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EARLY LADINIAN RADIOLARIAN FAUNA FROM THE MONTE SAN GIORGIO (SOUTHERN ALPS, SWITZERLAND): SYSTEMATICS, BIOSTRATIGRAPHY AND PALEO(BIO)GEOGRAPHIC IMPLICATIONS

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Abstract. A well-preserved radiolarian fauna was recovered from the lower part of the San Giorgio Dolomite (Monte San Giorgio, UNESCO WHL, Switzerland), belonging to the *Eoprotrachyceras curionii* Ammonoid Zone (earliest Ladinian). The depositional environment, consisting of an intraplatform basin with restricted circulation, seemingly resulted in unusual radiolarian assemblages displaying neglegible percentages and very low diversity of Nassellaria. Seventy-three species have been identified and seven new species have been described: *Eptingium danieli* n. sp., *Eptingium neriae* n. sp., *Parentactinosphaera eoladinica* n. sp., *Sepsagon ticinensis* n. sp., *Sepsagon? valporinae* n. sp., *Novamuria wirzi* n. sp. and *Pessagnollum? hexaspinosum* n. sp. The taxonomic status of the recovered species has been reassessed and four new genera have been introduced: *Bernoulliella* gen. n., *Eohexastylus* gen. n., *Ticinosphaera* gen. n. and *Lahmosphaera* gen. n. The new radiolarian assemblages, the first so far described from the Monte San Giorgio, supplement further information to the taxa occurring in the uppermost *Ladinocampe multiperforata* Radiolarian Zone, as yet poorly defined, also confirming the absence of major changes in the radiolarian fauna across the Anisian/Ladinian boundary. The widespread co-occurrence of taxa doubtlessly testifies to the existence, in early Ladinian times, of open-marine connections between the basin of the Monte San Giorgio and the pelagic "Buchenstein" basins of the central and eastern South-Alpine domain and farther afield across the Tethys.

Riassunto. Nel presente lavoro viene descritta una fauna a radiolari relativa alla parte inferiore della Dolomia del San Giorgio (Monte San Giorgio, UNESCO WHL, Ticino, Svizzera), appartenente alla Zona a *Eoprotrachyceras curionii* della zonazione ad ammonoidi (parte basale del Ladinico inferiore). L'inusuale composizione dell'associazione a radiolari, caratterizzata da una percentuale trascurabile di Nassellaria mostranti una bassissima diversità, è probabilmente il riflesso dell'ambiente deposizionale, rappresentato da un bacino intrapiattaforma a circolazione ristretta. Settantatré specie sono state identificate e sette nuove specie sono state istituite: *Eptingium danieli* n. sp., *Eptingium neriae* n. sp., *Parentactinosphaera eoladinica* n. sp., *Sepsagon ticinensis* n. sp., *Sepsagon? valporinae* n. sp., *Novamuria wirzi* n. sp. e *Pessagnollum? hexaspinosum* n. sp. Inoltre, la posizione tassonomica delle specie rinvenute è stata rivista e quattro nuovi generi vengono qui introdotti: *Bernoulliella* gen. n., *Eohexastylus* gen. n., *Ticinosphaera* gen. n. e *Lahmosphaera* gen. n. La nuova fauna a radiolari, la prima sinora descritta dal Monte San Giorgio, fornisce ulteriori informazioni sui taxa presenti nella parte superiore della Zona a *Ladinocampe multiperforata* (zonazione a radiolari), in origine basata su sezioni con un basso controllo per quanto concerne la stratigrafia ad ammonoidi. Essa conferma inoltre l'assenza di importanti cambiamenti nelle associazioni a radiolari attraverso il limite Anisico/Ladinico. Evidenti analogie tra la fauna studiata e quelle rinvenute nei bacini pelagici del "Buchenstein" attestano l'esistenza, durante la parte basale del Ladinico inferiore, di una interconnessione di tipo francamente marino tra il bacino del Monte San Giorgio e i bacini pelagici delle Alpi Meridionali e tetidei in generale.

Introduction

During the last three decades, radiolarian data from Triassic pelagic sediments of Western Tethys have rapidly accumulated, substantiating a high diversity of the assemblages and their great importance for defining the biostratigraphy of this period. In the present paper we systematically describe early Ladinian radiolarian species from the biostratigraphically well constrained *E. curionii* Ammonoid Zone of the Monte San Giorgio section (Canton Ticino, Southern Alps; Fig. 1). We also discuss the significance of their occurrence in the light of the palaeogeographic relationships between this intraplatform basin and the wide pelagic "Buchenstein" basins of the Southern Alps, also containing the GSSP

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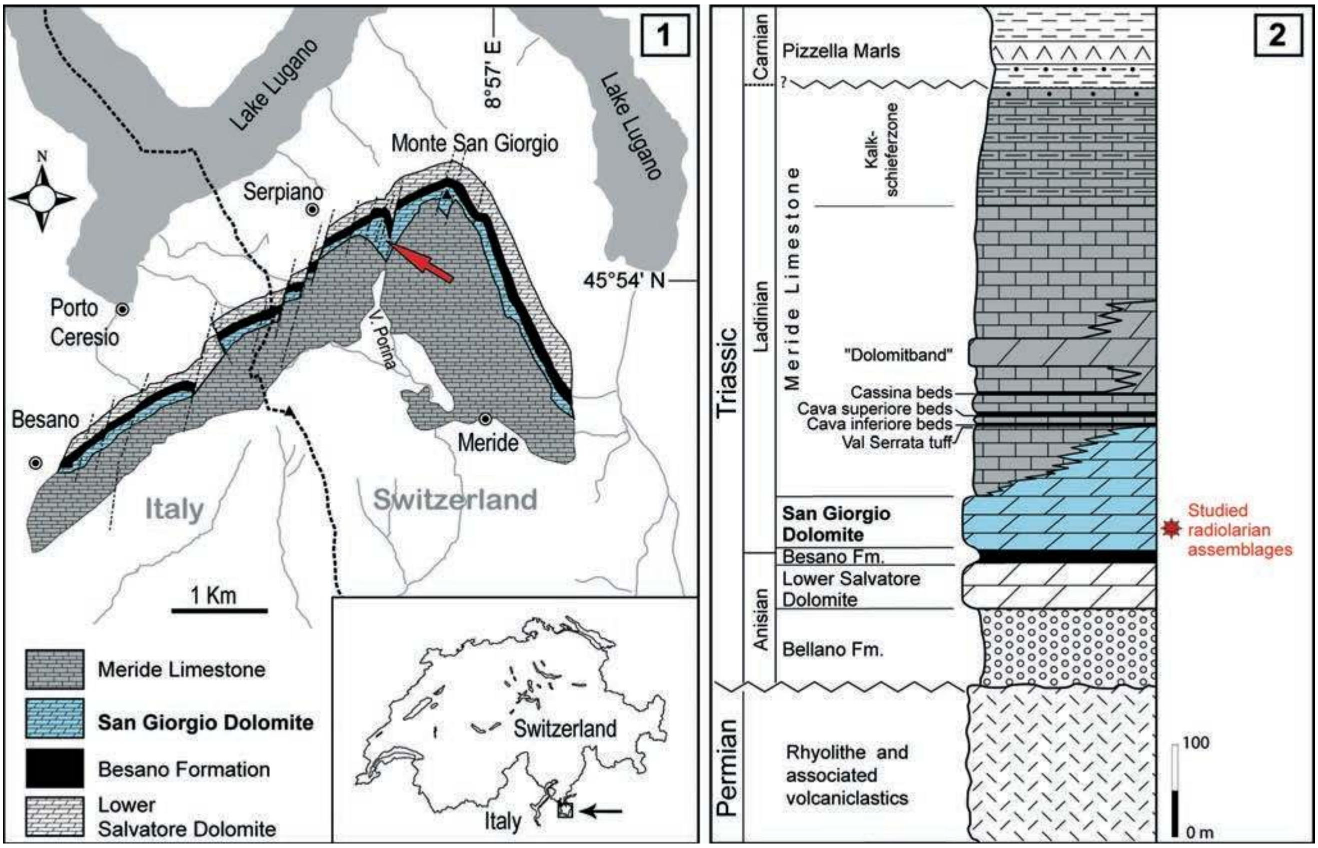


Fig. 1 - 1) Map of the Monte San Giorgio showing the Middle Triassic carbonate sequence and the location of the study area (Val Porina, arrowed). 2) Schematic stratigraphic section of the Middle Triassic sediments in the Monte San Giorgio area (modified from Furrer 1995) and position of the sampled interval.

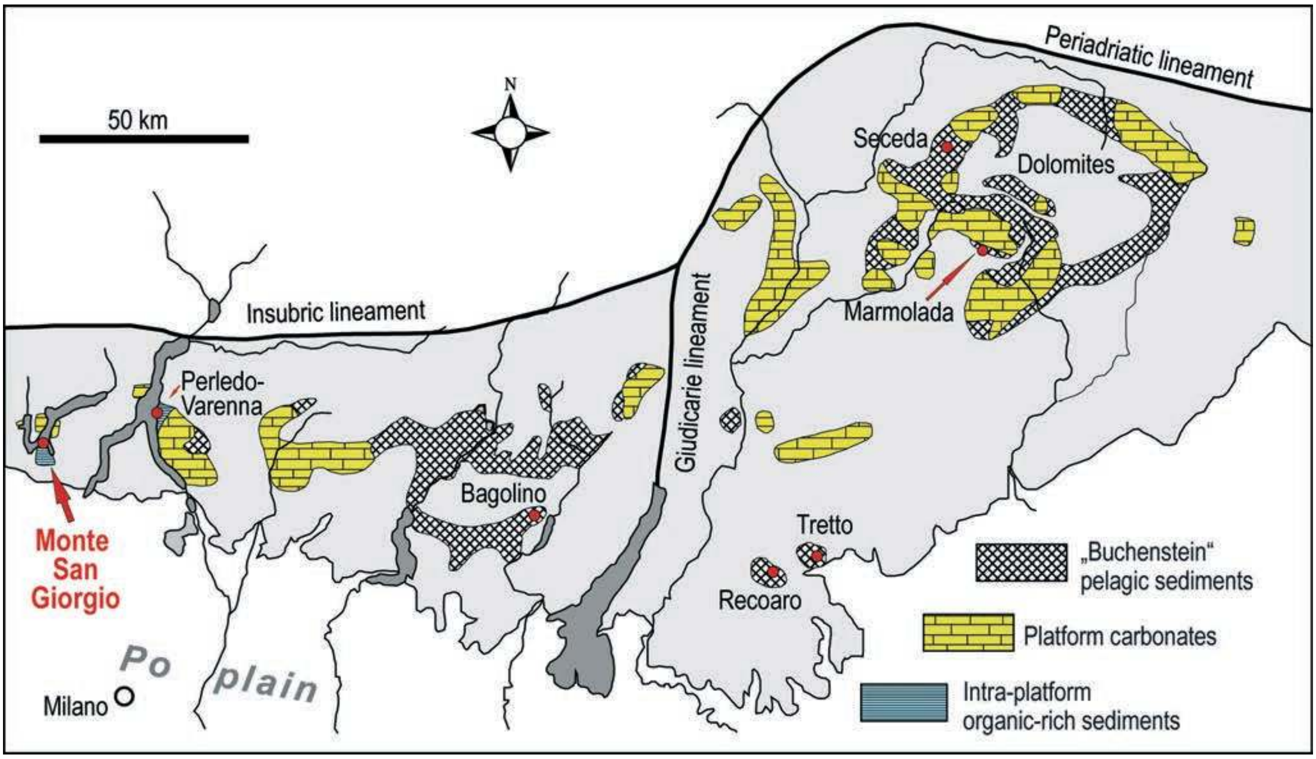


Fig. 2 - Distribution of the early Ladinian (*E. curionii* Ammonoid Zone) sediments in the Southern Alps (light-grey coloured area). From Brack & Rieber (1993), simplified. Red dots indicate the localities mentioned in the text.

(Global boundary Stratotype Section and Point; Bagolino, Brescian Prealps) for the base of the Ladinian Stage. The Monte San Giorgio has been inscribed in 2003 on the UNESCO World Heritage List because of its world-known Middle Triassic fauna of marine vertebrates. The radiolarian record from this Lagerstätte has so far been completely neglected, except for Wirz (1945), who first illustrated a few spheroidal specimens in thin sections from the early Ladinian San Giorgio Dolomite. Seventy-three radiolarian taxa are investigated in this paper. Four new genera are established and seven new species are described.

Geological framework of the South-Alpine Middle Triassic

The Southern Alps (Fig. 2) are a fold-and-thrust belt extending over an area of 500 km (east to west) by 50-150 km (north to south) and bounded by the Insubric/Periadriatic Lineament to the north and west. To the east, the Southern Alps continue into the external Dinarids, whereas to the south, the front of the South-Alpine wedge is buried below the post-orogenic deposits of the Po plain. The Giudicarie lineament is a first order structural transverse zone dividing the Southern Alps into an eastern and a western (Lombardian) sector, the latter including the area under study.

The South-Alpine Anisian to lower Ladinian sedimentary sequence reflects a long-term transgressive evolution following a period of distinct global sea-level lowstand at the end of the Permian and the recovery of marine and continental ecosystems after the most severe extinction in the Earth's history.

In Triassic times, the South-Alpine domain was situated on a passive continental margin open to the tropical Western Tethys (e.g. Brack et al. 1999; Stampfli & Borel 2002; Moix et al. 2007; Blakey 2008. Fig. 3). During the Middle Triassic, the region was affected by transtensive-transpressive tectonics and volcanism (Brack & Rieber 1993). The associated "Pietra verde" and equivalent volcanic ash layers today allow high-resolution U-Pb radiometric ages from single zircons to be determined (Mundil et al. 1996; Mundil et al. 2010; Stockar et al. 2012). Although the main structural subdivision of the South-Alpine basins occurred in the Late Triassic-Early Jurassic with the breakup of the Western Tethys and the opening of the Ligurian Ocean (Bertotti et al. 1993), the Middle Triassic intense tectonic activity resulted in a not necessarily related structural compartmentalization already starting in the Anisian within a tectonically mobile framework of repeatedly uplifted and subsiding blocks. The increasing differentiation of depositional environments occurring from late Anisian times onwards led to the development of a rapidly changing pattern of carbonate platforms, locally anoxic intraplatform basins and open-marine pelagic basins. Marked variations in time and space generated a large number of different facies reflected by a wealth of lithostratigraphic units of regional extent. During the latest Anisian-early Ladinian siliceous pelagic carbonates with tuff intercalations are a widespread deep-water facies of the South-Alpine basins. Well studied examples are the Buchenstein beds of Lombardy (Brack & Rieber 1993) and the Dolomites (where the unit is also known as Livinallongo Formation; Viel 1979), and its equivalents such as the Nodosus Formation of Recoaro/Tretto (Vicentinian Alps; Tornquist 1901). The deposition of the pelagic "Buchenstein" facies occurred under deep-marine conditions. It spans a time interval between the *R. reitzi* Ammonoid Zone (late Anisian) and the earliest *P. archelaus* Ammonoid Zone (early late Ladinian sensu Brack & Rieber 1993; Brack et al. 2005) reflecting a maximum basin depth close to the base of the *E. curionii* Ammonoid Zone (Gianolla & Jacquin 1998; Gaetani et al. 1998; Brack et al. 2005) when a peak transgression resulted in the maximum flooding of the whole Triassic. Water depth reached maximum values (around 800 m) in the Dolomites whereas it became likely shallower towards the west, i.e. in the Vicentinian Alps (including Recoaro/Tretto; Fig. 2) and eastern Lombardy (including Bagolino; Fig. 2) (Brack & Rieber 1993).

The Middle Triassic sequence at Monte San Giorgio

The Monte San Giorgio basin was located at the western termination of the South-Alpine domain (Fig. 2). This unique "remote" location resulted in a peculiar sedimentary succession and in at least temporarily severe dysoxic to anoxic bottom water conditions (Kuhn-Schnyder & Vonderschmitt 1954; Zorn 1971; Rieber 1973a; Bernasconi 1994; Furrer 1995; Röhl et al. 2001; Etter 2002; Stockar 2010; Stockar et al. accepted).

The Middle Triassic succession at Monte San Giorgio (Fig. 1) starts with a fluvio-deltaic sequence dated to the late Anisian (Bellano Formation, Illyrian; Sommaruga et al. 1997), overlying a Permian volcanic succession (Furrer 1995, but see Frauenfelder 1916). The upper Anisian sediments testify to a progressive transgression reaching this westernmost margin of the Lombardian Basin from the east and to the initiation of carbonate platform growth (Salvatore Dolomite/Esino Limestone; Zorn 1971) north of a land area today buried below the Po Plain (Picotti et al. 2007). Dolomitized microbial limestones, characterized by stromatolitic lamination, were deposited in a shallow subtidal to intertidal environment (Lower Salvatore Dolomite). During the latest Anisian and Ladinian, while in the north and in the east shallow-water sedimentation continued, in

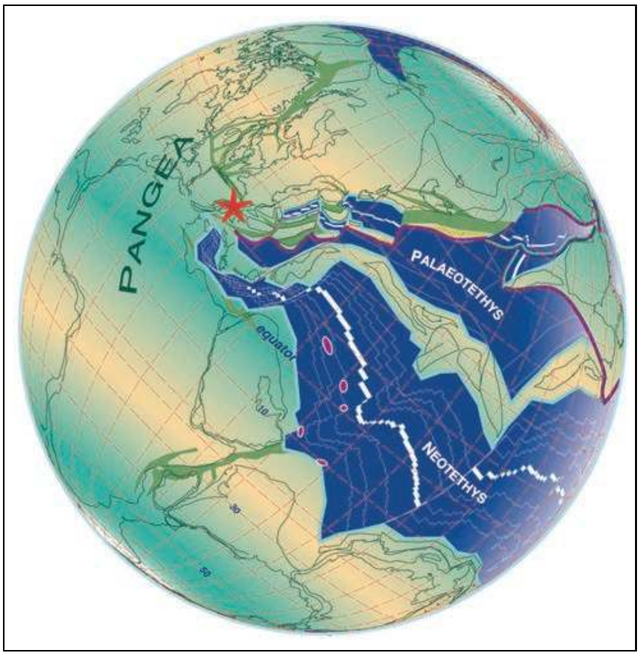


Fig. 3 - Palaeogeographic location (asterisk) of the South-Alpine domain in Ladinian times. From Stampfli & Borel (2002), modified.

the Monte San Giorgio area the formation of an intraplatform basin with a mostly restricted circulation resulted in the deposition of the Besano Formation, the San Giorgio Dolomite and the Meride Limestone (Furrer 1995).

The Besano Formation ("Grenzbitumenzone"; Frauenfelder 1916) directly overlies the Lower Salvatore Dolomite and is composed of a 16 m thick alternation of black shales and laminated dolostones. Its uppermost part (Figs 4-5) includes the Anisian/Ladinian boundary (= base of the *E. curionii* Ammonoid Zone) traced according to the distribution of daonellid bivalves (*Daonella golana*) and ammonoids belonging to the genera *Chieseiceras* (*C. chiesense*), *Nevadites*, *Falsanolcites* and "*Stoppaniceras*" (Rieber 1969, 1973b; Brack & Rieber 1993; Brack et al. 2005). This is supported by the occurrence of thin volcaniclastic layers which can be traced from Monte San Giorgio to Bagolino (GSSP for the base of Ladinian) and Seceda (Dolomites) (Brack & Rieber 1993). A volcanic ash layer lying a few metres below the Anisian/Ladinian boundary yielded an U-Pb

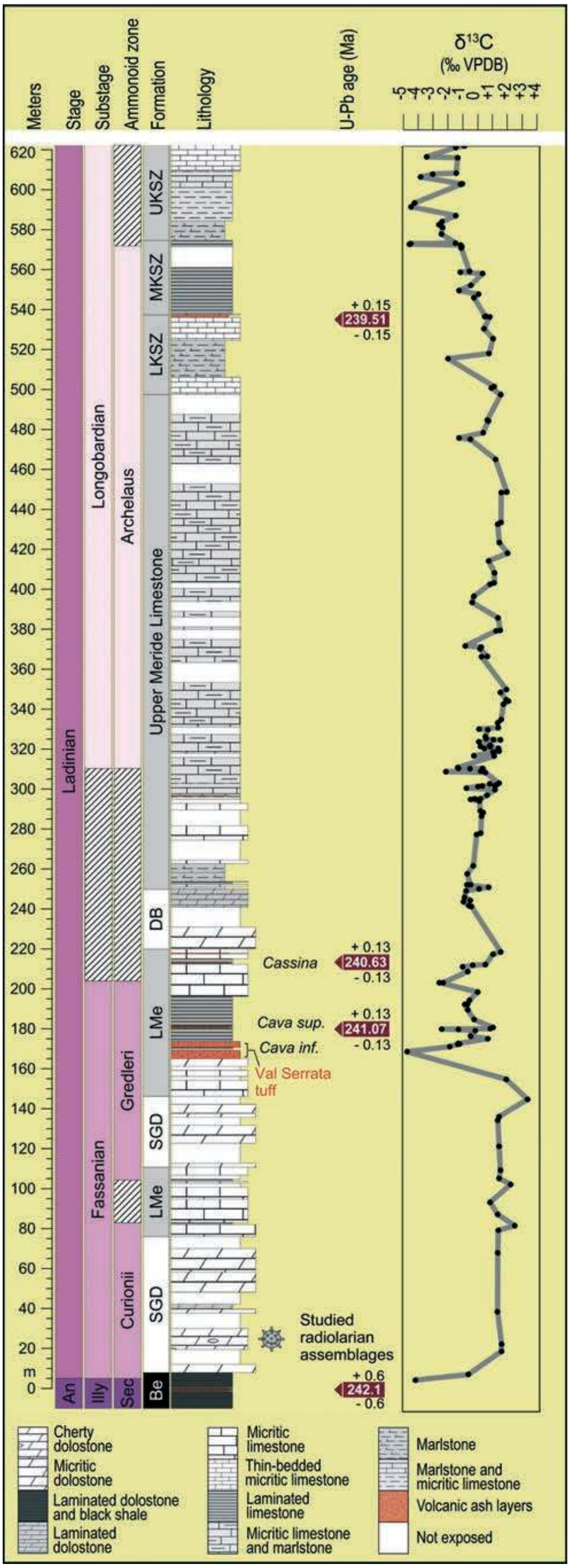


Fig. 4 - Stratigraphic log of the Ladinian succession at Monte San Giorgio, with position of the interval yielding the studied radiolarian assemblages. The 0-m level corresponds to Bed 85 of the Besano Formation (*N. secedensis* Ammonoid Zone) in the standard profile at locality Mirigioli. Biostratigraphic subdivisions after Stockar et al. (2012), based on the ammonoid zonal scheme of Rieber & Brack (1993) and Brack et al. (2005). U-Pb single-zircon ages after Stockar et al. (2012) for the Ladinian Stage and Mundil et al. (2010) for the Anisian Stage. Whole rock carbon isotope record ($\delta^{13}C$) after Stockar et al. (accepted). Be Besano Formation; SGD San Giorgio Dolomite; LMe Lower Meride Limestone; DB Dolomitband; LKSZ, MKSZ, UKSZ Lower, Middle and Upper Kalkschieferzone.

single-zircon age of 242.1 ± 0.6 Ma (Mundil et al. 2010). Most of the spectacular vertebrate fossils of Monte San Giorgio (reptiles and fishes) come from this formation (e.g. Kuhn-Schnyder 1974; Bürgin et al. 1989).

The Besano Formation grades upwards into the San Giorgio Dolomite and the Meride Limestone together constituting an around 600 m thick sequence (Furrer 1995; Stockar et al. 2012, accepted). The base of the San Giorgio Dolomite is defined at layer 187 of the standard profile at locality Mirigioli (Site P. 902. Rieber 1973b; Bernasconi 1994) where the Besano Formation was excavated bed by bed until the mid-1960s yielding exceptional vertebrate fossils. This section is not visible anymore, but thickness and lithofacies are laterally consistent enough to allow a reliable correlation of single beds at different localities of the Monte San Giorgio area, including Val Porina (Bernasconi 1994). Palynological data of the San Giorgio Dolomite (Stockar et al. 2012; Fig. 5) indicate the occurrence of taeniate bisaccates and *Ovalipollis* spp. showing a frequence >2% and the absence of both *Camerosporites secatus* and *Duplicisporites verrucosus*. According to Hochuli & Roghi (2002) this assemblage compares with the *plurianulatus-novimundanus* phase of Van der Eem (1983) and correlates with the early Fassanian *E. curionii* Ammonoid Zone. The transition from the Besano Formation to the San Giorgio Dolomite is marked by the disappearance of black shales, by a reduction of laminated dolostones and by a major decrease in the organic matter contents (Bernasconi 1994; Fig. 4). In addition, thin chert layers are frequent in the basal part of the formation; they are composed of microcrystalline quartz and chalcedony and contain abundant radiolarian molds and sponge spicules. Dolomitization and recrystallization usually obliterated the depositional fabric. The chert-bearing beds are sometimes slumped and chert layers are broken suggesting an early diagenetic origin. Undolomitized intercalations comprise lithofacies identical to those of the Meride Limestone and mainly consisting in structureless lime mudstones and wackestones. According to Furrer (1995), the thickness of the San Giorgio Dolomite is only 60 m. The section of Val Porina, however, clearly shows that this unit results from early and late diagenetic dolomitization, the latter cutting across stratification and affecting the original limestones in an irregular pattern. Indeed, limestone layers discontinuously are intercalated up to the

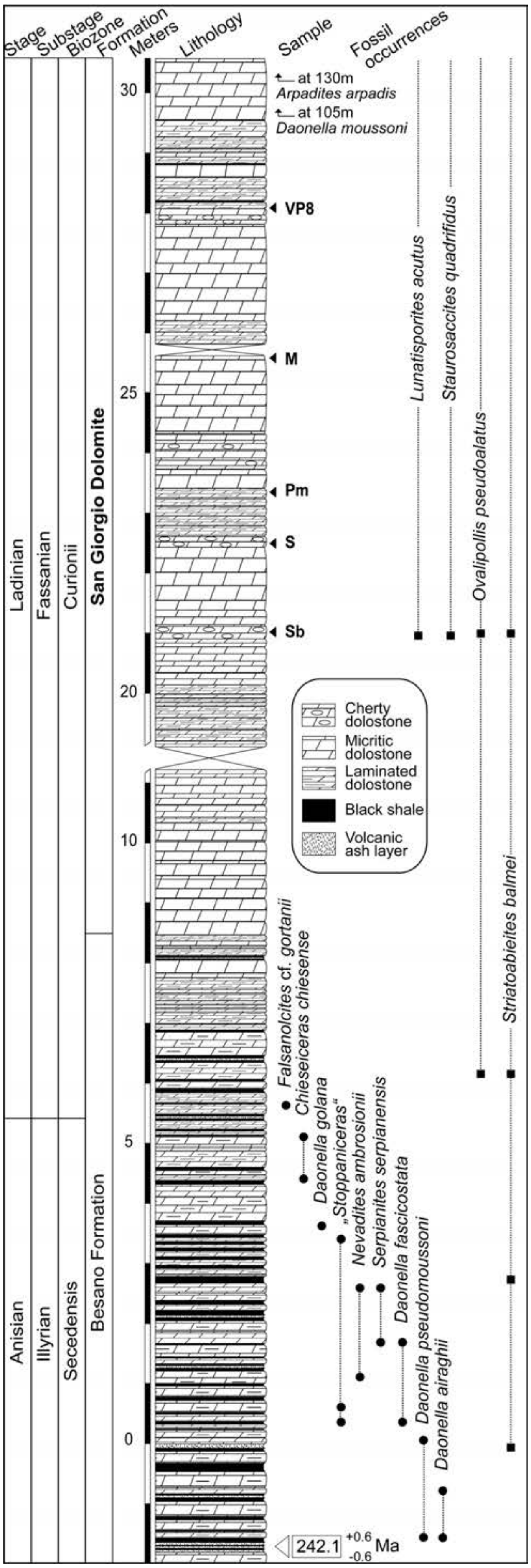


Fig. 5 - Detailed sedimentological log of the Val Porina section with the position of the radiolarian-bearing samples. Ammonoid and daonellid occurrences after Brack et al. (2005) (black dots, Besano Formation) and after Wirz (1945), Schatz (2005) and Stockar et al. (2012) (*A. arpadis* and *D. moussoni*). Palynomorphs occurrences (black squares) after Stockar et al. (2012). U-Pb single-zircon age after Mundil et al. (2010). 0-m level as in Fig. 4.

major volcaniclastic layer at the base of the Cava inferiore beds (the so-called "Val Serrata tuff"). This volcaniclastic level lies around 165 m above the base of the San Giorgio Dolomite. Around 40 m below the Val Serrata tuff, the section yielded the first age-diagnostic ammonoids (in particular *Arpadites arpadis*) indicating the *P. gredleri* Ammonoid Zone (Wirz 1945; Schatz 2005; Stockar et al. 2012).

