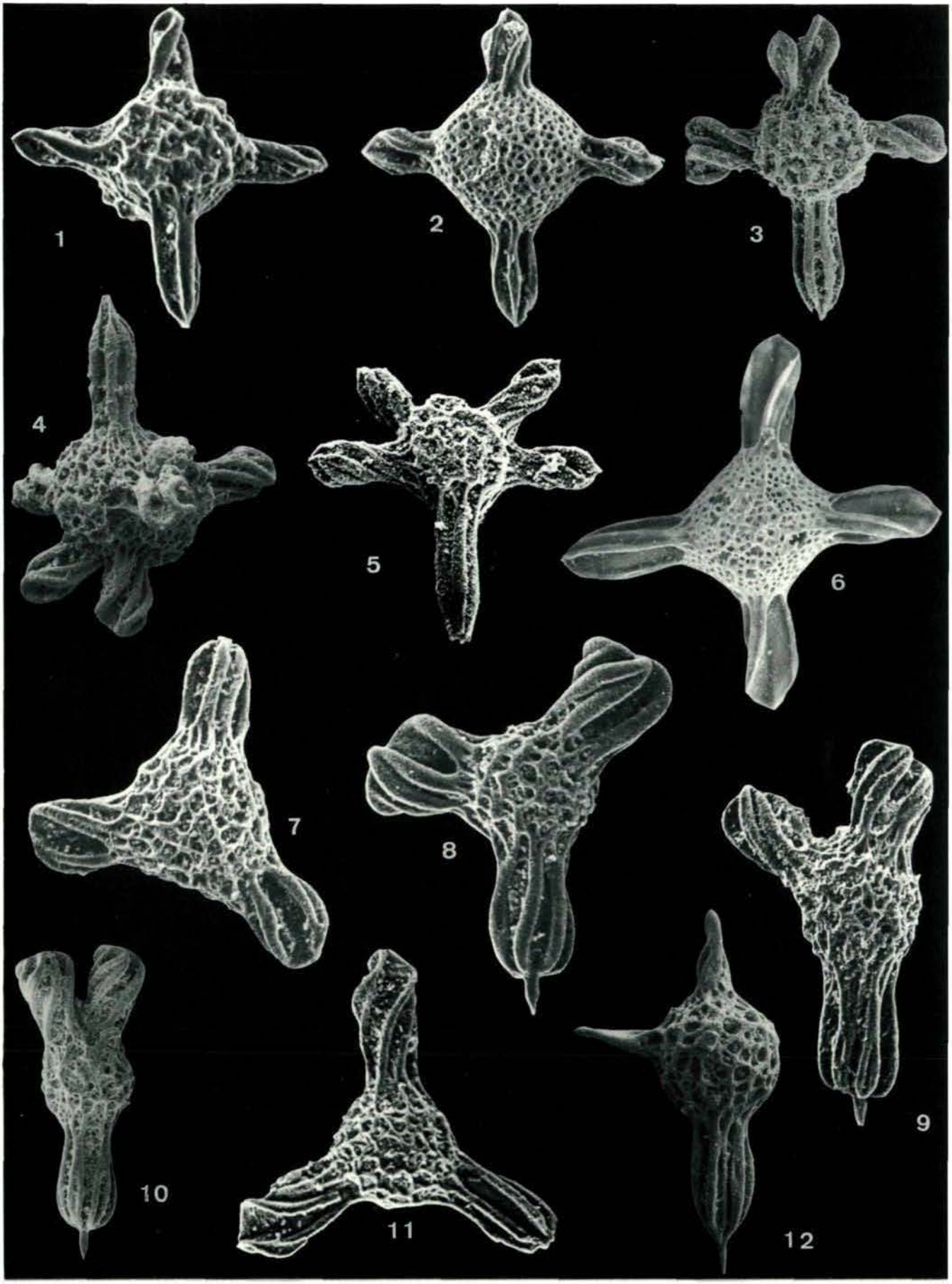
Fig. 6: *Muelleritortis quadrata quadrata* n. subsp., x 150, rep.-no. KOMO 1994 III-31.

Figs. 7, 8: *Tritortis latispina* n. sp., Fig. 7: x 200, rep.-no. KOMO 1994 III-14, fig. 8: holotype, x 210, rep.-no. KOMO 1994 III-13.

Figs. 9, 10: *Tritortis acutangulata* n. sp.; Fig. 9: x 200, rep.-no. KOMO 1994 III-16; fig. 10: holotype, x 130, rep.-no. KOMO 1994 III-15.

Fig. 11: *Tritortis kretaensis dispiralis* (BRAGIN, 1986), primitive specimen, x 190, rep.-no. KOMO 1994 III-12.

Fig. 12: *Tritortis inaequispina* n. sp., holotype, x 200, rep.-no. KOMO 1994 III-17.


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