The Lower Meride Limestone consists of well-bedded micritic and laminated limestones. Most of the carbonate was likely derived from the adjacent highly productive Salvatore/Esino carbonate platforms providing a constant supply of carbonate mud to the basin. Three levels (Cava inferiore beds, Cava superiore beds and Cassina beds), consisting of finely laminated organic-rich limestones with intercalated volcanic ash layers, are present in the upper part of this unit and yielded different vertebrate fossil assemblages (Peyer 1931; Sander 1989; Furrer 1995; Stockar 2010). The top of the Lower Meride Limestone is defined by a very irregular discontinuous dolomite horizon ("Dolomitband"; Frauenfelder 1916), averaging around 30 m in thickness (Wirz 1945; Furrer 1995). The overlying Upper Meride Limestone is a sequence of alternating well-bedded limestones and marlstones. The uppermost part is the 120 m thick "Kalkschieferzone", made up of thin-bedded, laminated limestones and marlstones with peculiar faunas of fishes, crustaceans and insects (e.g. Wirz 1945; Bürgin 1995; Furrer 1995; Krzeminski & Lombardo 2001; Lombardo 2002; Lombardo & Tintori 2004; Tintori & Lombardo 2007; Bechly & Stockar 2011). It represents the latest stage of the evolution of the intraplatform basin, testifying to lowstand sea-level conditions recording strong seasonal salinity variations (Furrer 1995; Stockar et al. accepted).

The Besano Formation, the San Giorgio Dolomite and the Meride Limestone were deposited in the same basin, whose east-west extension is estimated to have been about 20 km if they shared the same basin with the Perledo-Varenna Formation outcropping to the east of Lake Como (Gianotti & Tannoia 1988; Gaetani et al. 1992; Bernasconi 1994). Basin depths are regarded as varying between 30 and 130 m (Monte San Giorgio basin; Bernasconi 1994) and 160-260 m (Perledo-Varenna Formation; Gaetani et al. 1992). Further to the east, the depositional setting of the Perledo-Varenna Formation was, in turn, separated from the pelagic deposits of the "Buchenstein" facies by a shallow-water barrier (Esino Platform, equivalent, in the Como lake region, to the Salvatore Platform). Finally, as the Meride Limestone is considered to be the source rock of the Trecate-Villafortuna oil field (Riva et al. 1986; Mattavelli & Novelli, 1990; Picotti et al. 2007), the intra-platform basin probably extended southwards for over 60 km.

Materials and methods

Samples bearing radiolarians with highly variable preservation were collected from a section of the San Giorgio Dolomite discontinuously exposed in the upper Val Porina (Porina Valley; Figs 1, 4-5). Here, the Besano Formation was quarried in the early 20th century and both the upper part of its sequence and the base of the overlying San Giorgio Dolomite are still visible and can be correlated with the standard section at the locality Mirigioli. The entire sampled section is assigned to the lower part of the early Ladinian *E. curionii* Ammonoid Zone (Brack & Rieber 1993; Stockar et al. 2012). Of the 20 samples selected in the field and covering an interval of 60 m from the base of the formation upwards, only 5 samples yielded moderately to well preserved radiolarians, always associated with abundant sponge spicules, thin-shelled bivalves and rare nodosariid foraminifera. The remaining samples only yielded unidentifiable radiolarian molds. The 5 productive samples are described here below (and see Fig. 5):

Sample Val Porina Sb. Micritic grey calcareous dolostone with up to 15 mm thick bands of replacement cherts. It has been collected 12.5 m above the base of the formation. Swiss National Coordinates: 716'620/85'320.

Sample Val Porina S. Micritic grey calcareous dolostone with up to 10 mm thick chert layers. 14.0 m above the the base of the formation.

Sample Val Porina Pm. Laminated light grey calcareous dolostone. 15.0 m above the base of the formation.

Sample Val Porina M. Micritic light grey calcareous dolostone. 17.0 m above the base of the formation.

Sample Val Porina VP8. Laminated dark grey calcareous dolostone. 19.5 m above the base of the formation. Swiss National Coordinates: 716'590/85'290.

Rock samples of around 1 kg were broken using a jaw-crusher into small fragments and the fine powder was discarded. Fragments were placed in a 10% solution of formic acid, buffered with both calcium carbonate (20 grams every litre of acid solution) and tri-calcium phosphate (1.2 grams every litre of acid solution). After 24 hours the muddy residue was separated, thoroughly wet sieved and dried. The process was repeated on each fragmented sample for four to six weeks.

Microfossils were picked from the dry residue with a thin paintbrush under a stereoscopic microscope. Radiolarians still encrusted with dolomite crystals were further cleaned by using a 10% HCl solution. Transmitted light microscopy proved useless due to recrystallization or filling of the test with calcite or quartz. Selected tests were mounted on stubs and photographed with a Mira Tescan scanning electron microscope (SEM) at the Institut de Géologie et Paléontologie of the University of Lausanne (UNIL). For this study, about 2000 radiolarian specimens were preliminarily determined and 348 specimens SEM-photographed.

Silica diagenesis largely affected the radiolarian tests in the cherts, thus producing vugs filled with calcedony or microcrystalline quartz. Specimens from the carbonate samples have all undergone different degrees of diagenesis and dolomitization. Even when preserved in silica, radiolarian tests largely document a phase of dolomitization of the embedding carbonate, resulting in dolomite rombohedra growing on and cross-cutting the shell surface. Where the quartz grew against the dolomite rhombs, it molded itself around the dolomite crystals (Fig. 6). The rim between the chert nodules and the embedding carbonate matrix, that is just at the boundary between the two co-occurring diagenetic phases, proved by far the most suitable for yielding well-preserved and diversified radiolarian tests. By contrast, laminated organic-rich dolostones (Sample VP8) yielded the less diversified fauna.

The resulting preservation index (PI; Kiessling 1996) is usually 2 to 3 (very good to good) for samples Sb and S where radiolarians from chert rims, though recrystallized, show only a moderate modification of the fine structures. By contrast, radiolarians from samples Pm, M and VP8 are usually significantly recrystallized (Fig. 6) and sometimes

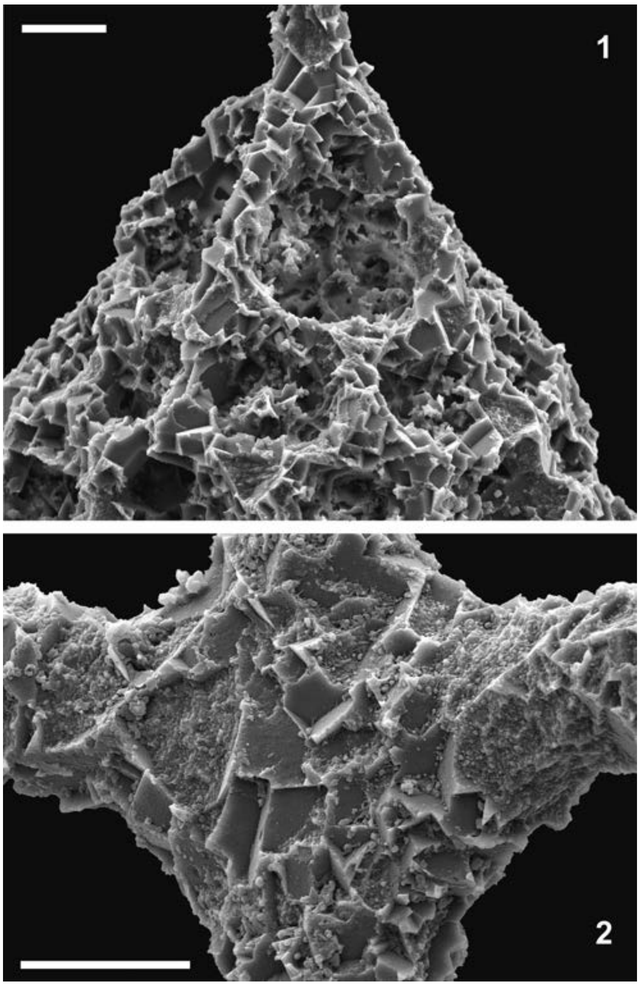


Fig. 6 - Details of the molded surface in radiolarian tests resulting from the growth of dolomite rombohedrs in the surrounding sediment. 1) *Pentactinocarpus fusiformis*, apical pores, 2) *Baumgartneria retrospina*, main spine. Both specimens from sample Pm. Scale bar = 20 µm.

the fine structures are not preserved at all (PI 4-6, average to poor). A comparison of the co-specific specimens in Pl. 8, fig. 2 (sample Sb, PI= 3) and in Pl. 8, fig. 3 (sample M, PI= 6) well exemplifies the different preservation.

The 5 productive samples yielded assemblages not only of different state of preservation but also of considerably variable diversity. However, since the species occurring in poorer samples also occur in the more diverse ones, the assemblages are regarded as faunistically equivalent and differences are ascribed to a diagenetic bias.

The Middle Triassic radiolarian biostratigraphy: state of the art and nomenclatural problems across the Anisian/Ladinian boundary

The first radiolarian zonation for the Middle (and Late) Triassic of the European Tethys was formally established by Kozur & Mostler (1994) on the basis of sections from Austria (Göstling and Grossreifling), Hungary (Felsöörs, Köveskal and Dallapuszta) and Italy (Recoaro and Tretto). This first comprehensive work followed earlier extensive studies started in the late 1970s in Europe (e.g. Dumitrica 1978a,b, 1982a,b; Dumitrica et al. 1980; Kozur & Mostler 1979, 1981; Lahm 1984; Gorican & Buser 1990) which led to the description of numerous new taxa and characteristic assemblages. Kozur & Mostler (1996b) and Kozur et al. (1996) further refined this zonation which was later completed by De Wever et al. (2001) by including data from outside the European Tethys. Finally, Kozur (2003) presented a proposal of integration of radiolarian, conodont and ammonoid zones with a promising high-resolution potential.

All the above mentioned studies consider the FAD (First Appearance Datum) of the ammonoid *Reitziites reitzi* as marking the base of the Ladinian Stage (base of the Fassanian substage = early Ladinian. Fig. 7). The Anisian/Ladinian boundary at the base of the *R. reitzi* Ammonoid Zone, correlated with the base of the *Spongosilicarmiger italicus* Radiolarian Zone, was consensually favoured by radiolarists because of the important radiation shown by radiolarians between the *P. trinodosus* and the *R. reitzi* Ammonoid Zones. This makes the biostratigraphic resolution of radiolarians across this time interval the strongest in the entire Mesozoic and as fine as that of the ammonoids (Kozur & Mostler 1994; Kozur 2003). In addition, Oertlispongidae diversified in this interval into species with high biostratigraphic value bearing dissolution-resistant highly differentiated main spines, easy recognizable even in the poorliest preserved faunas (De Wever et al. 2001; O'Dogherty et al. 2010).

The official ratification of the GSSP for the base of the Ladinian Stage at the base of the *Eoprotrachyceras curionii* Zone (Bagolino, South-Alpine Buchenstein Formation, Brack et al. 2005) postdated all the established radiolarian zonations mentioned above and had a major impact in redefining radiolarian age assignments published in previous works (O'Dogherty et al. 2010).

On the one hand, one should be aware that most of "early Ladinian" ("Fassanian") radiolarian-based ages published until 2005 have now to be regarded as late Anisian, to which two radiolarian zones formerly attributed to the early Ladinian (*Spongosilicarmiger italicus* and most of the *Ladinocampe multiperforata* zones) now belong (Fig. 7). This generates an obvious confusion in interpreting data from the literature. To make things worse, the newly accepted boundary is not consensually adopted and some workers seemingly preserve the base of Ladinian at the base of the *R. reitzi* Ammonoid Zone (e.g. Tekin & Göncüoglu 2007; Tekin & Sönmez 2010).

On the other hand, data available at the present time preclude the recognition of the ratified Anisian/Ladinian boundary on the basis of the radiolarian record. The published data suggest that the radiation of radiolar-

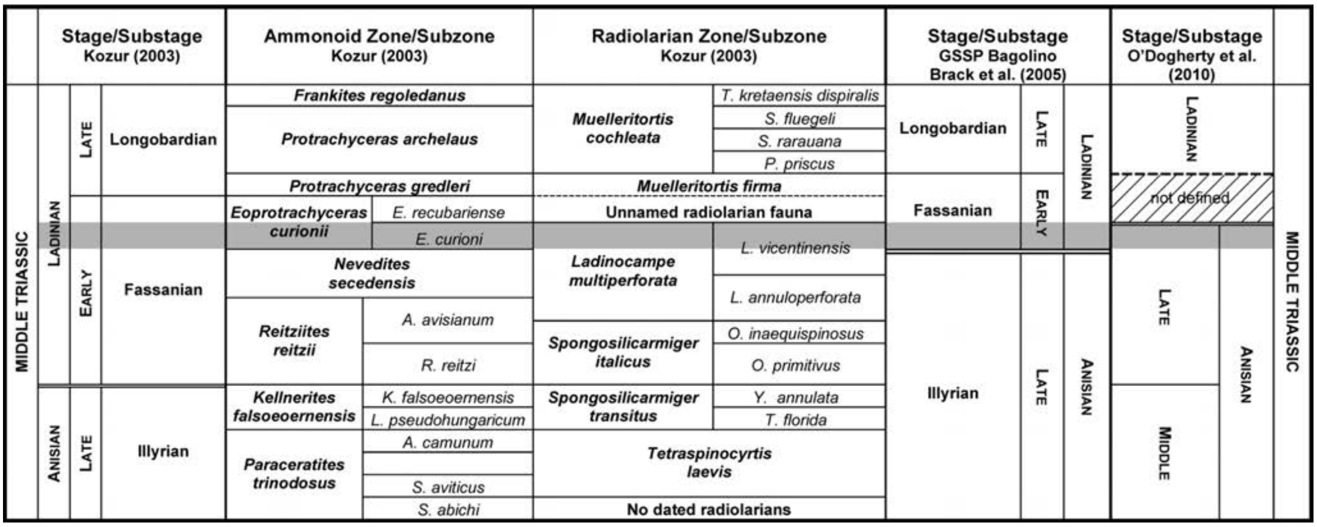


Fig. 7 - Comparative chart of radiolarian/ammonoid zonations and stage/substage boundaries across the Anisian-Ladinian times. The light-grey coloured interval indicates the age of the studied radiolarian assemblages (lower *E. curionii* Ammonoid Zone, uppermost *L. multiperforata* Radiolarian Zone). Note that they are assignable to the early Fassanian (earliest Ladinian) according to the ratified Ladinian GSSP (Brack et al. 2005) whereas they would belong to the late Fassanian according to the scheme of Kozur (2003; most of the pre-2005 radiolarian literature follows this scheme) or to the latest Anisian if the scheme of O'Dogherty et al. (2010) is applied. This highlights the confusion existing across the ratified Anisian/Ladinian boundary (= base of the *E. curionii* Ammonoid Zone), which does not correspond to any established radiolarian zonal limit.

ian taxa became much slower during the *N. secedensis* Ammonoid Zone and was particularly slow in the *E. curionii* Ammonoid Zone. No distinct change in the radiolarian fauna is supposedly recorded near the base of the *E. curionii* Ammonoid Zone (Kozur & Mostler 1994) whereas a second phase of rapid radiation began only in the *P. gredleri* Ammonoid Zone (Kozur 2003). No radiolarians occur in the Ladinian GSSP section (Kozur 2003; Brack et al. 2005; O'Dogherty et al. 2010), thus precluding any direct correlation with the ammonoid record. The most complete radiolarian-bearing section available from this time interval is that of the Recoaro/Tretto area (Vicentinean Alps, Brack et al. 2005). Its base lies in the *R. reitzi* Ammonoid Zone and the section yielded the best known fauna belonging to the *Oertlispongus inaequispinosus* Subzone of the *Spongosilicarmiger italicus* Radiolarian Zone (Dumitrica 1978a,b, 1982a,b; Dumitrica et al. 1980; Kozur & Mostler 1981, 1994; Lahm 1984). Unfortunately, this section lacks an adequate ammonoid control above the *R. reitzi* Ammonoid Zone (Kozur & Mostler 1994; Brack et al. 2005).

Finally, the base of the *E. curionii* Ammonoid Zone does not correspond to any existing radiolarian zonal boundary but it rather falls within the upper *Ladinocampe vicentinensis* Subzone of the *Ladinocampe multiperforata* Radiolarian Zone (Fig. 7). This subzone, however, is only questionably correlatable with the lower *E. curionii* Ammonoid Zone and this even in its type locality (Kozur & Mostler 1994: 165). The radiolarian fauna of the following upper part of the *E. curionii* Ammonoid Zone has not yet been described; consequently, in all published zonal schemes this interval correlates with an "unnamed zone" (Kozur & Mostler 1994; Kozur et al. 1996; Kozur 2003). In the last version of Kozur's zonal scheme, the "unnamed zone" is followed by the *Muelleritortis firma* Radiolarian Zone (Kozur 2003), where first Muelleritortidae without twisted spines occur which are regarded as possible forerunner of *M. cochleata* (*Muelleritortis firma* group; Kozur & Mostler 1996a; Tekin & Sönmez 2010). A radiolarian index fauna of this zone, however, has not been so far described.

In their accurate up-to-date biostratigraphic chart of Triassic genera, O'Dogherty et al. (2010) overcome the above problems by (Fig. 7):

a) Subdividing the Anisian into three parts, the late Anisian comprising the entire "old" Fassanian except for the upper part of the *E. curionii* Ammonoid Zone.

b) Identifying the Anisian/Ladinian boundary with the top of the *Ladinocampe vicentinensis* Subzone of the *Ladinocampe multiperforata* Radiolarian Zone.

c) Considering the Ladinian as undivided and being basically equivalent to the *Muelleritortis cochleata* Radiolarian Zone. It corresponds to the Longobardian sensu Brack et al. (2005). As O'Dogherty et al. (2010) regard both the two underlying subzones (*M. firma* Zone and the "unnamed" one) as not or unsufficently defined, the lower boundary of the Ladinian remains undistinct (see dashed interval in Fig. 7).

By this, a further at least nomenclatural issue appears just for the short time interval under study in the present paper. Important genera such as *Heptacladus* or *Parasepsagon*, regarded by O'Dogherty et al. (2010) as being upward confined to (their) late Anisian, actually are well represented in our section, which, belonging to the *E. curionii* Ammonoid Zone, is definitely early Ladinian in age (according to the ratified GSSP; Brack et al. 2005).

In the systematic part of this paper, published stratigraphic ranges are indicated for each species in the form in which they have been reported in literature. By contrast, in Fig. 8 the originally reported ranges have been "translated", as far as possible, to the post-2005 scheme. This results in a range chart which is inherently tentative, due to uncertainties residing in the original data and to the interpretation of the used terminologies. Note that in Fig. 8 the Fassanian substage (early Ladinian) comprises not only the *E. curionii* Ammonoid Zone (the only former Fassanian zone to "survive" the ratification of the above mentioned GSSP) but also the *P. gredleri* Ammonoid Zone (Brack et al. 2005).

Biostratigraphic significance of the radiolarian assemblages

Our radiolarian assemblages compare very well with the faunas described from the "Nodosus Fm." from the Recoaro/Tretto area (Dumitrica 1978a,b, 1982a,b; Dumitrica et al. 1980; Kozur & Mostler 1981, 1994; Lahm 1984. Fig. 2). Fourty-five species out the seventy-three species described here also occur in that section of the Vicentinian Alps (Fig. 8). This, however, does not mean that the two sections are coeval. The well studied fauna of the "Nodosus Fm." of the Vicentinian Alps (equivalent of the "Buchenstein Beds") mainly belongs to the (late Anisian) *Oertlispongus inaequispinosus* Subzone of the *Spongosilicarmiger italicus* Radiolarian Zone (Kozur & Mostler 1994: 162; Dumitrica 2004: 195). Nevertheless, none of the numerous species occurring in the *O. inaequispinosus* Subzone is restricted to the latter; on the contrary, species which appeared at the base or inside this subzone continue into the overlying *Ladinocampe multiperforata* Zone (Kozur & Mostler 1994), within which, consequently, ancestral forms co-occur with descendant ones. Therefore, for the biostratigraphic subdivision of this interval the first occurrence of a certain taxon is of crucial importance and the age of the assemblages is basically defined by the most advanced forms (see also Kozur & Mostler 1994).

Representatives of the family Oertlispongidae, the most important radiolarian family for the biochronology of the Tethyan late Anisian-Ladinian, are common in our assemblages. Together with rather primitive species such as *Pararchaeospongoprunum hermi*, *Paroertlispongus multispinosus, P. rarispinosus* and long-ranging forms such as *Oertlispongus inaequispinosus* and *Baumgartneria retrospina*, advanced representatives of the *Falcispongus calcaneum* lineage (sensu Kozur & Mostler 1994) already occur. According to Kozur & Mostler (1994), these forms, characterized by a short and broad stem (*Falcispongus postcalcaneum* sensu Kozur & Mostler 1994), appear only within the *L. multiperforata* Radiolarian Zone and their range extends up to the top of the "unnamed zone" (top of the *E. curionii* Ammonoid Zone).

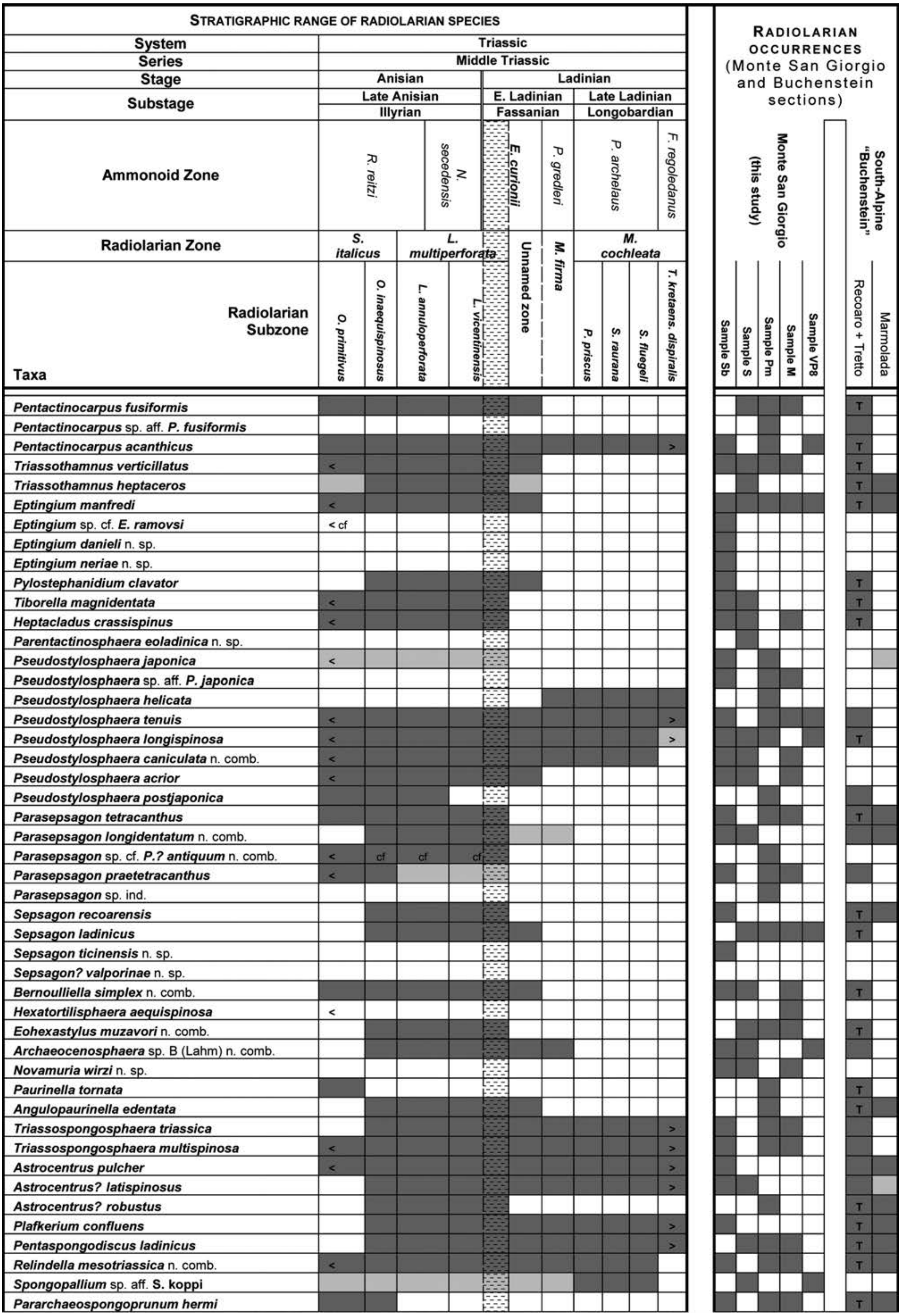
Eptingium manfredi Dumitrica, one of the dominant species of the assemblages, shows an impressive sequence of morphotypes, including the most advanced ones (*E. manfredi robustum* Kozur & Mostler in Dumitrica et al. 1980).

Pseudostylosphaera helicata was so far known only from the *Muelleritortis firma* (Tekin & Sönmez 2010) and *M. cochleata* Radiolarian Zones (Nakaseko & Nishimura 1979; Sashida et al. 1993). The occurrence in our material represents the older record of this species and maybe a first clue to a younger age compared to the (Anisian) classic radiolarian assemblages from Recoaro/Tretto. On the other hand, the absence of any representatives of the family Muelleritortidae, index taxa known to appear at the base of the *M. firma* Radiolarian Zone (Kozur & Mostler 1996a; Tekin & Sönmez 2010) and which became dominant in the *M. cochelata* Radiolarian Zone, suggests that the studied section is older than the *P. gredleri* Ammonoid Zone.

Already known species aside, the new forms described herein (7 new species and several others left in open nomenclature) definitely differentiate the assemblages from that described from Recoaro/Tretto. *Eptingium danieli* n. sp., for instance, shows features such as a strong torsion of spines which are otherwise unknown in the "Buchenstein" ("Nodosus") material. The massive occurrence of *Novamuria wirzi* n. sp. and the presence, even though subordinate, of *Eptingium neriae* n. sp., *Parentactinosphaera eoladinica* n. sp., *Sepsagon ticinensis* n. sp., *Sepsagon? valporinae* n. sp., *Pessagnollum? hexaspinosum* n. sp complete the peculiar character of this association which correlates with the lower part of the *E. curionii* Ammonoid Zone.

Comparison with other assemblages and paleo(bio)geographic significance

The first striking feature of the assemblages is the negligible occurrence of Nassellaria, which are represented by only 1-2% of the radiolarian specimens and by 6 species out of a total of 73 species identified herein. This is surprising, because in the Middle Triassic the number of species, genera and families of Nassellaria increased at a rate far greater than in Entactinaria and



STRATIGRAPHIC RANGE OF RADIOLARIAN SPECIES												RADIOLARIAN OCCURRENCES (Monte San Giorgio and Buchenstein sections)						
System	Triassic																	
Series	Middle Triassic																	
Stage	Anisian				Ladinian													
Substage	Late Anisian				E. Ladinian			Late Ladinian										
	Illyrian				Fassanian			Longobardian										
Ammonoid Zone	*R. reitzi*		*N. secedensis*			***E. curionii***	*P. gredleri*	*P. archelaus*			*F. regoledanus*	Monte San Giorgio (this study)					South-Alpine "Buchenstein"	
Radiolarian Zone	*S. italicus*		*L. multiperforata*			Unnamed zone	*M. firma*	*M. cochleata*										
Radiolarian Subzone / Taxa	*O. primitivus*	*O. inaequispinosus*	*L. annuloperforata*	*L. vicentinensis*				*P. priscus*	*S. raurana*	*S. fluegeli*	*T. kretaens. dispiralis*	Sample Sb	Sample S	Sample Pm	Sample M	Sample VP8	Recoaro + Tretto	Marmolada
Pentactinocarpus fusiformis	■	■	■	■	■	■							■	■	■		■ T	
Pentactinocarpus sp. aff. ***P. fusiformis***														■			■	
Pentactinocarpus acanthicus	■	■	■	■	■	■	■	■	■	■	■ >	■		■		■	■ T	
Triassothamnus verticillatus	■ <	■	■	■	■	■						■	■	■	■		■ T	
Triassothamnus heptaceros	▒	■	■	■	■	▒							■				■ T	■
Eptingium manfredi	■ <	■	■	■	■	■						■	■	■	■	■	■ T	■
Eptingium sp. cf. ***E. ramovsi***	< cf											■						
Eptingium danieli n. sp.												■						
Eptingium neriae n. sp.												■						
Pylostephanidium clavator		■	■	■	■	■						■					■ T	
Tiborella magnidentata	■ <	■	■	■	■							■	■				■ T	
Heptacladus crassispinus	■ <	■	■	■	■							■	■		■		■ T	
Parentactinosphaera eoladinica n. sp.													■					
Pseudostylosphaera japonica	▒ <	▒	▒	▒	▒							■		■				▒
Pseudostylosphaera sp. aff. ***P. japonica***												■		■	■			
Pseudostylosphaera helicata							■	■	■	■	■			■				
Pseudostylosphaera tenuis	■ <	■	■	■	■	■	■	■	■	■	■ >	■		■	■	■	■	
Pseudostylosphaera longispinosa	■ <	■	■	■	■	■	■	■	■	■	▒ >	■	■	■		■	■ T	
Pseudostylosphaera caniculata n. comb.	■ <	■	■	■	■	■	■	■	■	■		■	■		■			
Pseudostylosphaera acrior	■ <	■	■	■	■	■						■	■		■			
Pseudostylosphaera postjaponica	■	■	■											■			■	
Parasepsagon tetracanthus	■	■	■	■	■							■		■	■		■ T	■
Parasepsagon longidentatum n. comb.		■	■	■	■	▒	▒					■	■				■	■
Parasepsagon sp. cf. ***P.? antiquum*** n. comb.	■ <	■ cf	■ cf	■ cf	■									■				
Parasepsagon praetetracanthus	■ <	■	▒	▒	▒							■		■	■		■	
Parasepsagon sp. ind.														■				
Sepsagon recoarensis		■	■	■	■							■					■ T	■
Sepsagon ladinicus		■	■	■	■	■							■	■	■	■	■ T	
Sepsagon ticinensis n. sp.												■						
Sepsagon? valporinae n. sp.																		
Bernoulliella simplex n. comb.	■	■	■	■	■	■						■	■		■		■ T	
Hexatortilisphaera aequispinosa	<														■			
Eohexastylus muzavori n. comb.		■	■	■	■								■	■	■		■ T	
Archaeocenosphaera sp. B (Lahm) n. comb.		■	■	■	■	■	■					■	■			■	■	
Novamuria wirzi n. sp.												■	■		■			
Paurinella tornata	■													■			■ T	
Angulopaurinella edentata		■	■	■	■	■								■			■ T	■
Triassospongosphaera triassica		■	■	■	■	■	■	■	■	■	■ >	■		■	■		■	
Triassospongosphaera multispinosa	■ <	■	■	■	■	■	■	■	■	■	■ >	■		■	■		■	
Astrocentrus pulcher	■ <	■	■	■	■	■	■	■	■	■	■ >	■					■	■
Astrocentrus? latispinosus		■	■	■	■	■	■	■	■	■	■ >	■	■				■	▒
Astrocentrus? robustus		■	■	■	■									■			■ T	■
Plafkerium confluens		■	■	■	■	■	■	■	■	■	■ >	■					■ T	■
Pentaspongodiscus ladinicus		■	■	■	■	■	■	■	■	■	■ >		■	■	■		■ T	■
Relindella mesotriassica n. comb.	■ <	■	■	■	■	■	■	■	■	■		■		■	■		■ T	■
Spongopallium sp. aff. **S. koppi**	▒	▒	▒	▒	▒	▒	▒	■	■	■			■			■		
Pararchaeospongoprunum hermi	■	■										■		■	■		■ T	■

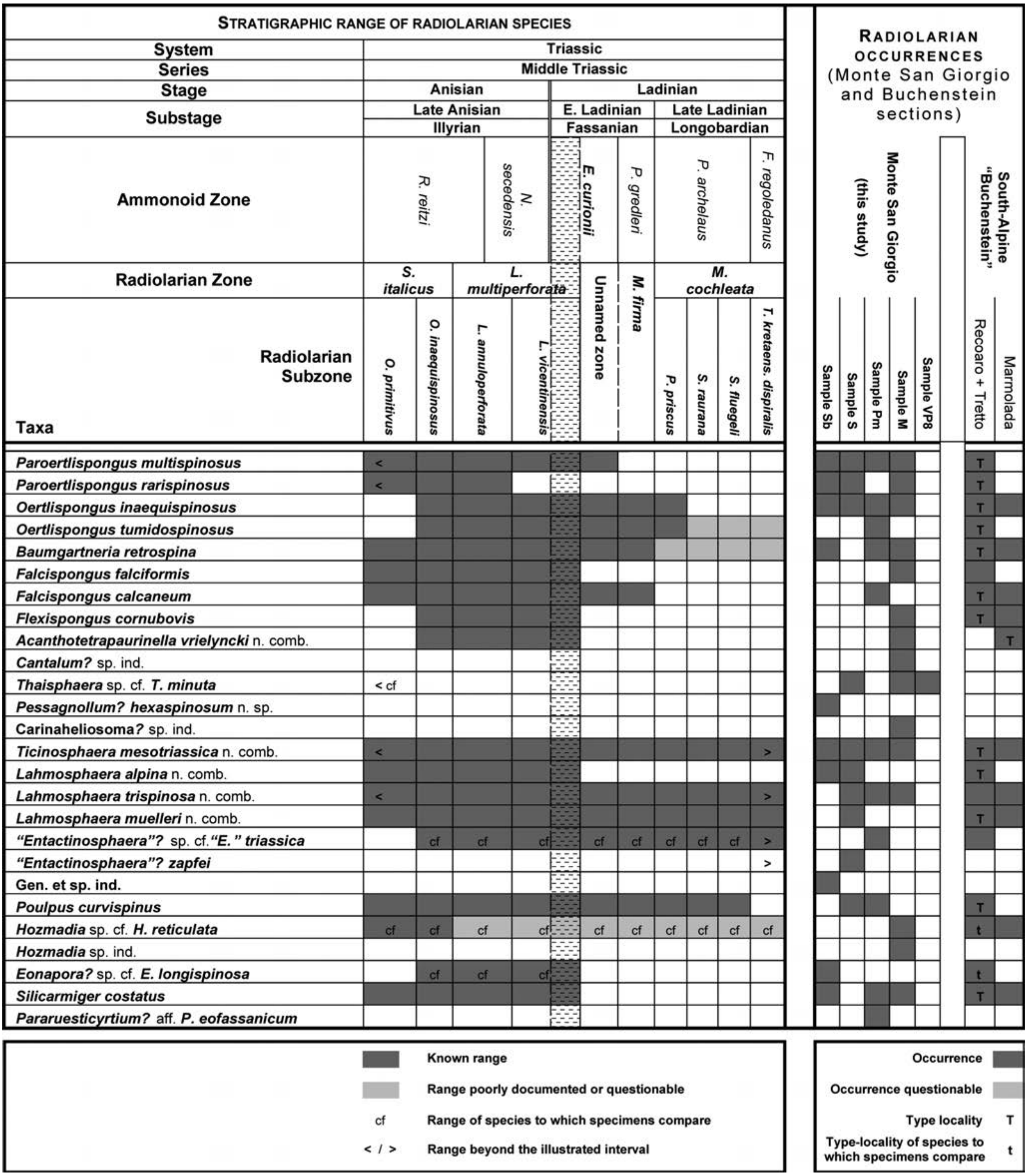


Fig. 8 - Composition of the radiolarian assemblage from the early Ladinian San Giorgio Dolomite. The dashed stratigraphic interval indicates the lower *E. curionii* Ammonoid Zone, to which the sampled interval belongs (Brack & Rieber 1993; Stockar et al. 2012). A tentative range chart for already known taxa is proposed on the basis of published data. Moreover, radiolarian occurrences are listed by samples and compared with those reported from important radiolarian-bearing sections of the South-Alpine "Buchenstein" (Dumitrica 1978a,b; Dumitrica 1982a,b; Dumitrica et al. 1980; Kozur & Mostler 1981,1994; Lahm 1984; Kellici & De Wever 1995).

Spumellaria (Dumitrica 1991; De Wever et al. 2003) and in late Anisian times nassellarians reached their maximum diversification (O'Dogherty et al. 2010). Accordingly, the widely accepted zonal schemes of Kozur and co-workers (Kozur & Mostler 1994; Kozur et al. 1996; Kozur 2003; De Wever et al. 2001) are largely based on the nassellarian diversification and this particularly in the late Anisian-earliest Ladinian *Ladinocampe multiperforata* Zone with index species belonging to the genera *Ladinocampe*, *Planispinocyrtis*, *Anisicyrtis*, *Cono-*

spongocyrtis and *Spongolophophaena*. None of these taxa occurs in the assemblages under study. By contrast, published data show that the composition of late Anisian-earliest Ladinian radiolarian assemblages from the Southern Alps (e.g. Kozur & Mostler 1994; Kellici & De Wever 1995) generally mirrors this evolutionary bloom, even though Nassellaria quantitatively always represent a minor fraction of faunas mainly consisting of Spumellaria and Entactinaria. However, in the radiolarian assemblages of Recoaro, Nassellaria amount to about 15% of the specimens and a similar percentage is also reached in other roughly coeval Italian and Romanian sections (Dumitrica 1991: 262). This percentage exceeds that observed at Monte San Giorgio by an order of magnitude.

Studies on modern Radiolaria have shown that the distribution of Spumellaria and Nassellaria is depth-dependent: Spumellaria tend to be as diverse as Nassellaria in surface waters, where Spumellaria dominate by abundance, while Nassellaria clearly dominate in waters deeper than 1000 m (Takahashi 1991; Casey 1993). More recently, different feeding strategies have been observed between these groups: while Spumellaria are passive "filter" feeders that mostly feed on nannoplankton, Nassellaria actively catch larger microplanktonic prey (Matsuoka 2007). Their distribution is, therefore, dependent on the planktonic food chain. Although the ecologic needs of these two radiolarian orders may have changed through time, many studies of Paleozoic and Mesozoic radiolarian distributions in known or inferred paleogeographic transects confirm absence or scarcity of Nassellaria in nearshore to offshore paleoenvironments and their dominance on basinal oceanic conditions (e.g. Kissling 1996). Lambert & De Wever (1996), based on a taxon-quantitative study of Lower Cretaceous radiolaria have established an interesting relationship between disappearance and appearance of Nassellaria and the now well-known mid-Cretaceous anoxic events. Nassellaria seem to be the first affected by decreasing oxygen levels rising from bottom waters upwards. They go extinct earlier than spumellarian species before the organic-rich deposition and new species appear later than spumellarian species after the organic-rich deposition. At first hand, the extreme scarcity of nassellarians at Monte San Giorgio may result from the bathymetry being considerably shallower compared to the classic "Buchenstein" basins which, just close to the base of the *E. curionii* Ammonoid Zone, reached their maximum depth (up to 800 m; Brack et al. 2005). More interestingly, Nassellaria may be virtually absent due to restricted circulation, water stratification and ensuing oxygen depletion in the deeper parts of the Monte San Giorgio basin. In addition, unstable surface water conditions, such as changes in salinity and/or temperature may have been better tolerated by spumellarians and fatal to most nassellarian species.

Alternatively, the scarcity of nassellarians could merely derive from a preservational bias affecting the radiolarian thanatocoenosis in favour of more dissolution-resistant Spumellaria and Entactinaria species. It is widely accepted, in fact, that in partially dissolved assemblages spumellarians are more abundant than nassellarians (De Wever et al. 2001).

We favour the hypothesis that the scarcity of Nassellaria somehow reflects the primary composition of the assemblage. This because of the preparation method used here, which is not expected to have negatively affected the preservation of delicate tests, and because even the well preserved assemblages from samples S and Sb show the same depletion of Nassellaria as the highly recrystallized material from samples Pm and M.

Whatever the nature of the scarcity of nassellarians, the radiolarian assemblages from the San Giorgio Dolomite doubtlessly testifies to a faunistic connection with the "Buchenstein" basins to the east. Spumellarian and entactinarian components show striking affinities with those of the Nodosus Formation of Recoaro/Tretto (Figs 2, 8). Of the 67 species present in the San Giorgio Dolomite, 41 species also occur at Recoaro/Tretto which, moreover, represents the type-locality for 31 of them (Dumitrica 1978a,b, 1982a,b; Dumitrica et al. 1980; Kozur & Mostler 1981, 1994; Lahm 1984). At least 20 spumellarian/entactinarian species also occur in the assemblage described by Kellici & De Wever (1995) from the Livinallongo Formation of the western Dolomites (SE of Marmolada massif; Figs 2, 8). This assemblage (sample BV 85-70) has been assigned to the early or middle Fassanian (sensu Kozur 2003) by Dumitrica (2004: 195). It corresponds to the *S. italicus-L. multiperforata* Radiolarian Zones, even though one can exclude the lower subzone of the *S. italicus* Zone (*O. primitivus* Subzone) due to the occurrence of *O. inaequispinosus* in the assemblage (Kellici & De Wever 1995, pl. 3, fig. 9). As a whole, at least 21 radiolarian species co-occur at Monte San Giorgio, Recoaro/Tretto and Marmolada even though these assemblages are not coeval, that of Monte San Giorgio most likely being slightly younger.

Most of the species of Monte San Giorgio, however, are typical components of the assemblage characterizing the *O. inaequispinosus* Radiolarian Subzone. In the South-Alpine "Buchenstein" this is also known from Seceda (Dolomites; Fig. 2), designated as the principal auxiliary section for the Ladinian GSSP in the Dolomites (Brack et al. 2005: 237). Moreover, this assemblage has been recognized not only across the European Tethys (e.g. Gorican & Buser 1990; Dosztaly 1993; Vörös et al. 2003) but also in the orogenic belts of the Asian branches of the Tethys from Oman (Dumitrica 1999) to China (e.g. Feng & Liang 2003; Feng et al. 2009), Thailand (Feng et al. 2005) and Indonesia (Sashida et al. 1999). Oertlispongidae have also been reported from Circum-Pacific orogenic belts of Panthalassa (Japan; Sugiyama 1997). The radiolarian fauna from the San Giorgio Dolomite, therefore, testifies to the existence in early Ladinian times of open-marine connections across the Esino Platform to the "Buchenstein" basins of the central and eastern South-Alpine domain and farther away throughout the Tethys and Panthalassa. Influence of open-marine Tethyan waters during this stratigraphic interval is in agreement with the carbonate carbon isotope record, showing $\delta^{13}C$ values which form a very stable plateau clustering around +1.4‰ (Stockar et al. accepted. Fig. 4). Such value fully conforms to the $\delta^{13}C$ signature of the Ladinian open marine Tethyan seawater (Veizer et al. 1999; Korte et al. 2005). By this, radiolarians from Monte San Giorgio supplement further evidence to the existence of the basinal connections which are regarded as having played a major role in the vertebrate faunal interchange between the Eastern and Western Tethyan realms during Anisian-Ladinian times. Marine vertebrate fossils from Monte San Giorgio, in fact, show striking analogies with those from China in particular, from where these taxa are thought to have migrated along the northern coastline of the Palaeo-Tethys (e.g. Lin et al. 2010; Rieppel 2010).

Systematic palaeontology

The systematic part mainly follows the final report of the InterRad Mesozoic Working Group on the taxonomy and stratigraphy of Mesozoic radiolarians at generic level (O'Dogherty et al. 2009a,b,c) together with the systematic scheme of De Wever et al. (2001). Open nomenclature is used in accordance to Bengston (1988).

All radiolarian morphotypes found in the studied samples are described, including poorly preserved unidentifiable ones. By this way we intend to illustrate the whole spectrum of a fauna belonging to the *E. curionii* Ammonoid Zone which, as far as radiolarians are concerned, is still inadequately known. Some new species with well-defined characters have been described on the basis of very few specimens or, in one case, even of a single specimen. All the studied material is deposited in the collection of the Museo cantonale di storia naturale, Lugano, Switzerland (MCSN).

In the species descriptions, published stratigraphic ranges follow the form in which they have been reported in literature. In Fig. 8 this information has been "translated", as far as possible, to the post-2005 stratigraphic scheme (see above for a discussion about biostratigraphic and nomenclatural problems across the Anisian/Ladinian boundary).

Class **Actinopoda**
Subclass **Radiolaria** Müller, 1858
Superorder **Polycystina** Ehrenberg, 1838 emend. Riedel, 1967b
Order **Entactinaria** Kozur & Mostler, 1982
Family Pentactinocarpidae Dumitrica, 1978b
Genus *Pentactinocarpus* Dumitrica, 1978b
Type species: *Pentactinocarpus fusiformis* Dumitrica, 1978b

Pentactinocarpus fusiformis Dumitrica, 1978b

Pl. 1, figs 1-6

1978b *Pentactinocarpus fusiformis* Dumitrica, p. 44, pl. 2, fig. 2.
1980 *Pentactinocarpus fusiformis* – Dumitrica et al., p. 8, pl. 4, figs 2-3, 5-6, non 7 (= *P. acanthicus* Dumitrica, 1978b),? 8.
1982 *Pentactinocarpus fusiformis* – Yao, pl. 1, fig. 20.
1982 *Pentactinocarpus fusiformis* – Yao et al., pl. 1, fig. 13.
1984 *Pentactinocarpus fusiformis* – Lahm, p. 24, pl. 3, fig. 1.
1989 *Pentactinocarpus fusiformis* – Martini et al., pl. 3, fig. 1.
1990 *Pentactinocarpus fusiformis* – Gorican & Buser, p. 150, pl. 7, fig. 11.
1994 *Pentactinocarpus fusiformis* – Kozur & Mostler, p. 46, pl. 2, fig. 4.
2006 *Pentactinocarpus fusiformis* – Marquez et al., pl. 2, fig. 19.

Description. Spindle-like single loosely latticed shell with large polygonal pores of different size. Shell diameter 160-185 µm, shell length without spines 250-270 µm. Apical pores very large. Short apical spine (maximal preserved length 45 µm) and longer, usually thinner antapical spine (maximal preserved length 140 µm). Both spines are needle-like with round cross section.

Anomalies. A single anomaly was recorded (Pl. 1, fig. 6). This specimen shows a duplication in the apical spine (preserved length = 40 µm).

Range (as published). Early Ladinian (Kozur & Mostler 1994). A very frequent species in the Middle Triassic of the Southern Alps (Dumitrica et al. 1980: 8).

Occurrence. Samples S, Pm, M. Very abundant.

Pentactinocarpus sp. aff. **P. fusiformis** Dumitrica, 1978b

Pl. 1, fig. 7

aff. 1978b *Pentactinocarpus fusiformis* Dumitrica, p. 44, pl. 2, fig. 2.
? 1980 *Pentactinocarpus fusiformis* – Dumitrica et al., p. 8, pl. 4, fig. 8.
? 2006 *Pentactinocarpus fusiformis* – Marquez et al., pl. 2. fig. 5.

Description. This morphotype resembles *Pentactinocarpus fusiformis* Dumitrica, 1978b, from which it differs in having a globular rather than a typically elongated, spindle-shaped shell. Shell diameter 200 µm, shell length without spines 250 µm.

Remarks. This morphotype compares with the specimens figured in Dumitrica et al. (1980) and in Marquez et al. (2006). Dumitrica et al. (1980: 29) regard this morphotype as possibly belonging to a different subspecies of *P. fusiformis* Dumitrica.

Range (this study). Lower *E. curionii* Ammonoid Zone, early Ladinian.

Occurrence. Sample Pm. Very rare.

Pentactinocarpus acanthicus Dumitrica, 1978b

Pl. 1, figs 8-10

1978b *Pentactinocarpus acanthicus* Dumitrica, p. 44, pl. 3, fig. 3.

1980 *Pentactinocarpus acanthicus* – Dumitrica et al., p. 7, pl. 4, fig. 7.

1984 *Pentactinocarpus acanthicus* – Lahm, p. 22, pl. 2, figs 9-10.

1990 *Pentactinocarpus acanthicus* – Gorican & Buser, p. 149, pl. 7, fig. 12.

1994 *Pentactinocarpus acanthicus* – Kozur & Mostler, p. 46, pl. 2, figs 3, 5.

1999 *Pentactinocarpus acanthicus* – Tekin, p. 133, pl. 27, fig. 6.

Description. Globular to spindle-like single loosely latticed shell with large polygonal pores of different size; diameter 220-240 µm. Eight spines in addition to the apical and antapical ones. Four spines are downward directed and represent projections of the four basal spines. The other four spines arise from the upper part of the shell and are upward directed. All spines are needle-like with round cross section.

Range (as published). Ladinian to middle Carnian (Kozur & Mostler 1994; Tekin 1999).

Occurrence. Samples Sb, Pm, VP8. Rare.

Family Thalassothamnidae Haecker, 1906

Genus *Triassothamnus* Kozur & Mostler, 1981

Type species: *Palacantholithus? verticillatus* Dumitrica, 1978b

Triassothamnus verticillatus (Dumitrica, 1978b)

Pl. 1, figs 11-16

1978b *Palacantholithus? verticillatus* Dumitrica, p. 42, pl. 1, fig. 1; pl. 2, fig. 5.

1981 *Triassothamnus verticillatus* – Kozur & Mostler, p. 5.

1982b *Archaeothamnulus verticillatus* – Dumitrica, p. 418, pl. 5, figs 3-4; pl. 7, fig. 4.

1990 *Triassothamnus verticillatus* – Gorican & Buser, p. 160, pl. 7, fig. 3.

1995 *Triassothamnus verticillatus* – Ramovs & Gorican, p. 196.

1996 *Triassothamnus verticillatus* – Kozur et al., p. 218, pl. 11, fig. 3.

Description. Skeleton composed of a spicule consisting of a straight apical spine and four curved basal spines, each bearing an umbrella-like verticil of four long needle-like spinules. Maximal preserved length of spines 620 µm, maximal diameter of spines 18 µm, maximal length of spinules 380 µm. The apical spine is clearly distinguished from the basal spines by its axial position. Apical verticil usually missing; if occurring, it is closer to the center of the spicule than the verticils of the four basal spines.

Range (as published). *S. transitus* Radiolarian Zone (Illyrian) to early Ladinian (Kozur et al. 1996: 219).

Occurrence. Samples Sb, S, Pm, M. Abundant.

Triassothamnus heptaceros (Dumitrica, 1982b)

Pl. 1, fig. 17

1982b *Archaeothamnulus heptaceros* Dumitrica, p. 421, pl. 5, figs 6-7; pl. 6 figs 6-8.

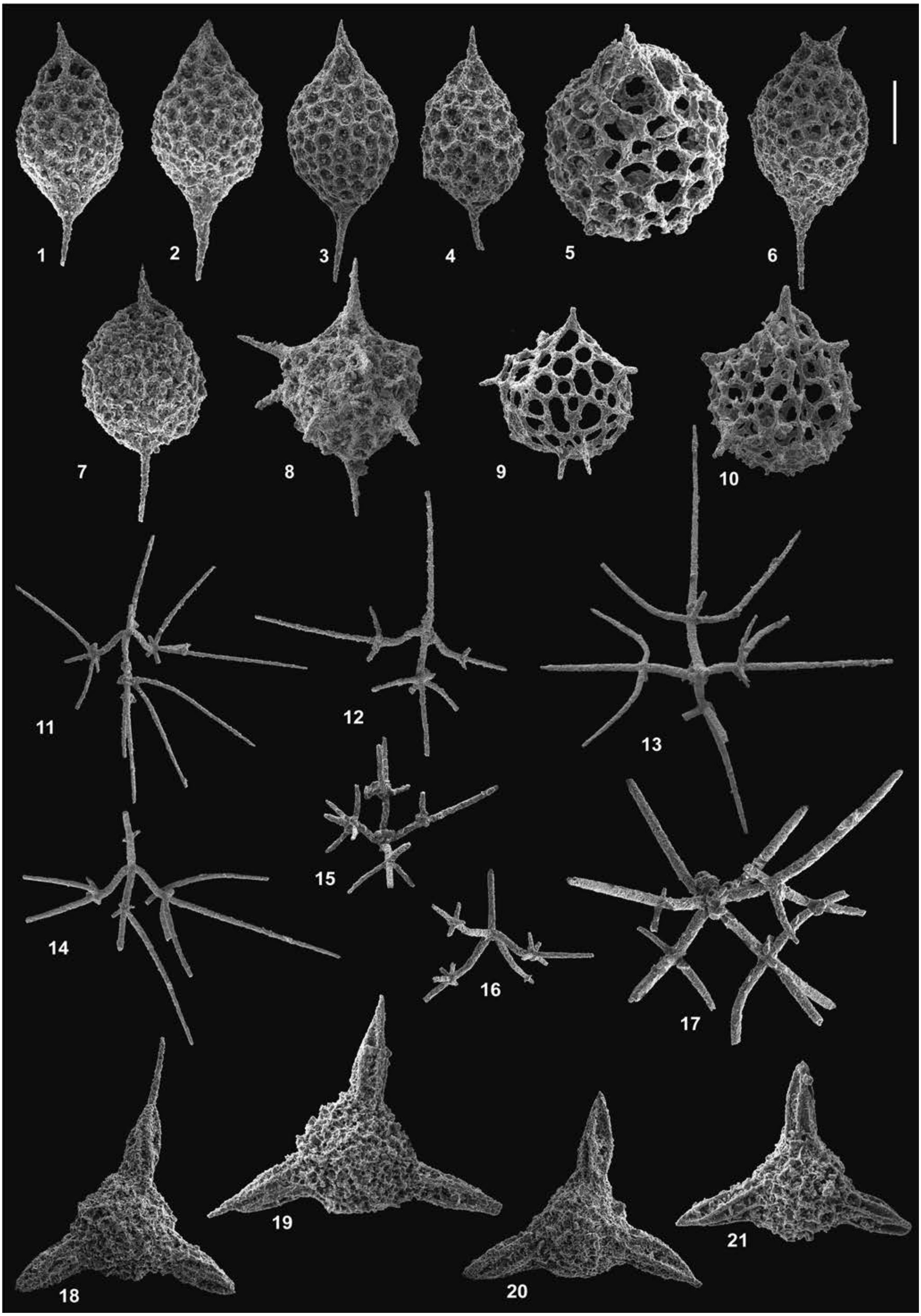
1995 *Triassothamnus heptaceros* – Kellici & De Wever, p. 163, pl. 6, figs 8-9.

Description. Skeleton composed of a spicule consisting of four basal spines and three apical spines, diverging in all directions. Maximal preserved length of spines 510 µm, maximal diameter of spines 22 µm. The basal spines bear a verticil of four well-developed spinules. The apical spines are distinguished from the basal ones by their unconspicuos verticils of 2-4 very short spinules which may be absent.

PLATE 1

Scanning electron photomicrographs of radiolarians from the San Giorgio Dolomite (*E. curionii* Ammonoid Zone, early Ladinian). All material is from Val Porina. For each figure, sample/specimen number and value of scale bar are indicated.

Figs 1-6	- *Pentactinocarpus fusiformis* Dumitrica, 1) Pm/9b, 100 µm, 2) Pm/9e, 100 µm, 3) M/b18a, 100 µm, 4) M/b18b, 100 µm, 5) S/14, 50 µm. 6) M/b17, anomalous specimen with a duplicated apical spine, 100 µm.
Fig. 7	- *Pentactinocarpus* sp. aff. *P. fusiformis* Dumitrica, Pm/9a, 100 µm.
Figs 8-10	- *Pentactinocarpus acanthicus* Dumitrica, 8) Pm/38b, 100 µm, 9) Sb/23, 100 µm, 10) VP8/20, 100 µm.
Figs 11-16	- *Triassothamnus verticillatus* (Dumitrica), 11) Pm/46c, lateral-apical view, 150 µm, 12) Pm/46f, lateral view, 150 µm, 13) Pm/46m, apical view, 150 µm, 14) Pm/46n, lateral view, 150 µm, 15) S/11, basal view, 150 µm, 16) Sb/45, lateral-basal view, 150 µm.
Fig. 17	- *Triassothamnus heptaceros* (Dumitrica), S/10, lateral-basal view, a basal spine is broken off near the base, 120 µm.
Figs 18-21	- *Eptingium manfredi* Dumitrica, 18) Pm/18e, 120 µm, 19) Pm/18a, 120 µm, 20) Pm/18c, 120 µm, 21) Pm/18b, 120 µm.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Range (as published). Early Fassanian (Dumitrica 1982b: 422); late Anisian to early Ladinian (Kellici & De Wever 1995).

Occurrence. Sample S. Rare.

Family Eptingiidae Dumitrica, 1978a

Genus *Eptingium* Dumitrica, 1978a

Type species: *Eptingium manfredi* Dumitrica, 1978a

Eptingium manfredi Dumitrica, 1978a

Pl. 1, figs 18-21; Pl. 2, figs 1-19

1978a *Eptingium manfredi* Dumitrica, p. 33, pl. 3, figs 3-4; pl. 4, figs 1-2, 5-7.
1979 *Eptingium manfredi* – Pessagno et al., p. 186, pl. 6, figs 9-11.
1980 *Eptingium manfredi manfredi* Dumitrica – Dumitrica et al., p. 19, pl. 3, figs 1-3; pl. 6, figs 5-7.
1980 *Eptingium manfredi robustum* Kozur & Mostler – Dumitrica et al., p. 20, pl. 6, figs 1-4, 8.
1990 *Eptingium manfredi* – Gorican & Buser, p. 144, pl. 8, figs 7-8.
1990 *Eptingium manfredi* – Kolar-Jurkovsek, pl. 10, figs 4a-4b.
1993 *Eptingium manfredi* – Sashida et al., p. 82, figs 6.1-6.2.
1993 *Eptingium manfredi* – Dosztaly, pl. 1, fig. 7.
1994 *Eptingium manfredi manfredi* – Kozur & Mostler, p. 42, pl. 1, fig. 3.
1994 *Eptingium manfredi robustum* – Kozur & Mostler, p. 42, pl. 1, figs 1-2.
1995 *Eptingium manfredi* - Kellici & De Wever, p. 144, pl. 1, figs 11-12.
1995 *Eptingium manfredi* – Ramovs & Gorican, p. 184, pl. 5, figs 6-8.
1996 *Eptingium manfredi manfredi* – Kozur, pl. 1, fig. 8.
1996 *Eptingium manfredi manfredi* – Kozur et al., p. 204, pl. 10, figs 1-4, 6, 10.
1999 *Eptingium manfredi manfredi* – Sashida et al., p. 773, figs 6.16-6.17.
2000 *Eptingium manfredi* – Sashida et al., p. 806, figs 9.13-9.16.
2000 *Eptingium manfredi* – Wenchen & Ning, pl. 1, figs 8-9.
2001 *Eptingium manfredi* – Feng et al., p. 188, pl. 4, figs 10-18.
2001 *Eptingium manfredi* – Hauser et al., pl. 2, fig. 31.
2006 *Eptingium manfredi* – Marquez et al., pl. 6, fig. 18.
? 2009 *Eptingium manfredi* – Feng et al., p. 596, fig. 6.6.
2009 *Eptingium manfredi* – Bortolotti et al., pl. 1, fig. 3.
2011 *Eptingium manfredi* – Thassanapak et al., p. 194, figs 6A-6D.
2011 *Eptingium manfredi* – Ozsvárt et al., fig. 10.9.

Description. Subspherical double-layered shell, 155-220 μm in diameter, with rounded subtriangular equatorial outline. Inner layer with small pores, outer layer with large irregular pore frames. Internal entactiniid spicular system usually preserved. Three tricarinate main spines 130-230 μm long, usually slightly twisted. Median grooves on the ridges always occurring; they can be as wide and deep as the primary ones. An always well visible aperture around 40 μm in diameter occurs in lateral position between two main spines. Some transverse bridges connecting adjacent ridges of the spines are usually visible. Spines are mainly gently tapering and sometimes they bear very long needle-like distal prolongations. Subordinately occurring are morphotypes with stout spines which distally terminate abruptly forming rounded ends with or without a short terminal tip.

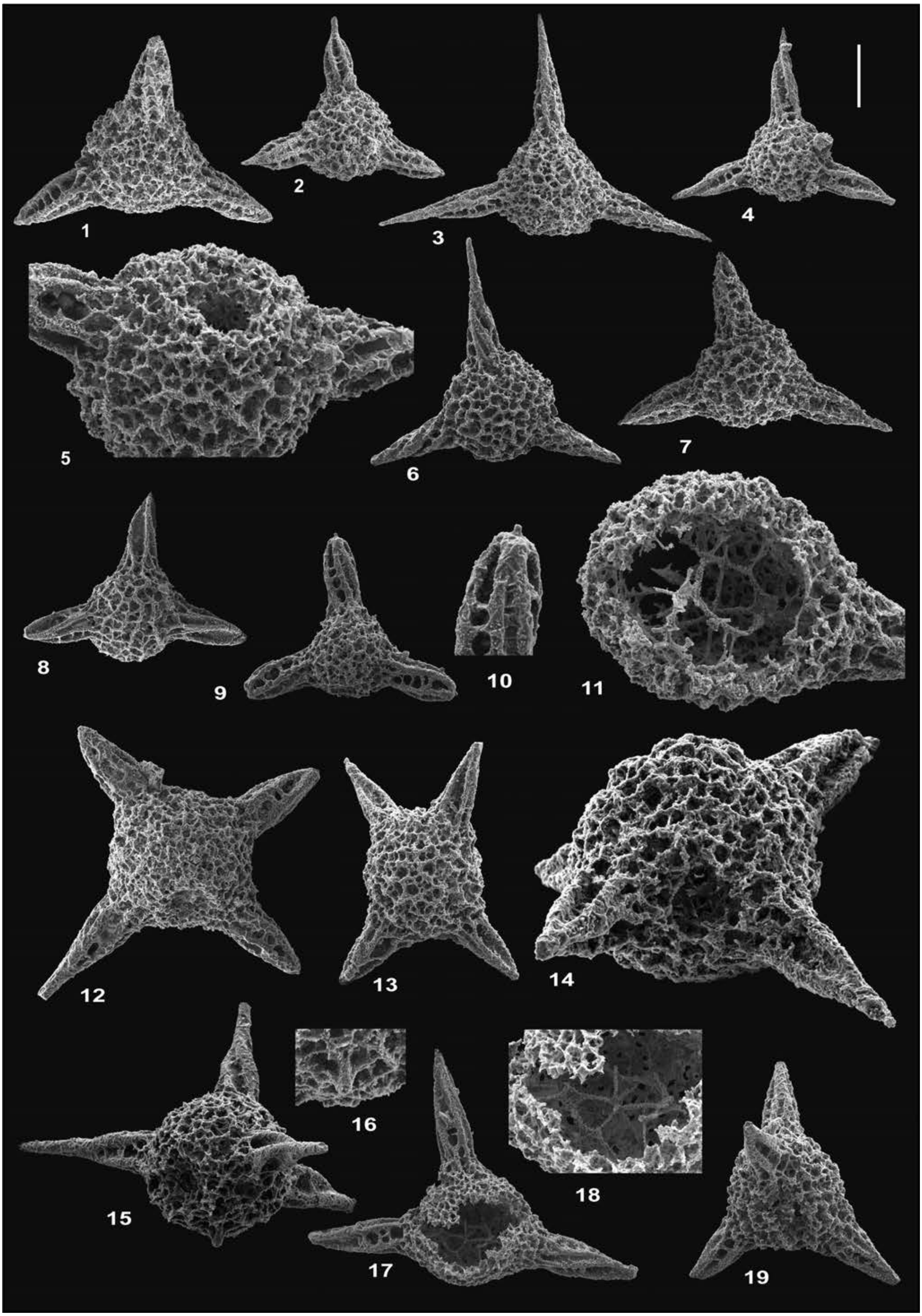
Anomalies. Six specimens have a fourth spine, disposed slightly obliquely (Pl. 2, figs 12-14) to perpendicularly (Pl. 2, figs 15, 17, 19) to the plane of the three (coplanar) spines. Moreover, a single specimen (Pl. 2, figs 15-16) bears a small additional spine, circular in cross section and 15 μm in diameter. It lies outside the plane containing the three (coplanar) spines and opposite to the fourth one. Even though anomalies resulting in the occurrence of a fourth spine have never been so far reported in *Eptingium* they have been documented in other genera belonging to the same family (*Cryptostephanidium*, Dumitrica et al. 2010. Eptingidae gen. et sp. ind., Kozur et al. 1996; Sashida et al. 1999).

Remarks. Kozur & Mostler (in Dumitrica et al. 1980) subdivided *Eptingium manfredi* Dumitrica, 1978a into two subspecies, namely *E. manfredi manfredi* Dumitrica, with gently tapering spines displaying needle-like distal ends, and *E. manfredi robustum,* with stout spines showing rounded distal ends sometimes with a small central tip. The same authors later attributed different stratigraphic distributions to these subspecies, considering the former as ranging from the Illyrian *S. transitus* Radiolarian Zone throughout the "Fassanian" and the latter as being restricted to the "Fassanian" (Kozur et al. 1996). Because of the occurrence of a continuous spectrum of transitional morphotypes between *E. manfredi manfredi* Dumitrica (e.g. Pl. 2, fig. 7) and *E. manfredi robustum* Kozur & Mostler (Pl. 2, fig. 9), *E.*

PLATE 2

Scanning electron photomicrographs of radiolarians from the San Giorgio Dolomite (*E. curionii* Ammonoid Zone, early Ladinian). All material is from Val Porina. For each figure, sample/specimen number and value of scale bar are indicated.

Figs 1-19 - *Eptingium manfredi* Dumitrica, 1) S/8b, 120 μm, 2) S/8a, 120 μm, 3) S/8c, 120 μm, 4) S/8d, 120 μm, 5) S/41, detail of the aperture, 50 μm, 6) Sb/37a, 120 μm, 7) Sb/37b, 120 μm, 8) Sb/37c, 120 μm, 9) Sb/37d, 120 μm, 10) Sb/37d, detail of the distal end of a spine, 50 μm, 11) Sb/37g, inner spicular system, 50 μm, 12) S/12, anomalous specimen with a fourth spine, 100 μm, 13) Sb/60, anomalous specimen with a fourth spine, 100 μm, 14) Sb/60, detail of the aperture through which the spicular system is visible, 50 μm, 15) Sb/59a, anomalous specimen with a fourth spine, 80 μm, 16) Sb/59a, detail of the small needle-like additional spine, 50 μm, 17) Sb/59b, opened anomalous specimen with a fourth spine (a spine has been removed), 100 μm, 18) Sb/59b, inner spicular system, 50 μm, 19) S9, anomalous specimen with a fourth spine, 100 μm.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manfredi is regarded here as a species having a wide intraspecific variability and, accordingly, a subspecific distinction is avoided.

Range (as published). A very common radiolarian species, worldwide ranging from the *S. transitus* Radiolarian Zone (Illyrian) to the Fassanian (Kozur et al. 1996). Feng et al. (2009) erroneously regarded the stratigraphic distribution as ranging up to the Late Triassic (early Carnian).

Occurrence. All samples. Very abundant.

Eptingium sp. cf. **E. ramovsi** Kozur, Krainer & Mostler, 1996

Pl. 3, figs 1-3

cf. 1979 *Tripocyclia japonica* Nakaseko & Nishimura, p. 73, pl. 4, fig. 6, non 4-5.

cf. 1994 *Eptingium manfredi japonicum* Kozur & Mostler, p. 42, pl. 1, fig. 4.

cf. 1995 *Eptingium* sp. A Ramovs & Gorican, p. 185, pl. 5, figs 4-5.

cf. 1996 *Eptingium ramovsi* Kozur, Krainer & Mostler, p. 206, non pl. 4, fig 13; pl. 10, fig. 8.

Description. Subspherical double-layered shell, 140-170 μm in diameter, with rounded subtriangular equatorial outline. Inner layer with small pores, outer layer with large irregular pore frames. Internal entactiniid spicular system usually preserved. Three tricarinate main spines 130-150 μm long, always twisted. Spines are gently tapering distalwards and sometimes they bear a short needle-like distal prolongation. Ridges are narrow, undivided and without transverse bridges.

Anomalies. Two specimens show a fourth spine, disposed nearly perpendicularly to the plane of the three (coplanar) spines (Pl. 3, fig. 3).

Remarks. The shell diameter of our specimens is somewhat larger than reported in the species description (90-135 μm in Kozur et al. 1996). This is probably due to the fact that the two specimens Kozur et al. (1996) illustrated under this species do not seem to be both conspecific with the population of *E. ramovsi* as illustrated by Ramovs & Gorican (1995) under *Eptingium* sp. A from which Kozur et al. chose the holotype. The specimens illustrated by Kozur et al. (1996) have a very small central shell bearing a small number of nodes and pointed spines, whereas the holotype and paratype have practically blunt spines, well convex aperture-bearing side of the test, and numerous smaller nodes. The central test of our specimens resembles that of the holotype but the spines are well pointed.

Range (this study). Lower *E. curionii* Ammonoid Zone, early Ladinian. *Eptingium ramovsi* is known from the *T. laevis* Radiolarian Zone to the *S. transitus* Radiolarian Zone (Illyrian) (Kozur et al. 1996: 206).

Occurrence. Sample Sb. Rare.

Eptingium danieli n. sp.

Pl. 3, figs 4-7

Etymology: In honour of Prof. Daniel Bernoulli (Basel) for having introduced the first author to the geology of the western Southern Alps and for his friendship.

Holotype: The specimen MCSN 8354 (sample Sb), Pl. 3, figs 4-5.

Paratype: The specimens MCSN 8355 (sample Sb), Pl. 3, figs 6-7.

Type locality: Val Porina, Monte San Giorgio, Canton Ticino, Southern Switzerland.

Type horizon: Basal section of the San Giorgio Dolomite, lower part of the *E. curionii* Ammonoid Zone (= uppermost part of the *L. multiperforata* Radiolarian Zone), early Ladinian, Middle Triassic.

Description. Spheroidal cortical shell. Inner layer with small pores, outer layer with large irregular pore frames bearing small conical tubercles on the vertices. Three tricarinate main spines proximally rather straight, then distally strongly twisted. Ridges of the spines separated by deep grooves and displaying median grooves never as deep as the primary ones. Some transverse bridges connecting adjacent ridges of the spines may occur in the proximal part of the spines. Spines end abruptly with a pointed termination or bear needle-like distal prolongations. One angle between the main spines is larger than the other two and contains the aperture of the shell. Entactinariid inner spicular system as for the genus.

Measurements. Diameter of the shell = 140-170 μm, length of the spines (without needle-like distal ends) = 110-130 μm, length of the needle-like distal prolongations = 40-70 μm, width of the spines (proximally) = 40-70 μm, diameter of the aperture = 44-46 μm.

Comparisons. Among the other *Eptingium* species with twisted spines, *Eptingium ramovsi* Kozur, Krainer & Mostler, 1996 and *Eptingium? tortile* Kozur & Mostler, 2006 have less twisted spines which gently taper distalwards; moreover, spine ridges are undivided, without transverse bridges. In *Eptingium manfredi japonicum* (Nakaseko & Nishimura, 1979) the spines, gently tapering distalwards, may be only sligthy twisted and with only a short shallow deepening in the proximal part of the ridges, but have no real median furrow (Kozur et al. 1996: 205). *Eptingium manfredi* Dumitrica, 1978a never displays a comparable spine torsion.

Range (this study). Lower *E. curionii* Ammonoid Zone, early Ladinian.

Occurrence. Sample Sb. Common.

Eptingium neriae n. sp.

Pl. 3, figs 8-9

Etimology: In honour of Dr. Neria Römer for years of wholehearted support to the first author.

Holotype: The specimen MCSN 8353 (sample Sb), Pl. 3, fig. 8.

Paratype: The specimen MCSN 8358 (sample Sb), Pl. 3, fig. 9.

Type locality: Val Porina, Monte San Giorgio, Canton Ticino, Southern Switzerland.

Type horizon: Basal section of the San Giorgio Dolomite, lower part of the *E. curionii* Ammonoid Zone (= uppermost part of the *L. multiperforata* Radiolarian Zone), early Ladinian, Middle Triassic.

Description. Spheroidal double-layered cortical shell with circular equatorial outline. Inner layer with small pores, outer layer with large irregular pore frames. Three slender tricarinate main spines distinctly shorter than the shell diameter. Spines never twisted. Ridges separated by short, wide but very shallow grooves in the proximal part of the spines where they may be connected by transverse bridges. An aperture occurs eccentrically on the shell between two main spines.

Measurements. Diameter of the shell = 180-210 µm, length of the spines = 130-140 µm, diameter of the aperture = 45 µm.

Comparisons. *E. nakasekoi* Kozur & Mostler, 1994 has a smaller shell with subtriangular equatorial outline. Besides being more robust, its spines never exhibit transverse bridges. Moreover, in *E. nakasekoi* the side bearing the aperture is concave to straight.

Range (this study). Lower *E. curionii* Ammonoid Zone, early Ladinian.

Occurrence. Sample Sb. Rare.

Genus *Pylostephanidium* Dumitrica, 1978a

Type species: *Pylostephanidium clavator* Dumitrica, 1978a

Pylostephanidium clavator Dumitrica, 1978a

Pl. 3, figs 10-11

1978a *Pylostephanidium clavator* Dumitrica, p. 34, pl. 2, figs 6-7.

1994 *Pylostephanidium clavator* – Kozur & Mostler, p. 43, pl. 1, fig. 6.

Description. Subspherical irregularly latticed cortical shell around 140 µm in diameter with rounded subtriangular equatorial outline. It bears 2 main spines and a tubopyle. Spines three-bladed, up to 105 µm long, with pointed ends circular in cross section; verticils of nodes occur on the ridges. Tubopyle bearing nodes and a distal pointed spine (Pl. 3, fig. 11); its lateral surface is perforated by pores.

Remarks. A rare species of the Tethys (Dumitrica 1978a; Kozur & Mostler 1994).

Range (as published). Middle-late Fassanian (Kozur & Mostler 1994).

Occurrence. Sample Sb. Very rare.

Family Austrisaturnalinae Kozur & Mostler, 1983

Genus *Tiborella* Dumitrica, Kozur & Mostler, 1980

Type species: *Tiborella magnidentata* Dumitrica,
Kozur & Mostler, 1980

Tiborella magnidentata Dumitrica, Kozur & Mostler, 1980

Pl. 3, figs 12-14

1980 *Tiborella magnidentata* Dumitrica, Kozur & Mostler, p. 18, pl. 1, figs 2, 6; pl. 11, figs 2-4; pl. 12, fig. 4.

1984 *Tiborella magnidentata* – Lahm, p. 108, pl. 19, fig. 7.

1990 *Tiborella magnidentata* – Gorican & Buser, p. 159, pl. 1, fig. 4.

1994 *Tiborella magnidentata* – Kozur & Mostler, p. 52.

1995 *Tiborella magnidentata* – Ramovs & Gorican, p. 192, pl. 4, fig. 6.

2001 *Tiborella magnidentata* – Hauser et al., pl. 2, fig. 27.

? 2007 *Tiborella magnidentata* – Marquez et al., pl. 4, fig. 42.

Description. Thick-walled spherical cortical shell, with latticed framework consisting of polygonally-framed large pores. Cortical shell diameter 130-140 µm, wall thickness 25 µm, 6-7 pores on the diameter. At the inner side of the large pores the remains of a thin lattice plate are visible. Four main spines, coplanar and crosswisely arranged. Spines are three-bladed with high ridges and wide grooves. Three spines are equal in length and rather wide and short (length 80-95 µm). A fourth spine is usually somewhat longer, up to 130 µm. All spines have pointed tips and are distinctly twisted after a short untorsioned proximal portion. An equatorial indistinct girdle made up by the connecting blades of adjoining spines lends a squarish outline to the shell. Main spines extend inside the cortical shell into radial beams connecting the cortical shell to a medullary shell; the latter is never completely preserved in our specimen.

Remarks. The original diagnosis (Dumitrica et al. 1980: 18) does not mention the occurrence of a length difference between one spine and the other three. This feature, however, is clearly shown by the holotype (Dumitrica et al. 1980, pl. 1, fig. 2) and also stressed by Lahm (1984). In our specimen the double lattice medullary shell is never preserved, but radial beams and thin rays connecting the outer medullary shell to the cortical one are sometimes visible (Pl. 3, fig. 14).

Range (as published). Middle Triassic according to Dumitrica et al. (1980). According to Kozur & Mostler (1994: 161) *T. magnidentata* is an important representative of the *O. primitivus* Radiolarian Subzone (*S. italicus* Radiolarian Zone).

Occurrence. Samples S, Sb. Rare.

Family Heptacladidae Dumitrica, Kozur & Mostler, 1980

Genus *Heptacladus* Dumitrica, Kozur & Mostler, 1980

Type species: *Heptacladus crassispinus* Dumitrica,
Kozur & Mostler, 1980

Heptacladus crassispinus Dumitrica, Kozur & Mostler, 1980

Pl. 3, figs 15-19

1980 *Heptacladus crassispinus* Dumitrica, Kozur & Mostler, p. 3, pl. 5, fig. 3; pl. 13, figs 1-3, 5.

1984 *Heptacladus crassispinus* – Lahm, p. 29, pl. 3, fig. 10.

1994 *Heptacladus crassispinus* – Kozur & Mostler, pl. 2, figs 8-9; pl. 3, figs 3, 8.

1996 *Heptacladus crassispinus* – Kozur et al., p. 223, pl. 7, fig. 12.

Description. Spherical coarse latticed cortical shell, 120-155 µm in diameter, with very large pores polygonally framed; 5-6 pores on the shell diameter. Seven very long cylindrical radial spines, 18-26 µm in cross section; maximal preserved length 340 µm. Numerous needle-like by-spines arise from the nodal points; they are up to 60 µm long and may branch distally.

Remarks. All the above-listed descriptions mention the presence of distally branched by-spines arising from the nodes of the cortical shell. Better preserved material shows that branches may connect to each other to form an uncomplete peripheral shell (Dumitrica et al. 1980: 4, pl. 13, fig. 5; Lahm 1984: 30).

Range (as published). Late Anisian to early Ladinian (Kozur et al. 1996). O'Dogherty et al. (2009b; 2010) regard the genus *Heptacladus* as restricted to the middle-late Anisian interval.

Occurrence. Samples Sb, S, M. Common.

Genus *Parentactinosphaera* Kozur & Mostler, 1979

Type species: *Parentactinosphaera oertlii* Kozur & Mostler, 1979

1979 *Parentactinosphaera* Kozur & Mostler, p. 73, type species *Parentactinosphaera oertlii* Kozur & Mostler, 1979, p. 73, pl. 2, fig. 2.

1981 *Weverisphaera* Kozur & Mostler, p. 33, type species *Weverisphaera fassanensis* Kozur & Mostler, 1981, p. 34, pl. 68, fig. 1.

1984 *Livinallongella* Lahm, p. 30, type species *Livinallongella hauseri* Lahm, 1984, p. 30, pl. 3, fig. 11-12.

1984 *Pseudoheptacladus* Lahm, p. 30, type species *Pseudoheptacladus tener* Lahm, 1984, p. 31, pl. 4, fig. 1.

1984 *Komoella* Lahm, p. 32, type species *Komoella symmetrica* Lahm, 1984, p. 32, pl. 4, fig. 5.

Remarks. In O'Dogherty et al. (2009b: 228) the last 4 genera from the list above have been included in the synonymy of *Parentactinosphaera* without any explanation because of the limited printing space. Since one of the co-authors of the present article (P.D.) was also the co-author of the article by O'Dogherty et al. (2009b) we shall try to explain the reason underlying this synonymy.

As the name of the family and of type genus shows, most of the Heptacladidae have 7 spines with a special position on test, a special microsphere originated in a six-rayed bar-centered spicule, and a peculiar mode of growth. All these features of the family have been well illustrated by Dumitrica in De Wever et al. (2001, figs 122-123). In the same publication it was mentioned that the number of spines may vary between four and nine. We must correct here this statement. Spine number can be 4 (in *Stauropylissa* Dumitrica), 6 (in an undescribed lower Ladinian genus), 7 (in *Heptacladus* Dumitrica, Kozur & Mostler and other genera) and 8 (in a special undescribed Pelsonian genus). The assignation to this family of the genus with 9 spines mentioned in De Wever et al. (2001) should be considered erroneous because it is now assigned to a new family (in preparation by Dumitrica & Tekin). Generally, all species with spherical cortical shell and more than 7 spines must not be assigned to the family Heptacladidae since they have another internal structure. In explaining the above synonymy list we have to go back to the holotype of the type species of each genus.

The holotype of the type species of the genus *Parentactinosphaera* (Kozur & Mostler 1979, pl. 2, fig. 2) shows rather clearly 7 spines in the special position of *Heptacladus* and other 7-spined genera, which is: 3 spines in the main plane of bilateral symmetry, of which one is antapical and two apical, and 4 spines crosswisely disposed in a transversal plane. Although the internal structure of this species is unknown, the number of spines and their position prove, almost un-

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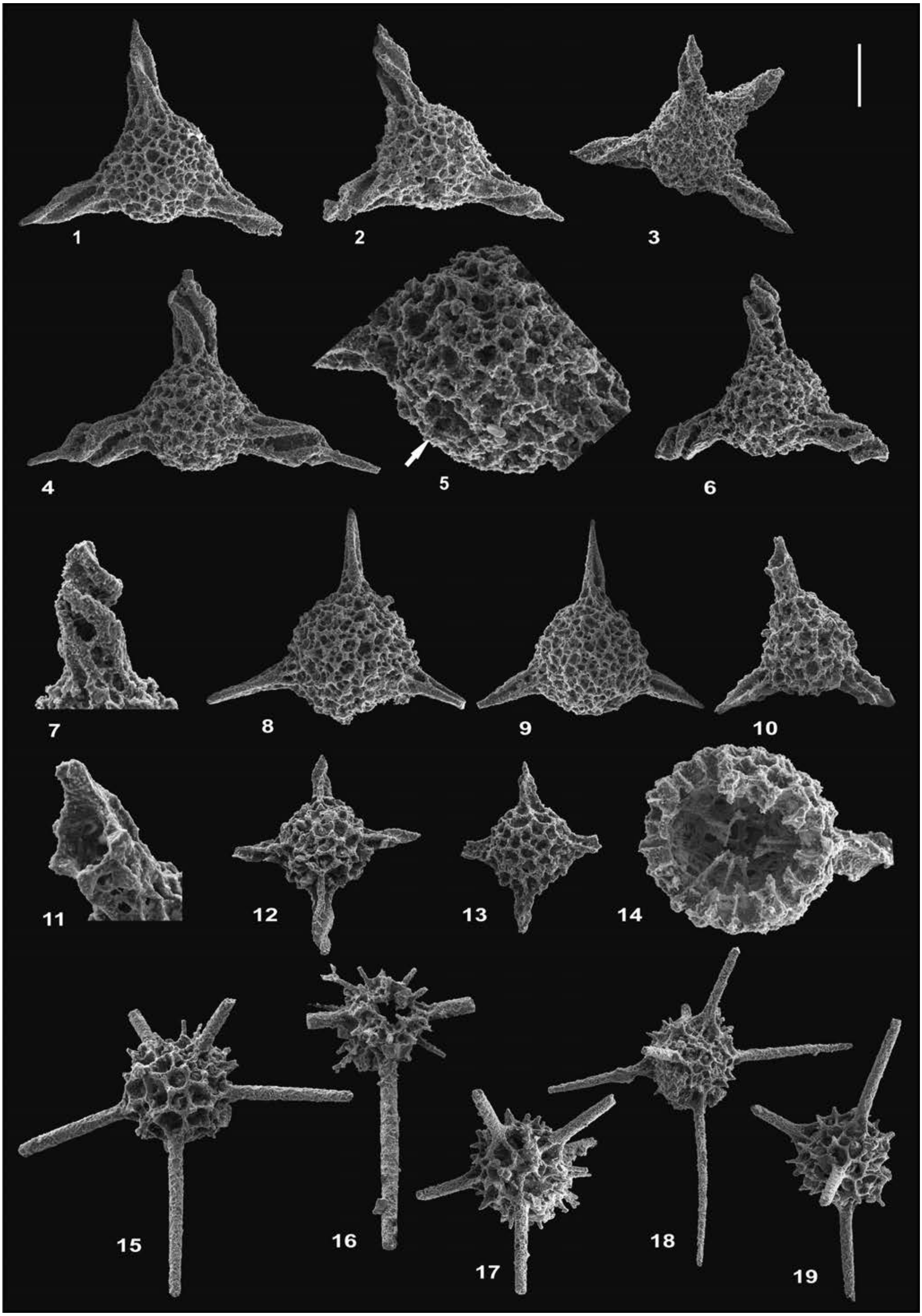
PLATE 3

Scanning electron photomicrographs of radiolarians from the San Giorgio Dolomite (*E. curionii* Ammonoid Zone, early Ladinian). All material is from Val Porina. For each figure, sample/specimen number, catalogue number (for type material) and value of scale bar are indicated.

Figs 1-3	- *Eptingium* sp. cf. *E. ramovsi* Kozur, Krainer & Mostler, 1) Sb/48b, 100 µm, 2) Sb/48c, 100 µm., 3) M/b16a, anomalous specimen with a fourth spine, 100 µm.
Figs 4-7	- *Eptingium danieli* n. sp., 4) MCSN 8354, holotype, total view, 100 µm, 5) MCSN 8354, holotype, detail of the aperture (arrowed), 50 µm, 6) MCSN 8355, paratype, total view, 100 µm, 7) MCSN 8355, paratype, detail of a spine, 50 µm.
Figs 8-9	- *Eptingium neriae* n. sp., 8) MCSN 8353, holotype, 100 µm, 9) MCSN 8358, paratype, 100 µm.
Figs 10-11	- *Pylostephanidium clavator* Dumitrica, 10) Sb/63, total view, 100 µm, 11) Sb/63, detail of the tubopyle, 30 µm.
Figs 12-14	- *Tiborella magnidentata* Dumitrica, Kozur & Mostler, 12) S/43a, 100 µm, 13) S/43c, 100 µm, 14) Sb/22c, broken shell showing a thin lattice closing the pores at the inner side, a radial beam prolonged outside into a spine and some thin rays connecting the (outer) medullary shell (not preserved) to the cortical shell, 50 µm.
Figs 15-19	- *Heptacladus crassispinus* Dumitrica, Kozur & Mostler, 15. S/17, 100 µm, 16) S/38a, 100 µm, 17) S/18, 100 µm, 18) S/38b, 100 µm, 19) S/38c, 100 µm.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doubtedly, the heptacladid status of the holotype of the type species and, implicitly, of the genus. The other species (*Parentactinosphaera*? *longispinosa* Kozur & Mostler, 1979) does not belong to this genus. Also the specimens Kozur & Mostler (1981, p. 17, pl. 2, figs 2, 4, 6; pl. 4, figs 1-2, 7) illustrated under the type species do not belong to it. As Lahm proved (Lahm, 1984, pl. 2, fig. 4), they have a spherical microsphere in the centre and have more external spines that represent external prolongations of the internal radial bars connecting the microsphere with the cortical shell. In the present paper we assign these species to the new Triassic genus *Ticinosphaera* gen. n. In the same paper Kozur & Mostler (1981: 16) erroneously synonymyzed this genus with *Helioentactinia* Nazarov, 1975 (type species *Entactinosphaera polyacantina* Foreman, 1963, from the Upper Devonian). Foreman (1963: 280) remarked that a delicate initial spicule with an indeterminate number of rays could be indistinctly seen, character that cannot be seen in the Triassic specimens Kozur & Mostler illustrated. Moreover, the long time interval between the Upper Devonian and the Middle Triassic prevents from using such an old genus name for the Triassic species. In conclusion, *Parentactinosphaera*, by its type species, is not a *Helioentactinia*. Nor are the other Triassic species Kozur & Mostler (1979, 1981) described under this genus. *Weverisphaera* Kozur & Mostler, 1981, with its 7 spines is clearly a synonym of *Parentactinosphaera*, and the same is *Pseudoheptacladus* Lahm, 1984, that shows very clearly the heptacladid disposition of its 7 spines. *Livinalongella* Lahm, 1984 is also a doubtless heptacladid. It could be retained as a distinct genus of this family only regarding the verticil of 3 spinules as a generic character. *Komoella* Lahm, 1984, although described as having 6 spines, seems to have also 7 spines. The paratype, if it belongs to this species, shows a clear heptacladid internal structure.

Parentactinosphaera eoladinica n. sp.

Pl. 4, fig. 1

Etymology: From the occurrence in the earliest (Greek prefix *eo*-) Ladinian.

Holotype: The specimen MCSN 8359 (sample S), Pl. 4, fig. 1.

Type locality: Val Porina, Monte San Giorgio, Canton Ticino, Southern Switzerland.

Type horizon: Basal section of the San Giorgio Dolomite, lower part of the *E. curionii* Ammonoid Zone (= uppermost part of the *L. multiperforata* Radiolarian Zone), early Ladinian, Middle Triassic.

Description. Cortical shell globular to polyhedral, latticed, with coarse polygonal pores of various size and seven spines arranged according to the seven-spined heptacladid pattern as follows: one antapical and two apical spines in the main plane of symmetry, and four intercalary spines in the transversal plane. Spines very long, incomplete in our material, three-bladed, and gently dextrally twisted.

Measurements. Diameter of the shell = 130 µm, maximum preserved length of the spines = 130 µm, width of the spines = 25 µm (proximally = 55 µm).

Comparisons. Although we ignore the structure of the internal skeleton, the position of the spines on shell prove that the species is a heptacladid and belongs to this genus. The species is easily distinguished from the other species of the genus by its long, gently twisted spines. A species of the same genus with twisted spines is the Middle Triassic species *Hexalonche mesotriassica* Kozur & Mostler (1981, p. 73, pl. 4, figs 4-5) but its spines are much shorter. Although the latter species was considered as having 6 spines and belonging to the Cenozoic genus *Hexalonche*, the position of the 6 visible spines on the holotype suggests the heptacladid pattern of test and the presence of a seventh spine behind the shell.

Range (this study). Lower *E. curionii* Ammonoid Zone, early Ladinian.

Occurrence. Sample S. Very rare.

Family Hindeosphaeridae Kozur & Mostler, 1981

Genus *Pseudostylosphaera* Kozur & Mostler, 1981

Type species: *Pseudostylosphaera gracilis* Kozur & Mostler, 1981

Pseudostylosphaera japonica

(Nakaseko & Nishimura, 1979)

Pl. 4, fig. 2

1979 *Archaeospongoprunum japonicum* Nakaseko & Nishimura, p. 67, pl. 1, figs 2, 4,?9.

1981 *Pseudostylosphaera japonica* – Kozur & Mostler, p. 32.

1989 *Pseudostylosphaera japonica* – Cheng, p. 143, pl. 6, fig. 1; pl. 7, fig. 7.

1991 *Pseudostylosphaera japonica* – Mandl & Ondrejickova, p. 311.

? 1995 *Pseudostylosphaera japonica* – Kellici & De Wever, p. 157, pl. 4, fig. 13.

1996 *Pseudostylosphaera japonica* – Kozur et al., p. 212, pl. 6, fig. 15.

Description. Subspherical double-layered cortical shell with inner layer displaying small pores and outer layer formed by nodes interconnected by narrow bars. Axial shell diameter 130-135 µm. Two opposite three-bladed polar spines more or less equal in length and as long as the main axis of the shell. Width of spines increases distally towards the midlength, where spines are broadest, and then it decreases towards the distal end. Ridges on the spines are rounded and separated by deep furrows.

Remarks. For comparison with *Pseudostylosphaera postjaponica* Kozur & Mostler see under the latter. The morphotype described from the Marmolada massif by Kellici & De Wever (1995) differs from the type material by displaying ridges with median furrows.

Range (as published). Illyrian (Kozur et al. 1996: 212).

Occurrence. Samples Sb, Pm. Rare.

Pseudostylosphaera sp. aff. **P. japonica** (Nakaseko & Nishimura, 1979)

Pl. 4, figs 3-5

aff. 1979 *Archaeospongoprunum japonicum* Nakaseko & Nishimura, p. 67, pl. 1, figs 2, 4, ?9.

1996 *Pseudostylosphaera coccostyla acrior* (Bragin, 1986) – Kozur et al., p. 211, pl. 6, figs 12-14.

Description. Subellipsoidal double-layered cortical shell with inner layer displaying small pores and outer layer formed by nodes interconnected by narrow bars. Axial shell diameter 165-170 µm. Two three-bladed opposite polar spines more or less equal in length and 1.55-1.75 times longer than the axial diameter of the shell. Ridges on the polar spines are broad and rounded. Width of spines gently increases distally towards the midlength, where spines are broadest, and then decreases towards the distal end.

Remarks. This species is very close to *Pseudostylosphaera japonica* from which it differs by having a larger shell with much longer and less dilated polar spines in the middle part. *P. postjaponica* Kozur & Mostler, 1994 and *P. compacta* (Nakaseko & Nishimura, 1979) emend. Kozur, Krainer & Mostler, 1996 both have comparably long spines but the former has spines with sharp blades, whereas the latter has parallel-sided spines.

Range (this study). Lower *E. curionii* Ammonoid Zone, early Ladinian.

Occurrence. Samples Sb, Pm, M. Common.

Pseudostylosphaera helicata (Nakaseko & Nishimura, 1979)

Pl. 4, figs 6-7

1979 *Archaeospongoprunum helicatum* Nakaseko & Nishimura, p. 68, pl. 2, figs 1-2; pl. 12, fig. 3.

1981 *Archaeospongoprunum helicatum* – Kozur & Mostler, p. 31.

1992 *Pseudostylosphaera helicata* – Otsuka et al., pl. 3, fig. 4; pl. 3, fig. 3.

1993 *Pseudostylosphaera helicata* – Sashida et al., p. 90, fig. 7.11.

2010 *Pseudostylosphaera helicata* – Tekin & Sönmez, fig. 7P.

Description. Subspherical cortical shell with fine meshwork, 115-120 µm in axial diameter. Two opposite equal polar spines, loosely twisted and 2.3-3.0 times longer than the axial shell diameter. Spines are three-bladed, with sharp ridges and wide grooves. Needle-like distal ends sometimes occurring.

Remarks. The specimen illustrated by Sashida et al. (1993) differs from our specimen by having a long ellipsoidal shell.

Range (as published). Late Ladinian (Kozur et al. 1996: 213).

Occurrence. Sample Pm. Rare.

Pseudostylosphaera tenuis (Nakaseko & Nishimura, 1979)

Pl. 4, figs 8-15

1979 *Archaeospongoprunum tenue* Nakaseko & Nishimura, p. 68, pl. 1, figs 8, 10.

1981 *Archaeospongoprunum tenue* – Kozur & Mostler, p. 31.

1982 *Archaeospongoprunum tenue* – Mizutani & Koike, pl. 3, fig. 2.

1984 *Pseudostylosphaera tenue* – Lahm, p. 36, pl. 5, figs 5-6.

1990 *Pseudostylosphaera tenuis* – Gorican & Buser, p. 155, pl. 5, fig. 6.

1991 *Pseudostylosphaera tenuis* – Mandl & Ondrejickova, p. 311.

1995 *Pseudostylosphaera tenuis* – Ramovs & Gorican, p. 196.

? 2005 *Pseudostylosphaera tenuis* – Gorican et al., pl.1, fig. 37.

? 2009 *Pseudostylosphaera tenuis* – Feng et al., p. 593, fig. 5.8.

Description. Subspherical to spherical cortical shell 145-165 µm in axial diameter; double-layered wall with small-pored inner layer and outer layer formed by nodes interconnected by narrow bars. Two opposite slender polar spines strongly unequal in length, the shorter being one half, more usually less, the length of the longer one. Spines are three-bladed, with ridges separated by wide grooves.

Remarks. Specimens figured in Gorican et al. (2005) and Feng et al. (2009) show rather stout spines instead of slender ones as in specimens constituting the type material.

Range (as published). Late Anisian? to early Carnian (Lahm 1984).

Occurrence. Samples Sb, Pm, M, VP8. Common.

Pseudostylosphaera longispinosa Kozur & Mostler, 1981

Pl. 4, figs 16-24

1981 *Pseudostylosphaera longispinosa* Kozur & Mostler, p. 32, pl. 1, fig. 6.

1981 *Pseudostylosphaera longobardica* Kozur & Mostler, p. 33, pl. 49, fig. 3.

1984 *Pseudostylosphaera longispinosa* – Lahm, p. 34, pl. 4, figs 11-12.

1990 *Pseudostylosphaera longispinosa* – Gorican & Buser, p.155, pl. 5, figs 3-5.

1990 *Pseudostylosphaera longispinosa* – Kolar-Jurkovsek, pl. 5, figs 6a-6b.

1995 *Pseudostylosphaera longispinosa* – Ramovs & Gorican, p. 196.

1997 *Pseudostylosphaera longispinosa* – Sugyiama, p. 186, fig. 48.16.

1998 *Pseudostylosphaera longispinosa* – Takahashi et al., pl. 1, fig. 4.

1999 *Pseudostylosphaera longispinosa* – Tekin, p. 129, pl. 25, fig. 14.

2001 *Pseudostylosphaera longispinosa* – Feng et al., p. 190, pl. 5, figs 22-24.

2006 *Pseudostylosphaera longispinosa* – Marquez et al., pl. 2, fig. 13.

2007 *Pseudostylosphaera longispinosa* – Tekin & Göncüoglu, pl. 2, fig. 25.

2010 *Pseudostylosphaera longispinosa* – Tekin & Sönmez, fig. 7R.

2011 *Pseudostylosphaera longispinosa* – Thassanapak et al., p. 195, fig. 6T.

2011 *Pseudostylosphaera longispinosa* – Ozsvárt et al., fig. 9.7.

2011 *Pseudostylosphaera longobardica* – Ozsvárt et al., fig. 9.8.

Description. Subspherical to subellipsoidal cortical shell with inner layer displaying small pores and outer layer formed by nodes interconnected by narrow bars. Axial shell diameter 110-170 μm. Two slender three-bladed opposite polar spines more or less equal in length and 1.6-2.8 times longer than the main axis of the shell. Spines are usually untwisted, sometimes only very loosely torsioned.

Remarks. In agreement with Gorican & Buser (1990: 155) and Tekin (1999: 129), *Pseudostylosphaera longobardica* is regarded here as synonym of *P. longispinosa*, most specimens representing transitional morphotypes between the latter (characterized by a spherical shell; Kozur & Mostler: 32) and the former (characterized by an ellipsoidal to subellipsoidal shell; Kozur & Mostler: 33).

Range (as published). Early-late Ladinian (up to the *S. fluegeli* Subzone of the *M. cochleata* Radiolarian Zone) to early Carnian? (Tekin 1999); Anisian to early Ladinian (Thassanapak et al. 2011).

Occurrence. Samples Sb, S, Pm, VP8. Very abundant.

Pseudostylosphaera canaliculata (Bragin, 1986) n. comb.

Pl. 5, fig. 1

1981 *Pseudostylosphaera coccostyla* – Kozur & Mostler, p. 31, pl. 15, fig. 3; pl. 46, fig. 5.

1984 *Pseudostylosphaera coccostyla* – Lahm, p. 33, pl. 4, figs 7-8.

1986 *Archaeospongoprunum*? *canaliculatum* Bragin, p. 69, pl. 2, fig. 6.

1990 *Pseudostylosphaera coccostyla* – Gorican & Buser, p. 153, pl. 5, fig. 1.

1991 "*Stylosphaera*" *canaliculata* – Bragin, p. 2, figs 6-7.

1994 *Pseudostylosphaera coccostyla coccostyla* (Rüst) – Kozur & Mostler, p. 44.

1995 *Pseudostylosphaera coccostyla* – Kellici & De Wever, p. 157, pl. 4, figs 11-12.

1996 *Pseudostylosphaera coccostyla* – Chiari et al., pl. 2, fig. 13.

1999 *Pseudostylosphaera coccostyla coccostyla* – Sashida et al., p. 770, fig. 8.10

1999 *Pseudostylosphaera coccostyla coccostyla* – Tekin, p. 128, pl. 25, fig. 8.

2009 *Pseudostylosphaera coccostyla* – Feng et al., p. 593, figs 5.3-5.4.

Description. Ellipsoidal to subspherical double-layered cortical shell with inner layer displaying small pores and outer layer formed by nodes interconnected by narrow bars. Axial shell diameter 220-230 μm. Two three-bladed opposite polar spines more or less equal in length and somewhat longer than the axial diameter of the shell. Ridges on the polar spines are rounded and subdivided by a secondary furrow.

Remarks. The reintroduction by Kozur & Mostler (1981) of the name *Spongatractus coccostylus* Rüst, 1892 for one species of the genus *Pseudostylosphaera* is quite erroneous. Even if this species was originally described from Felsöörs, Hungary, and in that locality species of this genus occur, the original illustration made from thin sections is so poor that it is virtually impossible to attach its name to a whatever radiolarian species of the genus *Pseudostylosphaera*. The original illustration by Rüst (1892) shows no blades on spines, no superficial structure and inside it shows a spindle-shaped test that has nothing to do with the inner shell of this genus. Kozur & Mostler themselves recognized that the original description and figure are indeterminable. Why then determine a species after that drawing? This species is and must remain a *nomen dubium* as most radiolarian species described by Rüst and other

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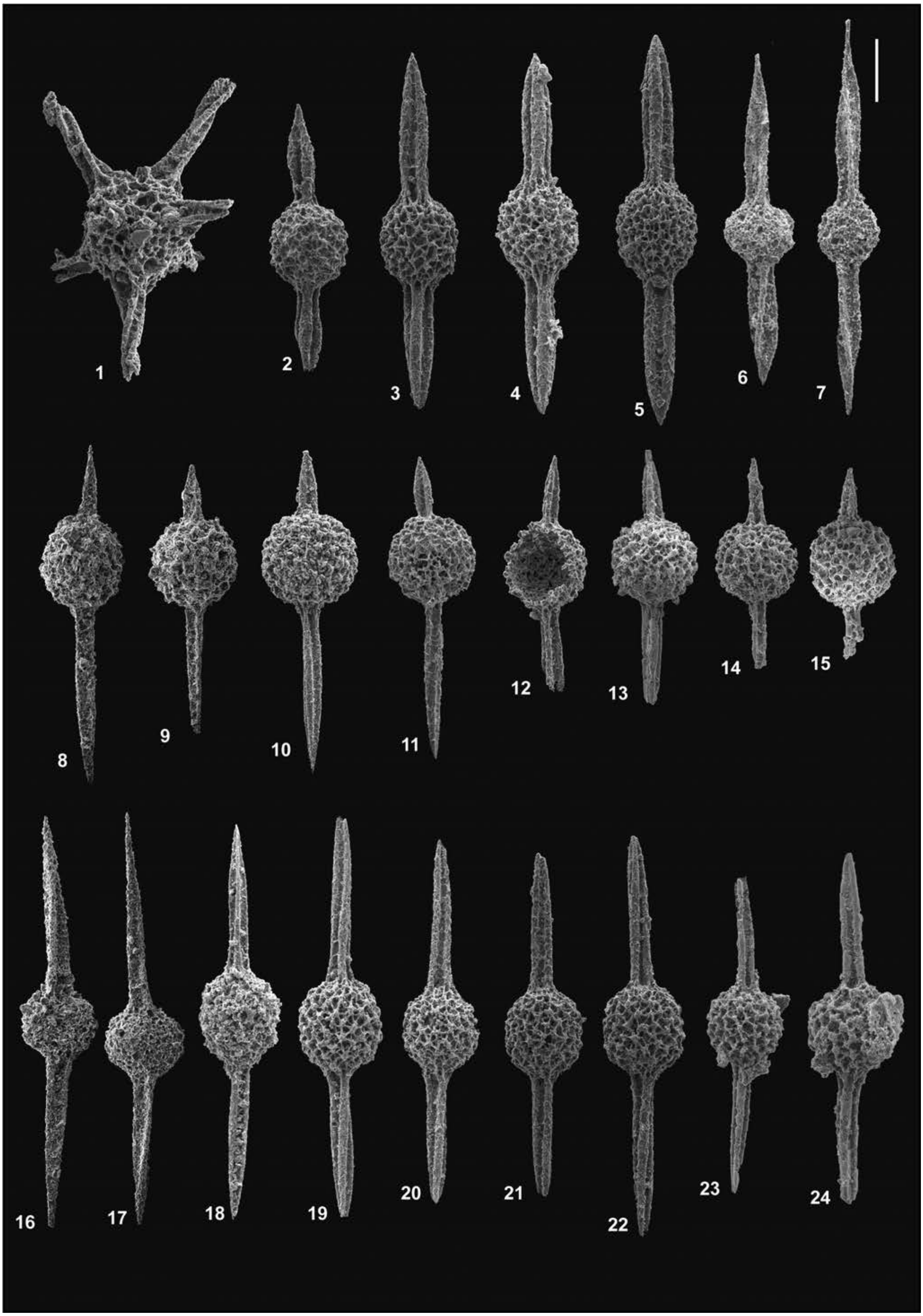
PLATE 4

Scanning electron photomicrographs of radiolarians from the San Giorgio Dolomite (*E. curionii* Ammonoid Zone, early Ladinian). All material is from Val Porina. For each figure, sample/specimen number, catalogue number (for type material) and value of scale bar are indicated.

Fig. 1	- *Parentactinosphaera eoladinica* n. sp., MCSN 8359, holotype, 80 μm.
Fig. 2	- *Pseudostylosphaera japonica* (Nakaseko & Nishimura), Sb/5b, 100 μm.
Figs 3-5	- *Pseudostylosphaera* sp. aff. *P. japonica* (Nakaseko & Nishimura), 3) Sb/5a, 120 μm, 4) Sb/4d, 120 μm, 5) Sb/4c, 120 μm.
Figs 6-7	- *Pseudostylosphaera helicata* (Nakaseko & Nishimura), 6) Pm/6e, 120 μm, 7) Pm/6b, 120 μm.
Figs 8-15	- *Pseudostylosphaera tenuis* (Nakaseko & Nishimura), 8) Pm/5b, 120 μm, 9) Pm/5a, 120 μm, 10) M/16, 120 μm, 11) Sb/41b, 120 μm, 12) Sb/41a, 120 μm, 13) VP8/3, 120 μm, 14) VP8/2, 120 μm, 15) VP8/1, 120 μm.
Figs 16-24	- *Pseudostylosphaera longispinosa* Kozur & Mostler, 16) Pm/7a, 120 μm, 17) Pm/7b, 120 μm, 18) Pm/6f, 120 μm, 19) S/5a, 120 μm, 20) S/5b, 120 μm, 21) Sb/19a, 120 μm, 22) Sb/19b, 120 μm, 23) VP8/4, 120 μm, 24) VP8/6, 120 μm.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pioneers of the radiolarian study who described new species and genera from thin sections. It is a pity but we cannot do otherwise. It is also a pity that all authors who published after the year 1981 took uncritically this determination.

Our specimens differ from the holotype by having less developed secondary furrows indicating probably an initial stage of speciation, that is of appearance of secondary furrows. The spines are also thinner and much more pointed.

Range (as published). Ladinian (Kozur & Mostler 1994: 44); early-late Ladinian (up to the *S. fluegeli* Subzone of the *M. cochleata* Radiolarian Zone) according to Tekin (1999: 128); Anisian to Ladinian according to Sashida et al. (1999: 770).

Occurrence. Sample S. Rare.

Pseudostylosphaera acrior (Bragin, 1986)

Pl. 5, figs 2-5

1979 *Archaeospongoprunum compactum* Nakaseko & Nishimura, p. 68, pl. 1, fig. 3, non 7.

1986 *Archaeospongoprunum*? *acrior* Bragin, p. 69, pl. 2, fig. 5.

1989 *Pseudostylosphaera coccostyla* (Rüst) – Martini et al., pl. 1, fig. 17; pl. 2, figs 11-12, 16; pl. 3, figs 10-11.

1991 *"Stylosphaera" acrior* (Bragin) – Bragin, p. 88, pl. 1, fig. 14, 17; pl. 2, figs 4-5.

1993 *Pseudostylosphaera japonica* (Nakaseko & Nishimura) – Sashida et al., p. 89, figs 7.9, 7.15.

1994 *Pseudostylosphaera coccostyla compacta* (Nakaseko & Nishimura) – Kozur & Mostler, p. 44, pl. 1, fig. 8.

1996 *Pseudostylosphaera coccostyla acrior* (Bragin, 1986) – Kozur et al., p. 211, pl. 6, figs 12-14.

2011 *Pseudostylosphaera coccostyla acrior* – Ozsvárt et al., fig. 9.6.

Description. Subspherical to ellipsoidal double-layered cortical shell with inner layer displaying small pores and outer layer formed by nodes interconnected by narrow bars. Axial shell diameter 145-165 µm. Two three-bladed opposite polar spines more or less equal in length and 1.05-1.40 (1.50) times longer than the axial diameter of the shell. Ridges on the polar spines are broad, rounded and never subdivided by a central furrow.

Remarks. In agreement with Kozur et al. (1996: 211), Nakaseko & Nishimura (1979) figured under *Archaeospongoprunum compactum* two specimens belonging to two different species. The paratype (Nakaseko & Nishimura 1979, fig. 3) shows shorter spines, which gently taper distalwards; the morphotypes with such a type of spines are herein assigned to *P. acrior* (Bragin, 1986).

Range (as published). Illyrian (common) to Fassanian (rare) (Kozur et al. 1996: 211).

Occurrence. Samples Sb, S, M. Very abundant.

Pseudostylosphaera postjaponica
Kozur & Mostler, 1994

Pl. 5, fig. 6

1984 *Pseudostylosphaera japonica* (Nakaseko & Nishimura) – Lahm, p. 34, pl. 4, figs 9-10.

1994 *Pseudostylosphaera postjaponica* Kozur & Mostler, p. 44, pl. 1, figs 9-10.

? 1999 *Pseudostylosphaera postjaponica* – Sashida et al., p. 770, fig. 8.11.

Description. Subellipsoidal cortical shell with outer framework formed by nodes interconnected by narrow bars. Axial shell diameter 135-140 µm. Two opposite three-bladed polar spines more or less equal in length and 1.4 times longer than the main axis of the shell. Width of spines increases distally towards the midlength, where spines are broadest, and then decreases towards the distal end. Ridges on the spines are sharp and separated by deep and wide furrows.

Remarks. *Pseudostylosphaera japonica* (Nakaseko & Nishimura, 1979) bears spines as long as, or shorter than, the main axis of the shell (Kozur & Mostler 1994: 45). In addition, ridges on the spines are broader and rounded (Nakaseko & Nishimura 1979, pl. 2, fig. 4).

Range (as published). *O. primitivus* Radiolarian Subzone to *L. annuloperforata* Radiolarian Subzone (Kozur & Mostler 1994: 45).

Occurrence. Sample Pm. Rare.

Genus *Parasepsagon* Dumitrica, Kozur & Mostler, 1980

Type species: *Parasepsagon tetracanthus* Dumitrica,
Kozur & Mostler, 1980

Remarks. *Parasepsagon* is very close to *Pseudostylosphaera* from which it differs in having two opposite internal basal rays extended outside into spines that are shorter than the main polar spines of the latter genus. In *Pseudostylosphaera* only two basal bars of the initial spicule are extended outside into spines.

Parasepsagon tetracanthus Dumitrica,
Kozur & Mostler, 1980

Pl. 5, figs 7-14

1980 *Parasepsagon tetracanthus* Dumitrica, Kozur & Mostler, p. 13, pl. 1, fig. 8; pl. 2, fig. 7.

1981 *Parasepsagon tetracanthus* – Kozur & Mostler, p. 36, pl. 36, fig. 2; pl. 51, fig. 3.

1984 *Parasepsagon tetracanthus* – Lahm, p. 41, pl. 6, fig. 11.

1990 *Parasepsagon tetracanthus* – Gorican & Buser, p. 149, pl. 6, fig. 1.

? 1990 *Parasepsagon tetracanthus* – Kolar-Jurkovsek, pl. 6, figs 5-6.

1994 *Parasepsagon tetracanthus* – Kozur & Mostler, p. 50, pl. 5, figs 4-5.

1995 *Parasepsagon tetracanthus* – Kellici & De Wever p. 152, pl. 3, fig. 18.

Description. Spherical to ellipsoidal double-layered cortical shell, 135-200 µm in diameter, with inner layer displaying small pores and outer layer formed by nodes interconnected by bars. Four coplanar three-bladed unequal spines are nearly crosswisely arranged. Two long sturdy opposite spines along the main axis are sometimes slightly twisted, as shown in the type material. The two shorter spines perpendicular to the main axis are straight and as long as the shell diameter.

Range (as published). Early Ladinian (Kozur & Mostler 1994). O'Dogherty et al. (2009b; 2010) regard the genus *Parasepsagon* as restricted to the middle-late Anisian interval.

Occurrence. Samples Sb, Pm, M. Common.

Parasepsagon longidentatum
(Kozur & Mostler, 1981) n. comb.

Pl. 5, fig. 15

1981 *Plafkerium? longidentatum* Kozur & Mostler, p. 71, pl. 51, fig. 1.

1984 *Plafkerium longidentatum* – Lahm, p. 87, pl. 15, fig. 12.

1995 *Plafkerium? longidentatum* – Kellici & De Wever, p. 156, pl. 4, fig. 9.

? 1999 *Plafkerium longidentatum* – Tekin, p. 27.

Description. Spherical cortical shell, around 120 µm in diameter, with coarse irregular framework formed by nodes interconnected by strong and narrow bars with tubercles on the vertices. Four strong main spines, coplanar and crosswisely arranged. A spine is longer than the other three. Spines are three-bladed with broad rounded ridges and wide grooves. Their distal parts are pointed and sometimes they bear a very short needle-like termination. Blades of adjacent spines join to each other to form an equatorial girdle.

Remarks. The assignations to this species suffer from the poor description and illustration of the holotype. Anyway, the slight inequality of the spines and especially the ornamentation of the surface of cortical shell consisting of nodes interconnected by bars is typical to the Hindeosphaeridae of which *Parasepsagon* is a member.

Range (as published). Late Anisian? to early Ladinian (Lahm 1984). Up to the *M. firma* Radiolarian Zone according to Tekin (1999: 27). See also under *P. tetracanthus*.

Occurrence. Samples Sb, S. Rare.

Parasepsagon sp. cf. **P.? antiquum** (Sugiyama, 1992) n. comb.

Pl. 5, figs 16-17

cf. 1992 *Plafkerium (?) antiquum* Sugiyama, p. 1218, figs 18.6, non 18.4-18.5.

Description. Large subspheroidal shell with coarse pore frames and four coplanar strong, three-bladed spines with broad ridges. Blades branch at the most proximal portion of the spines. Spines are comparable in length, their axes sometimes deviate from a strictly orthogonal arrangement.

Remarks. This morphotype differs from *Plafkerium? longidentatum* Kozur & Mostler, 1981 in having a test much larger (shell diameter 140 to 200 µm instead of 100-110 µm) and all the four spines similar in length. Sugiyama (1992) described morphotypes similar to our specimens from Spathian-Anisian deposits of Japan under *Plafkerium? antiquum* n. sp. which, however, includes two different morphotypes. The one with nearly complete bladed spines, i.e. the holotype (Sugiyama 1992, fig. 18.6) compares to the morphotype described here.

Range (as published). Spathian to Anisian (Sugiyama 1992). See also under *P. tetracanthus*.

Occurrence. Sample Pm. Rare.

Parasepsagon praetetracanthus Kozur & Mostler, 1994

Pl. 5, figs 18, ?19-20

1984 *Staurosphaera? fluegeli* Kozur & Mostler – Lahm, p. 75, pl. 13, fig. 7.

1990 *Plafkerium?* cf. *longidentatum* Kozur & Mostler – Gorican & Buser, p. 153. pl. 6, fig. 2.

1994 *Parasepsagon asymmetricus praetetracanthus* Kozur & Mostler, p. 49, pl. 5, fig. 3.

1995 *Parasepsagon asymmetricus praetetracanthus* – Ramovs & Gorican, p. 187, pl. 3, figs 1-2.

non 2001 *Parasepsagon asymmetricus praetetracanthus* – Feng et al., p. 198, pl. 8, figs 4-5.

2011 *Parasepsagon asymmetricus* – Ozsvárt et al., fig. 9.15.

Description. Latticed spherical cortical shell 130-190 µm in diameter, outer layer with coarse pore frames displaying rounded tubercles on the nodal points. Four three-bladed main spines, lying on the same plane. Their axes slightly deviate from a mutual orthogonal arrangement. Spines usually untwisted, sometimes with only loose torsion.

Remarks. The morphotype figured in Lahm (1984) does not belong to *Staurosphaera? fluegeli* Kozur & Mostler which is diagnosed as having a cortical shell with fine pores (or spongy; Kozur & Mostler 1979: 58).

Range (as published). Illyrian (Kozur & Mostler 1994). See also under *P. tetracanthus*.

Occurrence. Samples Sb, Pm, M. Rare.

Parasepsagon sp. ind.

Pl. 5, fig. 21

Description. Small globular latticed shell with coarse pore frames and four long, slender three-bladed spines with sharp ridges and wide and deep grooves. Spines are coplanar and equal in length, their axes slightly deviate from perpendicular. Shell diameter 120 μm, spine length 280-310 μm.

Remarks. *Plafkerium? longidentatum* Kozur & Mostler, 1981 has a subspheroidal shell of nearly comparable diameter (100-110 μm; Kozur & Mostler 1981: 71), but only the longest spine reaches a comparable length (265 μm), the other three being much shorter (120-140 μm).

Staurosphaera? fluegeli in Lahm (1984, pl. 13, fig. 7) from ?late Anisian-early Carnian sediments has similar shell dimensions but a shell distinctly spherical and spines which are narrower and shorter. Incidentally, the latter morphotype does not belong to *Staurosphaera? fluegeli* Kozur & Mostler 1979 which is diagnosed as having a cortical shell with fine pores (or spongy; Kozur & Mostler 1979: 58) contrary to the specimen figured in Lahm (1984).

Range (this study). Lower *E. curionii* Ammonoid Zone, early Ladinian.

Occurrence. Sample Pm. Rare.

Genus *Sepsagon* Dumitrica, Kozur & Mostler, 1980

Type species: *Triactoma longispinosum* Kozur & Mostler, 1979

Sepsagon recoarensis Lahm, 1984

Fig. 9; Pl. 6, figs 1-4

1984 *Sepsagon longispinosus recoarensis* Lahm, p. 40, pl. 6, fig. 8.

1984 *Sepsagon* cf. *longispinosus recoarensis* Lahm, p. 40, pl. 6, fig. 9.

1995 *Sepsagon longispinosus recoarensis* – Kellici & De Wever, p. 158, pl. 5, fig. 8.

2001 *Sepsagon longispinosus* (Kozur & Mostler) – De Wever et al., fig. 120.4.

Description. Double-layered spherical cortical shell, 170-200 μm in diameter. Inner layer with small pores, outer layer with large irregular pore frames displaying rounded tubercles on the nodal points. The three three-bladed slender main spines are of different length, one of them being sligthly longer (up to 320 μm) than the other two. All spines display rounded ridges with deep grooves. A fourth additional spine is situated in the plane of the three main spines; it is three-bladed, usually smaller than the main spines and represents the external prolongation of one apical spine of the spicule (see Fig. 9).

Remarks. Despite its similarity to *Parasepsagon* (having 4 unequal spines), *Sepsagon recoarensis* does not represent a transitional morphotype to the genus *Parasepsagon* because its spines correspond to 2 basal spines of the initial spicule, one apical spine, and one antapical spine arising from the antapical end of the first shell and not from the spicule. In *Parasepsagon* all spines are external prolongation of the basal spines of the initial spicule.

Range (as published). Late Anisian to early Ladinian (Lahm 1984; Kellici & De Wever 1995).

Occurrence. Sample Sb. Rare.

Sepsagon ladinicus Kozur & Mostler, 1994

Pl. 6, figs 5-7

1980 *Sepsagon longispinosus* (Kozur & Mostler) – Dumitrica et al., p. 15, pl. 5, figs 1-2, 5-6; pl. 15, fig. 1.

1984 *Sepsagon longispinosus longispinosus* (Kozur & Mostler) – Lahm, p. 39, pl. 6, fig. 5, non 3-4.

1984 *Sepsagon* cf. *longispinosus longispinosus* – Lahm, p. 39, pl. 6, figs 6-7.

? 1990 *Sepsagon longispinosus* – Gorican & Buser, p. 156, pl. 5, fig. 9.

1994 *Sepsagon ladinicus* Kozur & Mostler, p. 48, pl. 4, figs 5-9.

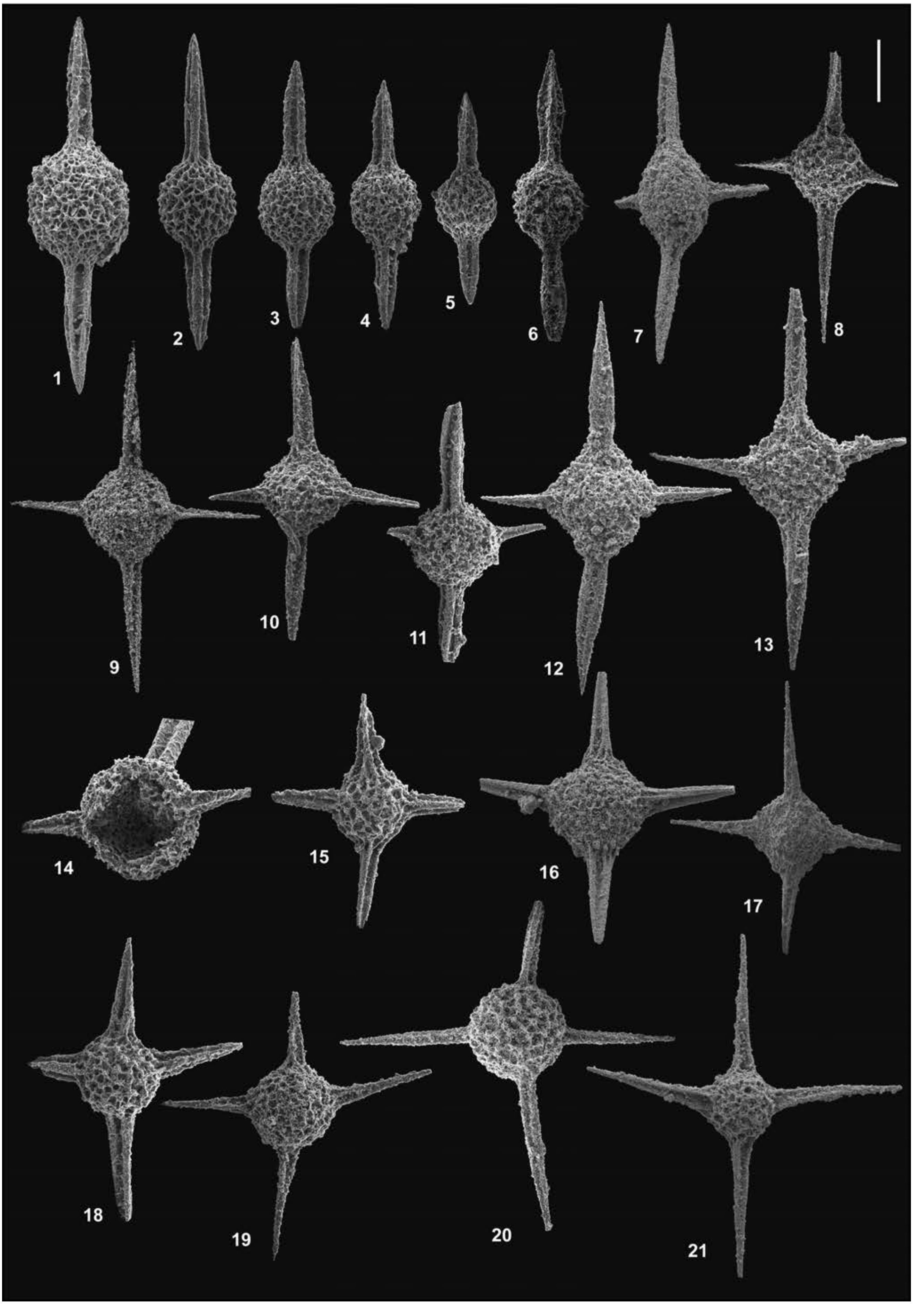
Description. Double-layered spherical cortical shell, 170-250 μm in diameter. Inner layer with small pores, outer layer with large irregular pore frames displaying rounded tubercles on the nodal points. The three-bladed slender spines are of different length; two of them are shorter, about as long as the shell diameter, the third spine is longer (up to 250 μm). The angle separating the two shorter spines is distinctly narrower than that between these and the longest spine.

Remarks. Lahm (1984: 39) stressed that, among the material he studied and referred to *Sepsagon longi-*

PLATE 5

Scanning electron photomicrographs of radiolarians from the San Giorgio Dolomite (*E. curionii* Ammonoid Zone, early Ladinian). All material is from Val Porina. For each figure, sample/specimen number and value of scale bar are indicated.

Fig. 1 - *Pseudostylosphaera caniculata* (Bragin), S/7, 120 μm.
Figs 2-5 - *Pseudostylosphaera acrior* (Bragin), 2) Sb/4b, 120 μm, 3) Sb/3a, 120 μm, 4) Sb/4a, 120 μm, 5) Sb/3a, 120 μm.
Fig. 6 - *Pseudostylosphaera postjaponica* Kozur & Mostler, Pm/6c, 100 μm.
Figs 7-14 - *Parasepsagon tetracanthus* Dumitrica, Kozur & Mostler, 7) Pm/10, 120 μm, 8) M/2c, 120 μm, 9) M/2a, 120 μm, 10) M/2d, 120 μm, 11) Sb/34a, 120 μm, 12) Pm/10a, 120 μm, 13) Pm/10b, 120 μm, 14) Sb/34b, 100 μm.
Fig. 15 - *Parasepsagon longidentatum* Kozur & Mostler, Sb/42c, 100 μm.
Figs 16-17 - *Parasepsagon* sp. cf. *P.? antiquum* Sugiyama, 16) Pm/12a, 120 μm, 17) Pm/12b, 120 μm.
Fig. 18 - *Parasepsagon pratetracanthus* Kozur & Mostler, Sb/34d, 120 μm.
Figs 19-20 - ? *Parasepsagon pratetracanthus* Kozur & Mostler, 19) M/b34, 120 μm, 20) Pm/13b, 120 μm.
Fig. 21 - *Parasepsagon* sp. ind., Pm/13a, 120 μm.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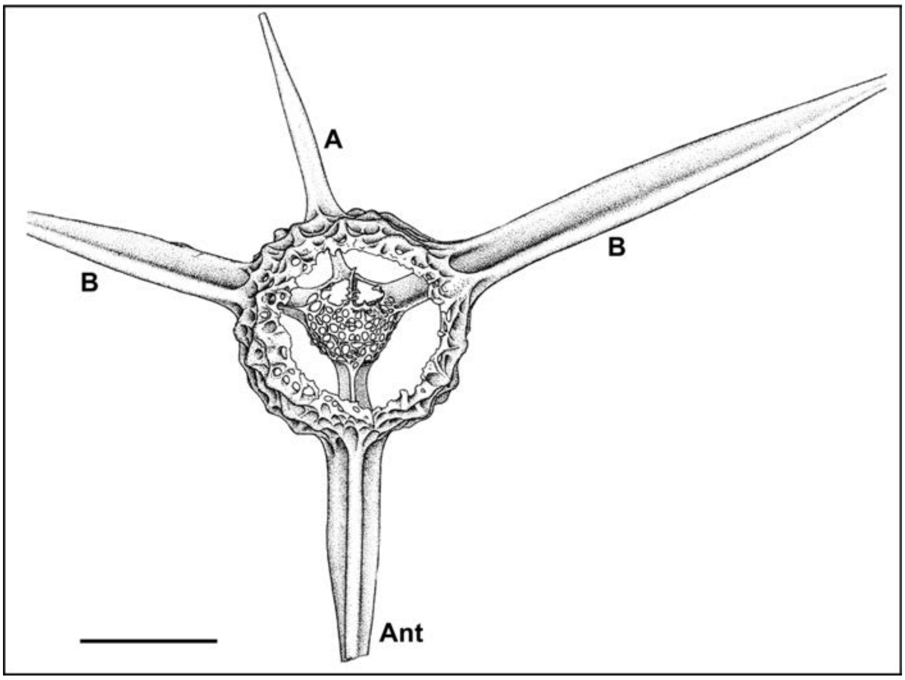


Fig. 9 - *Sepsagon recoarensis* Lahm, specimen sectioned to the medullary shell with an apical spine prolonged outside. A apical spine, B basal spines, Ant antapical spine. Scale bar = 100 µm. Middle Triassic of Recoaro, Vicentinian Alps. Drawing by P. Dumitrica (from De Wever et al. 2001).

spinosus longispinosus, spines of Carnian specimens were more slender and more similar in length to each other than those of the late Anisian?-early Ladinian specimens from Recoaro area. In addition, differences in the angle separating the spines were less evident in the Carnian specimens than in the older ones. Ten years later, Kozur & Mostler (1994: 48) used the same characters by distinguishing the two species *Sepsagon ladinicus* (type species *Sepsagon longispinosus* (Kozur & Mostler, 1980)) and *Sepsagon longispinosus* (type species *Triactoma longispinosum* Kozur & Mostler, 1979) which, in turn, were put into synonymy by Gorican & Buser (1990: 156). We follow here the revision by Kozur & Mostler (1994), which appears justified also from a stratigraphic point of view.

Range (as published). From the *O. inaequispinosus* Radiolarian Subzone throughout the Fassanian (Kozur & Mostler 1994).

Occurrence. Samples S, Pm, M, VP8. Common.

Sepsagon ticinensis n. sp.

Pl. 6, figs 8-13

Etymology: From the Canton Ticino, the region to which the Monte San Giorgio belongs.

Holotype: The specimen MCSN 8373 (sample Sb), Pl. 6, figs 8-9.

Paratype: The specimen MCSN 8374 (sample Sb), Pl. 6, figs 10-11.

Type locality: Val Porina, Monte San Giorgio, Canton Ticino, Southern Switzerland.

Type horizon: Basal section of the San Giorgio Dolomite, lower part of the *E. curionii* Ammonoid Zone (= uppermost part of the *L. multiperforata* Radiolarian Zone), early Ladinian, Middle Triassic.

Description. Coarse, rough subglobular cortical shell, made up of an inner layer with small equal polygonal to circular pores intimately connected with an outer layer showing node and tubercles irregularly interjoined by bars (Pl. 6, fig. 9). Three coplanar main spines. Angles between two of them are equal and wider than the third one (Y-arrangement). Spines three-bladed, sinistrally twisted and pointed; their ridges are sharp and separated by wide and deep grooves. Spines can show a rod-like to needle-like distal end, circular in cross section; this is particularly developed in the spine opposite to the smaller angle. Inner structure not observed.

Measurements. Diameter of the shell = 140-160 µm, length of the spines (without needle-like distal ends) = 110 µm, maximal preserved length of the spines (including needle-like distal ends) = 190 µm, width of the spines (proximally) = 50-54 µm.

Comparisons. Although the internal structure is unknown, the two-layered structure of the cortical shell with external tubercles interconnected by bars suggests a hindeosphaerid nature and a close relationship with the type species of the genus *Sepsagon*. By having twisted spines and tuberculate surface this new species seems to be closely related to *Pseudosepsagon illyricus* Kozur & Mostler, 1994 and *Pseudosepsagon*? *emonaensis* Ramovs & Gorican, 1995. From the former it differs in the sense of twisting of the spines, which is dextral in

Kozur & Mostler's species. Moreover, *P. illyricus* seems to be an anomaly of a three-spined species, having one spine smaller, pyramidate and not twisted, and a similar fourth spine obliquely placed between the two twisted primary spines. The superficial structure of this species proves that it is not congenerical with the type species of the genus *Pseudosepsagon*, that is not a hindeosphaerid but a heptacladid, its two obliquely upward directed spines undoubtedly attesting to the presence of other two symmetrically disposed spines on the other side of the cortical shell. The heptacladid nature of this species (see also O'Dogherty et al. 2009b, p. 228) and of the genus, respectively, is proved also by the internal structure, which is rather easily visible in the two magnified photos of the holotype. This genus is, in fact, very badly described as having two-layered cortical shell whereas the holotype of the type species shows clearly a single layer with wide pores. Its internal structure is also erroneously described and seemingly not understood by the authors. On the other hand, *Pseudosepsagon? emonaensis* differs from our species in having a smaller shell, and longer and dextrally twisted spines. Finally, representatives of the genus *Tritortis* Kozur, 1988 show an untwisted main spine.

Anomalies. A specimen (Pl. 6, figs 12-13) shows a furcate spine.

Range (this study). Lower *E. curionii* Ammonoid Zone, early Ladinian.

Occurrence. Sample Sb. Rare.

Sepsagon? valporinae n. sp.

Pl. 6, figs 14-16

Etymology: From the type locality Val Porina (Porina valley).

Holotype: The specimen MCSN 8360 (sample Sb), Pl. 6, figs 14-15.

Paratype:The specimen MCSN 8361 (sample Sb), Pl. 6, fig. 16.

Type locality: Val Porina, Monte San Giorgio, Canton Ticino, Southern Switzerland.

Type horizon: Basal section of the San Giorgio Dolomite, lower part of the *E. curionii* Ammonoid Zone (= uppermost part of the *L. multiperforata* Radiolarian Zone), early Ladinian, Middle Triassic.

Description. Test latticed, globular, slightly flat, bearing three coplanar spines at slightly unequal angles. Cortical shell seemingly double layered, external layer with polygonally framed rounded pores and small tubercles at vertices. Spines three-bladed and slightly sinistrally twisted proximally, and needle-shaped distally. Internal structure unknown.

At least in the holotype two additional broken-off spines are visible on the cortical shell outside the plane of the main spines and opposite to each other; they are round in cross section.

Measurements. Diameter of the shell = 132-140 μm, maximal length of the spines (including the needle-like distal ends) = 145 μm, width of the spines (proximally) = 32-45 μm, maximal preserved length of the additional spines = 22 μm, width of the additional spines = 4 μm.

Comparisons. Externally, this new species shares characters partly with the type species (*Triactoma longispinosum* Kozur & Mostler, 1979) of the genus *Sepsagon* (a hindeosphaerid genus), partly with the type species (*Pseudosepsagon pentaspinosus* Kozur & Mostler, 1994) of the genus *Pseudosepsagon* (a heptacladid genus). With *S. longispinosus* it has in common the morphology of the cortical test, the number of spines and the unequality of the angles between them, but differs from it in having shorter and twisted spines. From the species *Sepsagon? robustus* Lahm, a species that does not seem to belong to the genus *Sepsagon*, it differs in having twisted spines and in lacking a spine much longer than the other two. With the species *Pseudosepsagon pentaspinosus* Kozur & Mostler, 1994, a heptacladid species with 7 spines of which the four spines lying in the transversal plane are much shorter, *Sepsagon? ticinensis* n. sp. shares rather similar spines and sinistral twisting, but differs in having smaller cortical pores and probably double layered cortical shell. From *Pseudosepsagon illyricus* Kozur & Mostler, 1994, a species that does not belong to the genus under which it was described because of the double-layered cortical shell (see remarks under *Sepsagon ticinensis*), our new species differs in having sinistrally twisted spines. Another species with which our new species can be compared is *Sarla? anisica* Kozur & Mostler, 1994, later renamed *Pseudosepsagon? anisicus* (Kozur et al. 1996). This species has, however, much more twisted spines and a single-layered cortical shell.

Range (this study). Lower *E. curionii* Ammonoid Zone, early Ladinian.

Occurrence. Sample Sb. Rare.

Genus *Bernoulliella* gen. n.

Type species: *"Hexalonche" simplex* Lahm, 1984

Etymology: The genus is named for Prof. Daniel Bernoulli (Basel), to honour his contribution to the understanding of the geological evolution of the western Southern Alps.

Diagnosis: Test large, spherical with 6 three-bladed spines representing external extension of one apical ray, the four basal rays of the initial spicule and one ray arising from the antapical part of the first shell (Figs 10-11). First shell latticed and sack-like with the initial spicule at one end. Cortical shell double-layered, spherical in shape.

Remarks. This new genus differs from the other genera of the family Hindeosphaeridae in having 6 spines arranged approximately in three isometric axes. The cortical test with its double-layered wall is characteristic of the family. The use of the genus *Hexalonche* Haeckel for Mesozoic six-spined spherical radiolarians

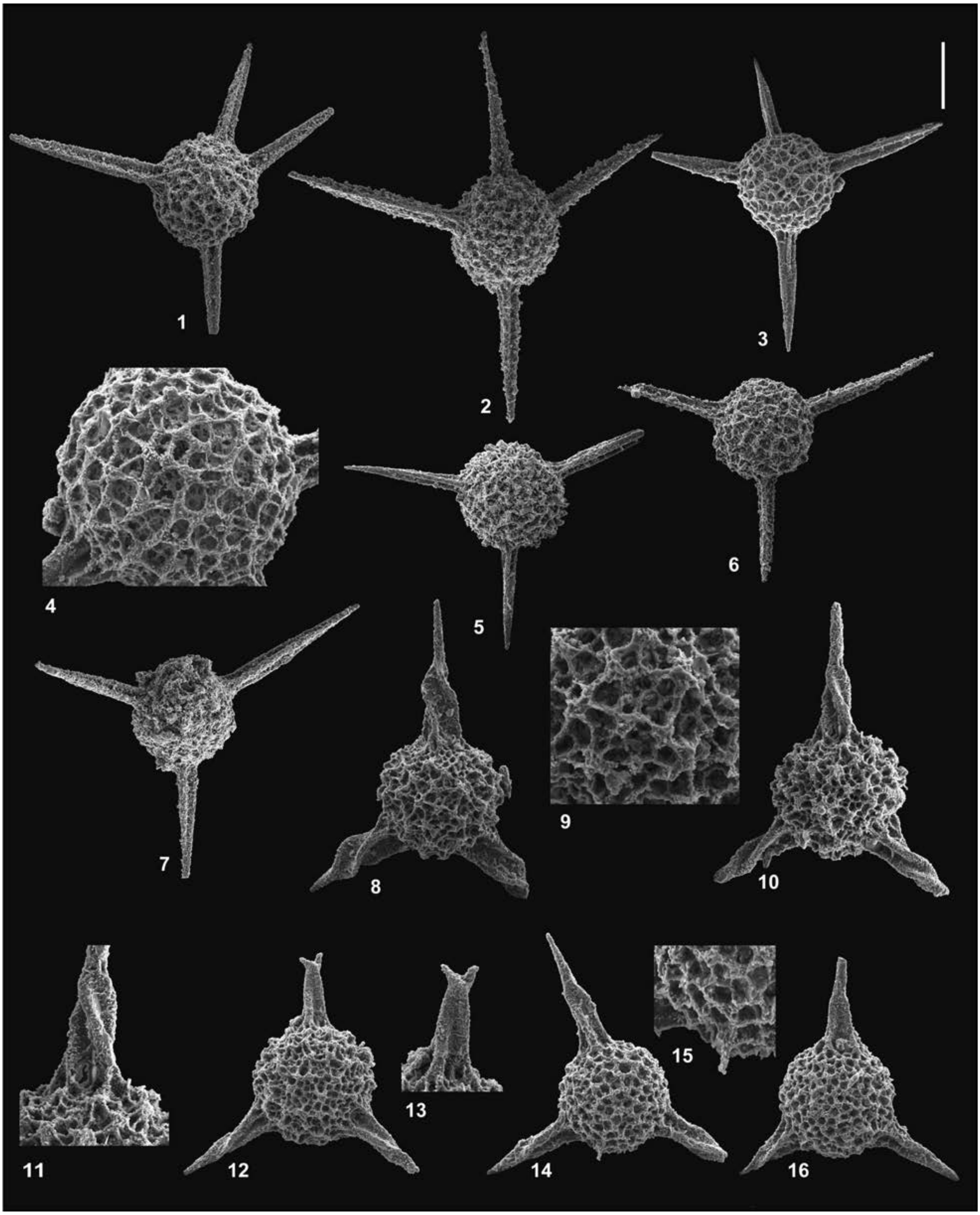


PLATE 6

Scanning electron photomicrographs of radiolarians from the San Giorgio Dolomite (*E. curionii* Ammonoid Zone, early Ladinian). All material is from Val Porina. For each figure, sample/specimen number, catalogue number (for type material) and value of scale bar are indicated.

Figs 1-4 - *Sepsagon recoarensis* Lahm, 1) M/10, 120 µm, 2) M/b34, 120 µm, 3) Sb/39, 120 µm, 4) Sb/39, detail of the double-layered shell, 50 µm.

Figs 5-7 - *Sepsagon ladinicus* Kozur & Mostler, 5) Pm/19, 120 µm, 6) M/b22b, 120 µm, 7) S/1c, 120 µm.

Figs 8-13 - *Sepsagon ticinensis* n. sp., 8) MCSN 8373, holotype, 80 µm, 9) MCSN 8373, holotype, detail of cortical shell, 30 µm, 10) MCSN 8374, paratype, 80 µm, 11) MCSN 8374, paratype, detail of cortical shell and base of a spine, 50 µm, 12) Sb/62, anomalous specimen with a forcate spine, 80 µm, 13) Sb/62, detail of the forcate spine, 50 µm.

Figs 14-16 - *Sepsagon? valporinae* n. sp., 14) MCSN 8360, holotype, 80 µm, 15) MCSN 8360, holotype, detail of the additional spine, 30 µm, 16) MCSN 8361, paratype, 80 µm.

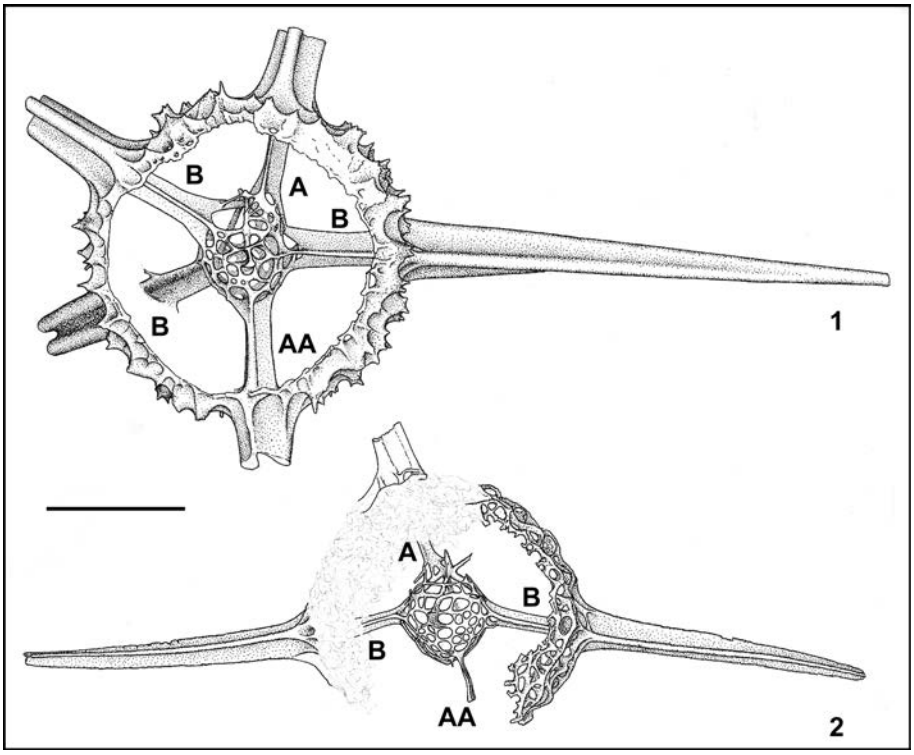


Fig. 10 - Internal structure of *Bernoulliella* gen. n. 1) Specimen from the *S. italicus* Radiolarian Zone (late Anisian); sample Rc4, Recoaro, Vicentinian Alps, N Italy, 2) Specimen from the Pelsonian (middle Anisian) of Cristian, Eastern Carpathians, Romania. Cortical shell only partly illustrated. A apical bar, AA antapical bar, B basal bar. Scale bar = 100 μm. Drawing by P. Dumitrica.

is erroneous (O'Dogherty et al. 2009a). With the latter genus, representing a Cenozoic and especially a late Cenozoic taxon, *Bernoulliella* gen. n. shares only the presence of the six radial spines in isometric position and the occurrence of two concentric shells, but essentially differs from it in having a seven- or eight-rayed initial spicule at one end of the first shell and a double-layered cortical shell. In the present state of knowledge the genus is monospecific. Indeed, no relevant morphologic differences seemingly occur between the middle Anisian, early Ladinian and middle Carnian specimens.

Range. Pelsonian (Middle Anisian) or older to Carnian.

Bernoulliella simplex (Lahm, 1984) n. comb.

Fig. 11; Pl. 7, figs 1-5

1984 *Hexalonche simplex* Lahm, p. 79, pl. 14, figs 2-3.
1996 *Hexalonche simplex* – Kozur et al., p. 222, pl. 8, figs 1, 4.

Description. Very large double-layered spherical cortical shell, 270-360 μm in diameter. Inner layer displaying small pores, outer layer formed by an irregular network of tridimensionally interlaced long and short bars. Six slender three-bladed main spines along three mutually orthogonal axes, around 1.5 times as long as the shell diameter and gently tapering distalwards. Ridges on the spines are rounded and separated by deep grooves. Main spines extend inside the cortical shell into six thick radial beams connecting the cortical shell to a spheroidal medullary shell 70-80 μm in diameter.

Remarks. The specimen figured under *Hexalonche* aff. *simplex* in Kellici & De Wever (1995, pl. 2, fig. 12) has very different dimensions and shape, single-layered latticed shell and different spine shape; accordingly, it doubtlessly belongs to another genus and family.

Range (as published). Late Anisian to early Ladinian (Kozur et al. 1996). The range possibly extends into the middle Anisian (Pelsonian) and the middle Carnian.

Occurrence. Samples Sb, S, M. Abundant.

Entactinaria incertae sedis

Genus *Hexatortilisphaera* Kozur, Krainer & Mostler, 1996

Type species: *Hexatortilisphaera aequispinosa* Kozur, Krainer & Mostler, 1996

Hexatortilisphaera aequispinosa Kozur, Krainer & Mostler, 1996

Pl. 7, fig. 6

1996 *Hexatortilisphaera aequispinosa* Kozur, Krainer & Mostler, p. 214, pl. 8, fig. 7.

Description. Subspherical cortical shell around 130-140 μm in diameter bearing six equal main spines; they lie along three axes arranged perpendicularly to each other. Spines are three-bladed and twisted, with high ridges separated by wide and deep grooves. A needle-like prolongation is always present.

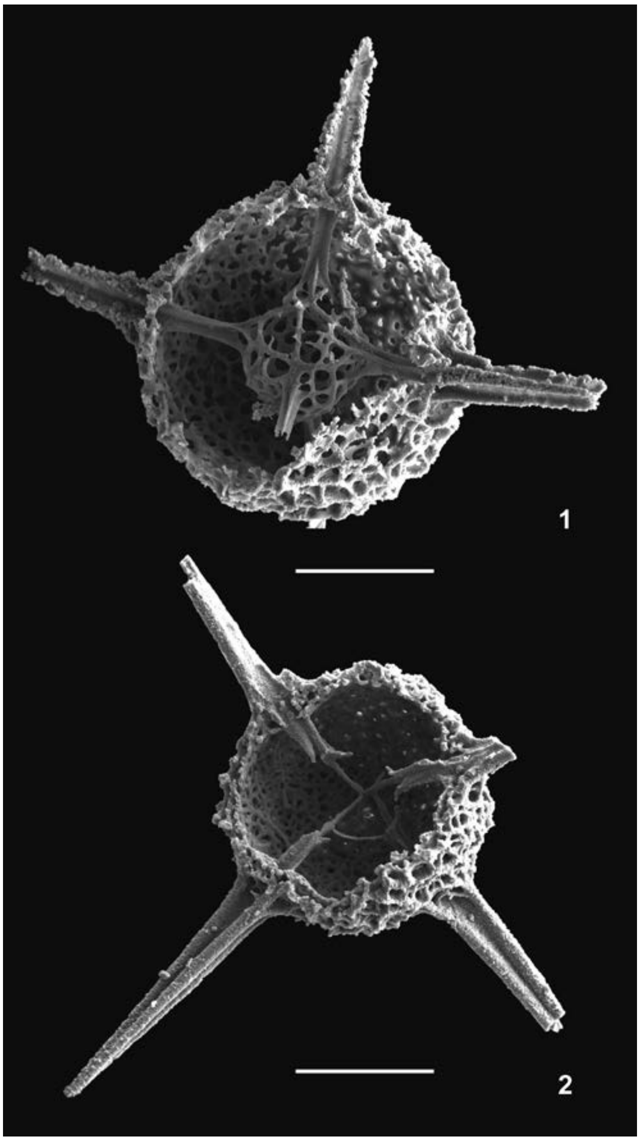


Fig. 11 - Internal structure of *Bernoulliella simplex* (Lahm), 1) Specimen with very well preserved first shell 2) Specimen with spicule and proximal ring preserved. Pelsonian (middle Anisian), Cristian, Eastern Carpathians, Romania. Scale bar = 100 µm.

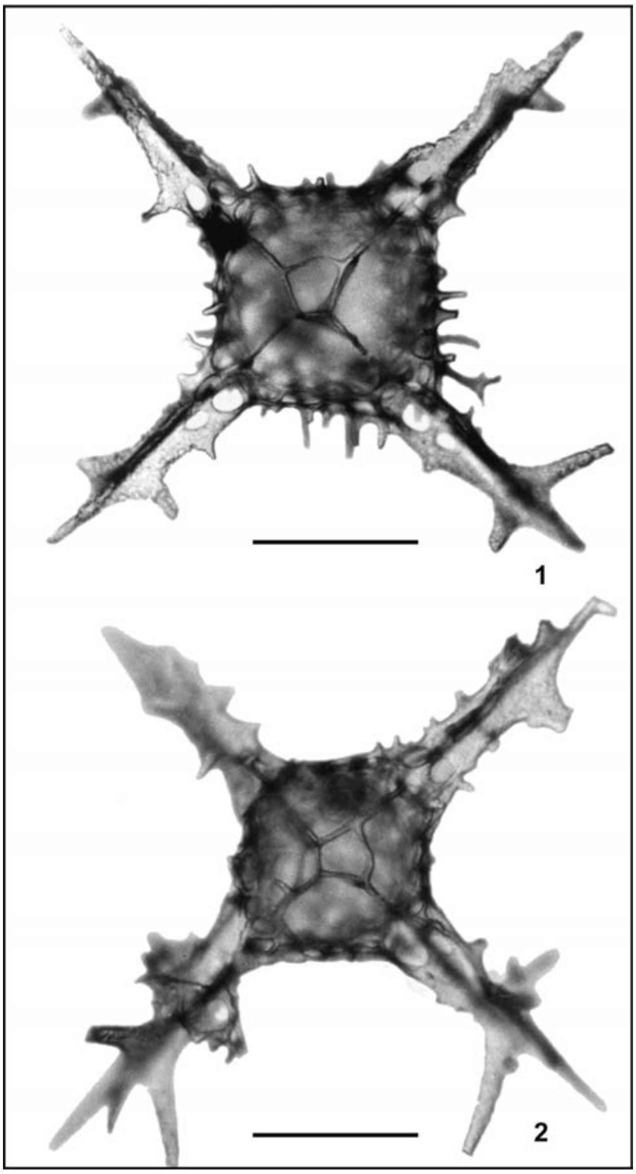


Fig. 12 - *Eohexastylus muzavori* (Lahm). Internal structure of two different specimens (see text for discussion). Pelsonian (middle Anisian) of Cristian, Eastern Carpathians. Transmitted light microphotographs. Scale bar = 100 µm.

Remarks. The poor preservation of our specimens precludes a description of the framework of the shell. Overall morphology and dimensions, however, well match those of *Hexatortilisphaera aequispinosa* Kozur, Krainer & Mostler.

Range (as published). *T. florida* Radiolarian Subzone (Illyrian) (Kozur et al. 1996). O'Dogherty et al. (2009b; 2010) regard the genus as restricted to the middle-late Anisian interval.

Occurrence. Sample M. Rare.

Genus *Eohexastylus* gen. n.

Type species: *Hexastylus muzavori* Lahm, 1984

Etymology: From the Greek *eo* – earliest, oldest, and *Hexastylus*, a generic name used for Cenozoic single-shelled radiolarians with 6 spines and an initial spicule or none.

Diagnosis: Shell spherical or subspherical, latticed with 6 three-bladed spines arranged in the 3 isometric axes and usually bearing a distal verticil of three spinules. Internal skeleton consisting of an initial spicule with a median bar and three rays at each end. Rays are aligned with the six spines and are arranged into two groups: two, one from each end, are free, the other four are interconnected by a few arches sketching a rather slightly outlined globular microsphere (Fig. 12).

Remarks. The use of the genus *Hexastylus* Haeckel for the Triassic single-shelled radiolarians with 6 isometric spines is erroneous. The Cenozoic species of this genus have a very thin spicule without connecting arches (see Hollande & Enjumet, 1960), whereas in the Triassic specimens the spicule has 3-4 irregular arches interconnecting four of the six radial bars (see Fig. 12). In the current state of knowledge, it is still difficult to assign the present genus to one of the families or subfamilies of the order Entactinaria. We include in it the species *Hexastylus muzavori* Lahm, *Hexalonche? petrae* Lahm and *Hexalonche magniperforata* Lahm, all described from the upper Anisian-lower Ladinian Buchenstein Formation of Recoaro (see Lahm 1984). *Hexastylus carnicus* Kozur & Mostler, 1979 and *Hexalonche simplex* Lahm do not belong to this genus. The former is close to the genus *Lahmosphaera* gen. n., the latter belongs to the genus *Bernoulliella* gen. n.

The new genus is probably close to the middle Carnian genus *Nazarovella* Kozur & Mostler, 1979 and the late Anisian genus *Hexatortilisphaera* Kozur, Krainer & Mostler, 1996. However, neither for the former genus, nor for the latter any information on the internal structure is available.

Range. Pelsonian (Middle Anisian) to Carnian so far as known.

Eohexastylus muzavori (Lahm, 1984) n. comb.

Fig. 12; Pl. 7, figs 7-9

1984 *Hexastylus muzavori* Lahm, p. 78, pl. 14, fig. 1.
1984 *Hexalonche? petrae* Lahm, p. 79, pl. 14, fig. 4.
1995 *Phyletripes muzavori* – Kellici & De Wever, p. 156, pl. 2, fig. 11.

Description. Cortical shell small with six three-bladed spines situated along three mutually perpendicular axes. Spines have a broad base, sharp ridges and wide longitudinal grooves. All spines branch distally, forming one verticil with three lateral spinules. Lateral spinules are medium-sized, triangular in shape, aligned with the ridges of the spines and centrifugally oriented. Behind the verticils a short needle-like prolongation of the axis of the spines occurs.

Remarks. *Hexalonche? petrae* Lahm is herein considered a synonym of *Hexastylus muzavori* Lahm. Specimens occurring in the Buchenstein Formation and studied by one of us (P.D.) suggest that the former species represents individuals of *H. muzavori* with an external spongy layer resulted by the branching and fusion of the by-spines developed from the vertices of the pore frames of the cortical shell. In our material, specimens ascribed to this species are common but always very poorly preserved.

Range (as published). Late Anisian to early Ladinian (Lahm 1984; Kellici & De Wever 1995).

Occurrence. Samples S, Pm, M. Common.

Order Spumellaria Ehrenberg, 1875

Family Xiphostylidae Haekel, 1881

Genus *Archaeocenosphaera* Pessagno & Yang, 1989 in Pessagno et al. 1989

Type species: *Archaeocenosphaera ruesti* Pessagno & Yang in Pessagno et al. 1989

Archaeocenosphaera sp. **B** (Lahm, 1984) n. comb.

Pl. 7, figs 10-11

1984 *Cenosphaera* sp. B Lahm, p. 16, pl. 1, figs 5-6.
1984 *Cenosphaera clathrata* Parona – Lahm, p. 15, pl. 1, figs 1-2.
2001 *Archaeocenosphaera* sp. – Hauser et al., pl. 3, fig. 10.

Description. Test with spherical cortical shell only, 210-270 µm in diameter and lacking spines. Wall of cortical shell consisting of two fused layers with latticed framework; inner layer thinner than outer layer. Polygonal pore frames, mostly hexagonal, occasionally pentagonal in shape. Very small nodes occur on the frame vertices. Intervening bars are quite narrow; their external part is triangular in cross section. Around 14-15 pores on the shell diameter.

Remarks. *Archaeocenosphaera* Pessagno & Yang, 1989 differs from *Cenosphaera* Ehrenberg, 1854 by having a thick cortical shell with two fused latticed layers and by usually having symmetrical polygonal pore frames (Pessagno et al. 1989). When established the new genus *Archaeocenosphaera*, Pessagno et al. (1989) included in it only two new species without revising the numerous morphotypes occurring in the Mesozoic, mainly regarded as "difficult to speciate and of no great biostratigraphic value". Our morphotypes differ from *Archaeocenosphaera laseekensis* Pessagno & Yang, 1989 in having a larger test with much larger pores and from *Archaeocenosphaera ruesti* Pessagno & Yang, 1989 in having a larger test (210-270 µm instead of 154-209 µm) and in lacking comparably nodose pore frames. Among the morphotypes described from the Triassic, the dimension of the shell and size, shape and distribution of pores conform rather well to *Cenosphaera* sp. B and *C. clathrata* Parona in Lahm (1984; late Anisian?-early Ladinian), and to *Archaeocenosphaera* sp. in Hauser et al. (2001; early Longobardian). It differs, however, from *Archaeocenosphaera clathrata* (Parona, 1890), also reported from the Middle Triassic even though without always fully conforming to the holotype (e.g. Kozur & Mostler 1979; Chiari et al. 1996; Feng et al. 2009), in being larger (diameter of the holotype of *A. clathrata* = 183 µm) and in having distinctly more pores on the shell diameter (10 in the holotype of *A. clathrata*, even fewer according to Dumitrica et al. 1997, p. 17, pl. 1, fig. 2). Anyway, it is not possible to assign Middle Triassic specimens to *C. clathrata* Parona because of the very different age, Parona's species being late Tithonian or early Cretaceous in age.

Range (as published). Late Anisian?-early Longobardian (Lahm 1984; Hauser et al. 2001). *Archaeocenosphaera* is a genus with high conservative morphology. It appeared in the middle Anisian (O'Dogherty et al. 2010) and was able to survive the crisis at the end of the Triassic (De Wever et al. 2003) diffusing throughout the

Mesozoic (up to the late Campanian according to O'Dogherty et al. 2010).

Occurrence. Samples Sb, S, VP8. Abundant.

Genus *Novamuria* Özdikmen, 2009

Type species: *Amuria impensa* Whalen & Carter in Carter et al., 1998

Novamuria wirzi n. sp.

Pl. 7, figs 12-17; Pl. 8, figs 1-4

Etymology: In honour of Dr. Albert Wirz who in 1945 first figured radiolarians from thin sections of the San Giorgio Dolomite.

Holotype: The specimen MCSN 8365 (sample S), Pl. 7, figs 12-13.

Paratypes: The specimens MCSN 8366 (sample S), Pl. 7, fig. 14, MCSN 8367 (sample S), pl. 7, fig. 15, MCSN 8370 (sample Sb), Pl. 7, figs 16-17, MCSN 8368 (sample S), Pl. 8, fig. 1, MCSN 8369 (sample Sb), Pl. 8, fig. 2, MCSN 8371 (sample M), Pl. 8, fig. 3, MCSN 8372 (sample M), Pl. 8, fig. 4.

Type locality: Val Porina, Monte San Giorgio, Canton Ticino, Southern Switzerland.

Type horizon: Basal section of the San Giorgio Dolomite, lower part of the *E. curionii* Ammonoid Zone (= uppermost part of the *L. multiperforata* Radiolarian Zone), early Ladinian, Middle Triassic.

Description. Test with spherical cortical shell only and with peripheral spines. Wall of cortical shell consisting of two fused layers with latticed framework; inner layer thinner than outer layer. Numerous small polygonal pore frames, mostly hexagonal, more rarely pentagonal in shape. Pores are quite regular in size and arrangement. Around 30, most likely 32, stout pyramidal spines, usually straigth and only sometimes slightly torsioned. Spines are commonly tetracarinate with sharp blades separated by wide grooves each ending in a pore of the cortical shell. The distal part of the spines bears a short needle-like termination.

Measurements. Diameter of the cortical shell = 180-260 μm, thickness of the cortical shell = 6-10 μm, length of the spines = 60-95 μm, width of the base of the spines = 25-35 μm, length of the by-spines 20-25 μm.

Comparisons. Outer morphology recalls *Acanthosphaera mocki* Kozur & Mostler, 1979 which, however, differs in having a medullary shell (Kozur & Mostler 1981: 65) and fewer spines (14 according to the original diagnosis. Kozur & Mostler 1979: 49), which are tricarinate in shape. From the Anisian two further *Acanthosphaera* species with carinate spines have been described, namely *A. carterae* Kozur, Krainer & Mostler, 1996 and *A. nicorae* Kozur, Krainer & Mostler, 1996, the latter ranging up to the late Ladinian (Tekin & Mostler 2005). Both species are smaller, with larger and more irregular pore frames bearing much fewer three-bladed spines (7-10 and 7-8 respectively). All other known *Acanthosphaera* species have needle-like spines with round cross-section (*A. austriaca* Kozur & Mostler, 1979, *A. reiflingensis* Lahm, 1984) or long tricarinate branched spines (*A. ramustyla* Lahm, 1984). Internal prolongation of the spines as well as a medullary shell never occur in our material. The new species is attributed to *Novamuria* (Whalen & Carter, 1998) because of the presence of a spherical cortical shell only and of peripheral spines evenly distributed over the shell surface. *Novamuria* is a replacement name for *Amuria* Whalen & Carter, 1998, junior homonym of *Amuria* Staudinger, 1887 (Özdikmen 2009). The presence of spines distinguishes this genus from *Archaeocenosphaera* Pessagno & Yang, 1989, which, however, shows a latticed framework of the cortical shell similar to that of our specimens. *Novamuria impensa* (Whalen & Carter, 1998) differs from the present species in having up to twelve spines circular in cross section.

Range (this study). Lower *E. curionii* Ammonoid Zone, early Ladinian. According to O'Dogherty et al. (2009b; 2010), the genus *Novamuria*, characterized by conservative morphology (as *Archaeocenosphaera*), crosses the Triassic/Jurassic boundary ranging from the late Anisian to the early Hauterivian.

Occurrence. Samples Sb, S, M. Very abundant.

Family Intermediellidae Lahm, 1984

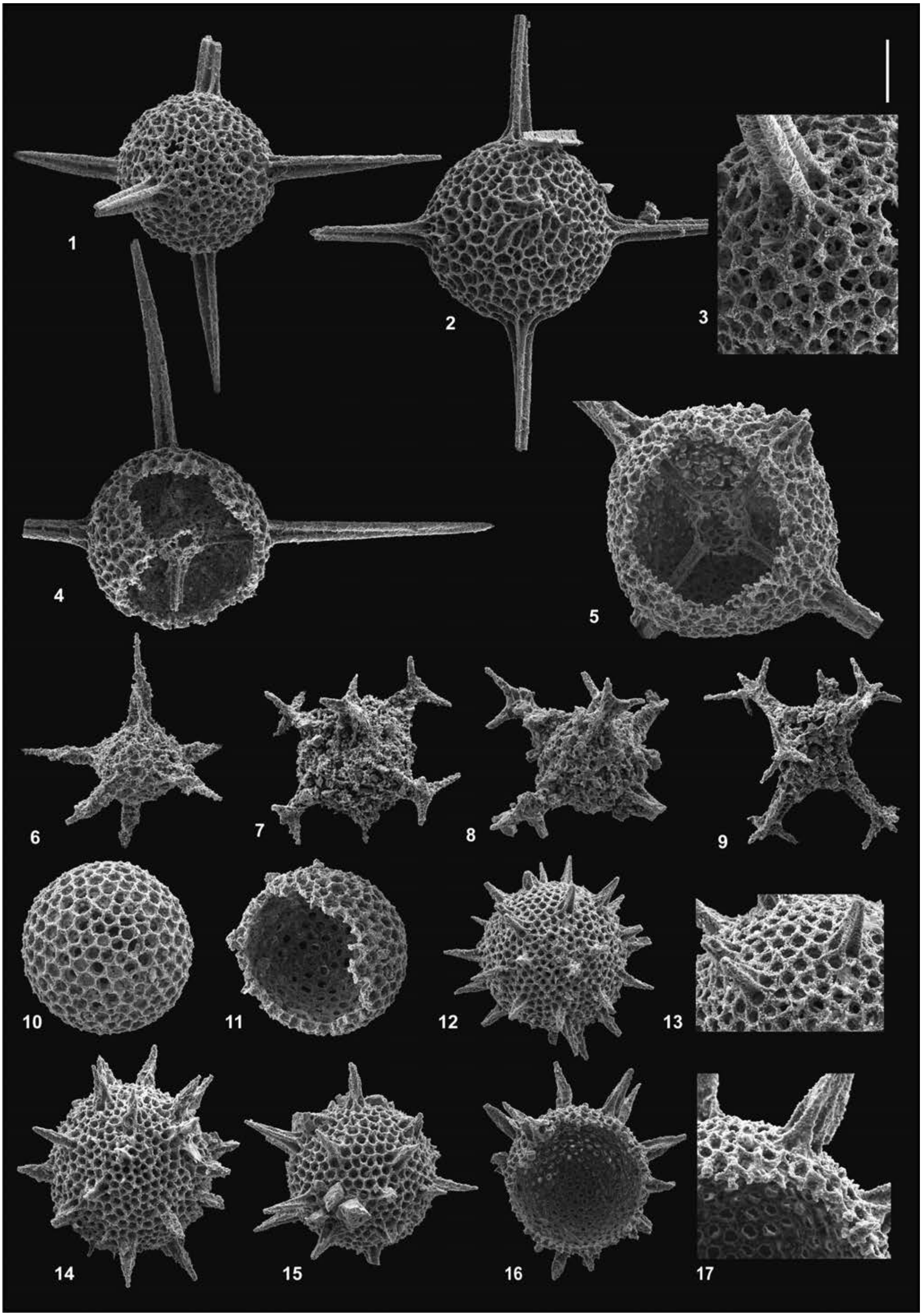
Genus *Paurinella* Kozur & Mostler, 1981

Type species: *Paurinella curvata* Kozur & Mostler, 1981

PLATE 7

Scanning electron photomicrographs of radiolarians from the San Giorgio Dolomite (*E. curionii* Ammonoid Zone, early Ladinian). All material is from Val Porina. For each figure, sample/specimen number, catalogue number (for type material) and value of scale bar are indicated.

Figs 1-5	- *Bernoulliella simplex* (Lahm) 1) Sb/30, 120 μm, 2) S/25b, 120 μm, 3) Sb/30, detail of the double-layered shell, 50 μm, 4) S/25a, specimen with first shell preserved, 120 μm, 5) Sb/29a, specimen with first shell preserved, 80 μm.
Fig. 6	- *Hexatortilisphaera aequispinosa* Kozur, Krainer & Mostler, M/b13, 120 μm.
Figs 7-9	- *Eohexastylus muzavori* (Lahm) 7) Pm/27d, 80 μm, 8) S/4a, 80 μm, 9) Pm/26, 80 μm.
Figs 10-11	- *Archaeocenosphaera* sp. B (Lahm), 10) Sb/15b, 100 μm, 11) S/26b, 100 μm.
Figs 12-17	- *Novamuria wirzi* n. sp. 12) MCSN 8365, holotype, total view, 100 μm, 13) MCSN 8365, holotype, detail of the cortical shell and peripheral spines, 50 μm, 14) MCSN 8366, paratype, 100 μm, 15) MCSN 8367, paratype, 100 μm, 16) MCSN 8370, paratype, opened shell, total view, 100 μm, 17) MCSN 8370, paratype, detail of the wall of the cortical shell, 50 μm.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Paurinella tornata Kozur & Mostler, 1994
Pl. 8, fig. 5

1994 *Paurinella tornata* Kozur & Mostler, p. 73, pl. 16, fig. 3.

Description. Shell strongly recrystallized, but probably spongy and inflated discoidal in shape as frequently occuring in genus *Paurinella* (Kozur & Mostler 1994: 70). Shell diameter around 150 µm. The three slender spines, over 180 µm long, have round cross section and are all curved in the same direction.

Remarks. Our specimens are slightly smaller than those belonging to the material described by Kozur & Mostler (1994).

Range (as published). *O. primitivus* Subzone of the *S. italicus* Radiolarian Zone (Kozur et al. 1996).

Occurrence. Sample Pm. Very rare.

Genus *Angulopaurinella* Kozur & Mostler, 2006
Type species: *Angulopaurinella crassa* Kozur & Mostler, 2006

Angulopaurinella edentata Dumitrica, Tekin & Bedi (submitted)
Pl. 8, fig. 6

Submitted *Angulopaurinella edentata* Dumitrica, Tekin & Bedi, figs 3D, 1H, 4P, R.

Description. Shell small, completely obliterated by diagenetic processes, possibly spherical, around 100 µm in diameter. Three three-bladed spines, with wide grooves and slightly different in length (210-260 µm). Spines are parallel-sided in the proximal half, then they taper over a short distance. All spines are slightly dextrally twisted, distinctly the longest one, only loosely the other two, which, in addition, are sligthly broader than the former. Spines are situated on the same plane but at different angles, the angle between the long spine and both the shorter ones being the same and the wider one (Y-arrangement).

Range (as published). Late Anisian to early Ladinian (Dumitrica et al. submitted)

Occurrence. Sample Pm. Very rare.

Genus *Triassospongosphaera* Kozur & Mostler, 1979
Type species: *Spongechinus triassicus* Kozur & Mostler, 1979

Triassospongosphaera triassica (Kozur & Mostler, 1979)
Pl. 8, figs 7-9

1979 *Spongechinus triassicus* Kozur & Mostler, p. 52, pl. 13, figs 6-7.

1981 *Triassospongosphaera triassica* - Kozur & Mostler, p. 67, pl. 58, fig.? 4; pl. 59, fig. 4.

1984 *Triassospongosphaera triassica* - Lahm, p. 66, pl. 11, fig. 9.

2005 *Triassospongosphaera triassica* - Feng et al., p. 242, pl. 1, figs 1-2.

Description. Spherical shell with multi-layered thick spongy framework, 130-210 µm in diameter. (11?)-14 needle-like main spines. Spines are shorter than, or as long as the shell diameter and display a round cross section except for their base, which is usually carinate.

Remarks. Some specimens have only 11 spines instead of 14 as stated in the original diagnosis (Kozur & Mostler 1979). As this might be due to a preservational bias, these specimens are included here as well.

Range (as published). Late Ladinian to early Carnian (Kozur & Mostler 1981); late Anisian? to early Carnian (Lahm 1984).

Occurrence. Samples Sb, Pm, M. Common.

Triassospongosphaera multispinosa (Kozur & Mostler, 1979)
Pl. 8, figs 10-11

1979 *Acanthosphaera? multispinosa* Kozur & Mostler, p. 50, pl. 20, fig. 3.

1981 *Triassospongosphaera multispinosa* – Kozur & Mostler, p. 67, pl. 58, fig. 3.

1984 *Triassospongosphaera multispinosa* – Lahm, p. 66, pl. 11, fig. 10.

1990 *Triassospongosphaera multispinosa* – Kolar-Jurkovsek, pl. 8, fig. 2.

1996 *Triassospongosphaera multispinosa* – Kozur et al., p. 222, pl. 8, figs 8, 12.

1999 *Triassospongosphaera multispinosa* – Sashida et al., p. 772, figs 8.14-8.15.

2009 *Triassospongosphaera multispinosa* – Feng et al., p. 591, figs 5.20-5.22.

2010 *Triassospongosphaera multispinosa* – Tekin & Sönmez, fig. 6B.

2011 *Triassospongosphaera multispinosa* – Thassanapak et al., p. 188, figs 4G-H.

2011 *Triassospongosphaera multispinosa* – Ozsvárt et al., fig. 9.18.

Description. Spherical cortical shell with spongy framework, 180-240 µm in diameter. More than 20 (exceptionally up to 30) main spines, always distinctly shorter than the shell diameter. Spines are slender, needle-like in shape and round in cross section, except for the widened carinate base.

Remarks. Compared to the type material (Kozur & Mostler 1979) our specimens are larger and usually bear fewer and shorter spines (more than 30 in type material). All these features, however, occur in the above-listed specimens of this species and are here attributed to a wide intraspecific variability.

Range (as published). Late Anisian to middle Carnian (Kozur et al. 1996).

Occurrence. Sample Sb, Pm, M. Abundant.

Genus *Astrocentrus* Kozur & Mostler, 1979

Type species: *Astrocentrus pulcher* Kozur & Mostler, 1979

Astrocentrus pulcher Kozur & Mostler, 1979

Pl. 8, figs 12-13

1979 *Astrocentrus pulcher* Kozur & Mostler, p. 72, pl. 1, fig. 2; pl. 2, figs 1, 3.

1984 *Astrocentrus* cf. *pulcher* Kozur & Mostler – Lahm, p. 20, pl. 2, fig. 6.

1995 *Astrocentrus pulcher* – Kellici & De Wever, p. 144, pl. 1, fig. 4.

Description. Spherical shell 190-200 µm in diameter with fine spongy framework and subhexagonal outline. Ten (?) strong three-bladed main spines, around 90 µm long, with sharp blades and wide and deep grooves. Spines can bear needle-like prolongations.

Remarks. All specimens are uncomplete, precluding a reliable count of the number of spines.

Kozur & Mostler (1979: 72) stated that the number of spines in the genus *Astrocentrus* ranges from 10 to 18, 14 being the number of spines in *A. pulcher* Kozur & Mostler, 1979 (type species of the genus). Our specimens fully conform to the type material of *Astrocentrus pulcher* except for the number of spines, which is probably smaller.

Range. *Astrocentrus pulcher* sensu lato (i.e. having same shell structure but wider variability in spine number) ranges from the Anisian to the early Carnian (Lahm 1984; Sugiyama 1992).

Occurrence. Sample Sb. Rare.

Astrocentrus? latispinosus (Kozur & Mostler, 1979)

Pl. 8, figs 14-16

1979 *Spongechinus? latispinosus* Kozur & Mostler, p. 52, pl. 5, fig. 4.

1981 *Triassospongosphaera? latispinosa* – Kozur & Mostler, p. 67, pl. 3, fig. 6.

1984 *Astrocentrus? latispinosus* – Lahm, p. 21, pl. 2, fig. 7.

? 1995 *Astrocentrus?* aff. *latispinosus* – Kellici & De Wever, p. 142, pl. 1, fig. 3.

non 2011 *Astrocentrus latispinosus* – Ozsvárt et al., fig. 9.16.

Description. Spherical shell 160-210 µm in diameter, with medium-sized irregular outer pore frames. Fourteen stout three-bladed main spines with high and sharp blades and wide and deep grooves. Spines are mostly parallel-sided and taper only in the distal third. The distal end is pointed and it usually bears a short needle-like termination.

Remarks. Our specimens closely resemble the holotype of *Spongechinus? latispinosus* Kozur & Mostler, 1979 (*Spongechinus* Haeckel, 1881 is a nomen dubium; O'Dogherty et al. 2009 a,c). However, the attribution of this species to the genus *Astrocentrus* Kozur & Mostler is questionable, as the type species of *Astrocentrus* (*A. pulcher* Kozur & Mostler, 1979) shows a shell with a fine spongy framework (see also Kozur et al. 1996: 226). *Astrocentrus?* aff. *latispinosus* in Kellici & De Wever (1995) differs in having fewer spines and larger pore frames. Our specimens roughly recall *Acanthosphaera mocki* Kozur & Mostler, 1979 which, however, has more regular pore frames and is diagnosed as having spines whose width continuously decreases distalwards (Kozur & Mostler 1979: 50).

Range (as published). Late Anisian? to Carnian (Lahm 1984).

Occurrence. Samples Sb, S. Common.

Astrocentrus? robustus (Kozur & Mostler, 1981)

Pl. 8, fig. 17

1981 *Triassospongosphaera? robusta* Kozur & Mostler, p. 67, pl. 1, fig. 7.

1984 *Astrocentrus? robustus* – Lahm, p. 21, pl. 2, fig. 8.

1995 *Astrocentrus robustus* – Kellici & De Wever, p. 144, pl. 1, fig. 5.

Description. Spongy spherical shell 140-150 µm in diameter. Fourteen strong three-bladed main spines with sharp blades and wide and deep grooves. Spines become sometimes wider distalwards assuming a shape defined as club-like in the original description (Kozur & Mostler 1981: 67) and lance-like in Kellici & De Wever (1995) who, however, question the taxonomic value of such feature.

Remarks. According to Kozur & Mostler (1981: 67), the shape of the spines permits to distinguish *A.? robustus* from *A.? latispinosus* (Kozur & Mostler, 1979), which never displays distally widened spines. In addition, the latter species has a shell structure with larger pore frames (Kozur & Mostler 1979, pl. 5, fig. 4).

Range (as published). Late Anisian? to early Ladinian (Lahm 1984).

Occurrence. Sample Pm. Rare.

Genus *Plafkerium* Pessagno, 1979

Type species: *Plafkerium abbotti* Pessagno, 1979

Plafkerium confluens Dumitrica, Kozur & Mostler, 1980

Pl. 8, fig. 18

1980 *Plafkerium confluens* Dumitrica, Kozur & Mostler, p. 13, pl. 1, fig. 1.

1984 *Plafkerium contortum* Dumitrica, Kozur & Mostler – Lahm, p. 86, pl. 15, fig. 9, non 10.

1995 *Plafkerium? confluens* - Kellici & De Wever, p. 156, pl. 4, fig. 8.

1995 *Plafkerium?* cf. *contortum* Dumitrica, Kozur & Mostler – Ramovs & Gorican, p. 188, pl. 2, figs 15-16, ?17.

2001 *Plafkerium confluens* - Hauser et al., pl. 2, fig. 12.

Description. Spherical cortical shell, around 110 µm in diameter, with coarse spongy framework. Cortical bars tuberculate. Four twisted main spines, coplanar and crosswisely arranged. Spines are three-bladed with high ridges and wide grooves, around 120 µm long. Their distal parts are pointed and sometimes they bear short needle-like ends. Blades of adjacent spines join to each other to form an equatorial girdle.

Remarks. The specimens are somewhat smaller than the holotype of *Plafkerium? confluens* (Dumitrica et al. 1980, pl. 1, fig. 1) which, in addition to the distinct girdle on the equatorial plane, shows weak ridges connecting the spine blades on the shell surface. These are not evident in our specimens, which fully conform to *Plafkerium? confluens* figured in Kellici & De Wever (1995). *Plafkerium contortum* figured in Lahm (1984, plate 15, fig. 9) does not display the destrally-twisted spines typical of *Plafkerium? contortum* Dumitrica, Kozur & Mostler (Dumitrica et al. 1980, p. 13, pl. 1, fig. 4).

Range (as published). Late Anisian to early Carnian (Lahm 1984; Ramovs & Gorican 1995; Kellici & De Wever 1995).

Occurrence. Sample Sb. Rare.

Family Relindellidae Kozur & Mostler in Dumitrica et al. 1980

Genus *Pentaspongodiscus* Kozur & Mostler, 1979

Type species: *Pentaspongodiscus tortilis* Kozur & Mostler, 1979

Pentaspongodiscus ladinicus Dumitrica, Kozur & Mostler, 1980

Pl. 8, figs 19-21

1980 *Pentaspongodiscus tortilis ladinicus* Dumitrica, Kozur & Mostler, p. 10, pl. 8, fig. 5.

1981 *Pentaspongodiscus ladinicus* Dumitrica, Kozur & Mostler – Kozur & Mostler, p. 62, pl. 45, fig. 2.

1984 *Pentaspongodiscus ladinicus* – Lahm, p. 55, pl. 9, fig. 8.

1990 *Pentaspongodiscus ladinicus* – Gorican & Buser, p. 150, pl. 2, fig. 3.

1994 *Pentaspongodiscus ladinicus* – Kozur et al. pl. 9, fig. 9.

1995 *Pentaspongodiscus ladinicus* – Kellici & De Wever, p. 154, pl. 4, fig.4

1999 *Pentaspongodiscus ladinicus ladinicus* Dumitrica, Kozur & Mostler – Tekin, p. 122.

2011 *Pentaspongodiscus ladinicus* – Ozsvárt et al., fig. 9.19.

Description. Spongy discoidal shell with subpentagonal outline. Diameter 110-140 µm. Five three-bladed twisted spines lying on the equatorial plane. Spines longer than shell diameter, with sharp ridges and deep grooves, and with a pointed termination, sometimes bearing a needle-like spinule.

Remarks. This morphotype was firstly introduced as a subspecies of *P. tortilis* (Dumitrica et al. 1980) and later elevated to the specific rank (Kozur & Mostler 1981). Tekin (1999) subdivided the species into two subspecies, namely *P. ladinicus ladinicus* Dumitrica, Kozur & Mostler and *P. ladinicus discoides* Tekin. The latter differs from the former (to which our morphotypes conform) by having more strongly twisted stronger spines shorter than the shell diameter. However, no distinction at a subspecific rank is applied here.

Range (as published). Late Anisian? to Carnian (Lahm 1984).

Occurrence: Samples S, Pm, M. Common.

Genus *Relindella* Kozur & Mostler, 1980 in Dumitrica et al. 1980

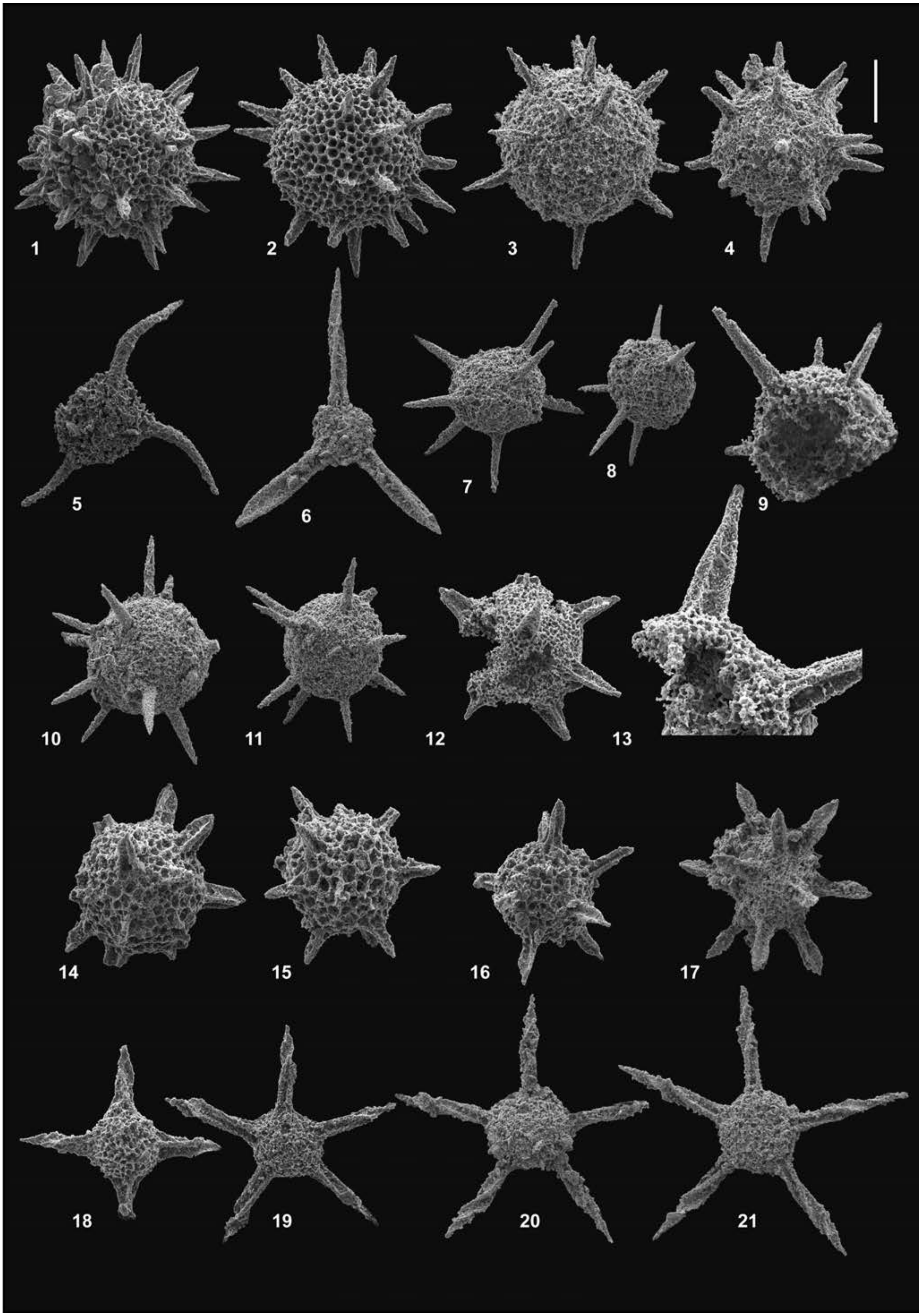
Type species: *Relindella hexaspinosa* Kozur & Mostler, 1980 in Dumitrica et al. 1980

Remarks. In agreement with Dumitrica et al. (in press), we use the genus *Relindella* for all species with lens-shaped spongy shell and 6 three-bladed spines. Previously, it included also species with 5 three-bladed spines.

PLATE 8

Scanning electron photomicrographs of radiolarians from the San Giorgio Dolomite (*E. curionii* Ammonoid Zone, early Ladinian). All material is from Val Porina. For each figure, sample/specimen number, catalogue number (for type material) and value of scale bar are indicated.

Figs 1-4 - *Novamuria wirzi* n. sp. 1) MCSN 8368, paratype, 100 µm, 2) MCSN 8369, paratype, 100 µm, 3) MCSN 8371, paratype, 100 µm, 4) MCSN 8372, paratype, 100 µm.
Fig. 5 - *Paurinella tornata* Kozur & Mostler, Pm/45, 100 µm.
Fig. 6 - *Angulopaurinella edentata* Dumitrica, Tekin & Bedi, Pm/20, 120 µm.
Figs 7-9 - *Triassospongosphaera triassica* (Kozur & Mostler), 7) M/b21, 120 µm, 8) Pm/36m, 120 µm, 9) Sb/6, detail of the spongy shell, 80 µm.
Figs 10-11 - *Triassospongosphaera multispinosa* (Kozur & Mostler), 10) Pm/36d, 120 µm, 11) M/19a, 120 µm.
Figs 12-13 - *Astrocentrus pulcher* Kozur & Mostler, 12) Sb/61, 100 µm, 13) Sb/61, detail of the spongy framework of the shell, 50 µm.
Figs 14-16 - *Astrocentrus? latispinosus* (Kozur & Mostler), 14) Sb/31a, 100 µm, 15) Sb/31b, 100 µm, 16) S/42a, 100 µm.
Fig. 17 - *Astrocentrus? robustus* (Kozur & Mostler), Pm/29, 100 µm.
Fig. 18 - *Plafkerium confluens* Dumitrica, Kozur & Mostler, Sb/42e, 100 µm.
Figs 19-21 - *Pentaspongodiscus ladinicus* Dumitrica, Kozur & Mostler, 19) M/b14, 100 µm, 20) Pm/17, 100 µm, 21) Pm/16, 100 µm.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Relindella mesotriassica (Dumitrica, Kozur & Mostler, 1980) n. comb.

Pl. 9, figs 1-3

1980 *Pentaspongodiscus mesotriassicus* Dumitrica, Kozur & Mostler, p. 10, pl. 8, fig. 7.

1984 *Pentaspongodiscus mesotriassicus* – Lahm, p. 56, pl. 9, fig. 11.

1990 *Pentaspongodiscus mesotriassicus* – Gorican & Buser, p. 151, pl. 2, figs 1-2.

1994 *Pentaspongodiscus mesotriassicus* – Kozur & Mostler, pl. 9, fig. 7.

1995 *Pentaspongodiscus mesotriassicus* – Kellici & De Wever, p. 196.

1995 *Pentaspongodiscus mesotriassicus* – Ramovs & Gorican, p. 153, pl. 4, fig. 2.

1996 *Pentaspongodiscus mesotriassicus* – Kozur et al., p. 231, pl. 4, fig. 14.

2005 *Pentaspongodiscus mesotriassicus* – Tekin & Mostler, p. 39, fig. 6.6.

2011 *Pentaspongodiscus mesotriassicus* – Thassanapak et al., p. 193, fig. 5Q-R.

Description. Discoidal shell 150-160 μm in diameter, with spongy framework and subhexagonal outline. Six slender, long, three-bladed and twisted spines lying on the equatorial plane. Spines have a pointed termination, sometimes bearing a needle-like spinule.

Remarks. Number of spines aside, these morphotypes are very similar to those here referred to *P. ladinicus* Dumitrica, Kozur & Mostler.

Range (as published). *S. transitus* Radiolarian Zone (Illyrian) to *S. fluegeli* Radiolarian Subzone (late Ladinian) (Kozur et al. 1996; Tekin & Mostler 2005).

Occurrence. Samples Sb, Pm, M. Common.

Family Spongopalliidae Kozur, Krainer & Mostler, 1996

Genus *Spongopallium* Dumitrica, Kozur & Mostler, 1980

Type species: *Spongopallium contortum* Dumitrica, Kozur & Mostler, 1980

Spongopallium sp. aff. **S. koppi** (Lahm, 1984) sensu Tekin & Sönmez 2010

Pl. 9, fig. 4

2010 *Spongostylus* aff. *koppi* (Lahm) – Tekin & Sönmez, p. 208, fig. 6E.

? 2011 *Spongopallium* sp. cf. *S. koppi* (Lahm) – Thassanapak p. 189, fig. 4S.

Description. Globular spongy shell 100-150 μm in diameter. Two short three-bladed opposite polar spines unequal in length. Length of shell including spines up to 370 μm. Spines are carinate in the proximal part with large and rounded ridges and narrow furrows; distal part circular in cross section.

Remarks. Our specimens differ from the type material of *Spongopallium koppi* (Lahm, 1984) and from subsequent records of the same species (Gorican & Buser 1990; Kellici & De Wever 1995; Sashida et al. 1999; Tekin & Mostler 2005) in having stouter polar spines. *Spongostylus* is a generic name erroneously used for Mesozoic occurrences (O'Dogherty et al. 2009a).

Range (as published). *Spongopallium* sp. aff. *koppi* (Lahm, 1984) sensu Tekin & Sönmez 2010 is reported from the late Ladinian (*Muelleritortis cochleata* Radiolarian Zone; Tekin & Sönmez 2010) and possibly from the late Anisian (Thassanapak 2011).

Occurrence. Samples S, VP8. Rare.

Family Oertlispongidae Kozur & Mostler in Dumitrica et al. 1980

Genus *Pararchaeospongoprunum* Lahm, 1984

Type species: *Pararchaeospongoprunum hermi* Lahm, 1984

Pararchaeospongoprunum hermi Lahm, 1984

Pl. 9, figs 5-7

1984 *Pararchaeospongoprunum hermi* Lahm, p. 42, pl. 7, fig. 1.

1990 *Paroertlispongus* sp. – Kolar-Jurkovsek, pl. 7, fig. 6.

1994 *Paroertlispongus hermi* – Kozur & Mostler, p. 69, pl. 10, fig. 10; pl. 11, figs 3, 5; pl. 47, fig. 11.

? 1994 *Paroertlispongus obliquus* Kozur & Mostler, p. 69, pl. 11, fig. 8.

1995 *Pararchaeospongoprunum hermi* – Kellici & De Wever, p. 152, pl. 3, figs 10-11.

Description. Subellipsoidal spongy shell with two opposite unequal needle-like polar spines. These are round in cross section except for the very base, where, despite the poor preservation, they appear tricarinate with very round ridges ("stark gerundete Kanten" of Lahm 1984: 42), a feature diagnostic for the genus (Lahm 1984).

Remarks. Kozur & Mostler (1994: 68) regarded *Pararchaeospongoprunum* Lahm, 1984 as a junior synonym of *Paroertlispongus* Kozur & Mostler, 1981 of which it would represent primitive morphotypes with transitional characters. According to the above authors, this synonymy would be confirmed by the carinate base of the spines, which may occur in both spines or in only one, but may also be absent: in the latter case the spine displays a round cross section throughout its length, as occurring in *Paroertlispongus*. The recent revision of O'Dogherty et al. (2009b), however, maintains the genus *Pararchaeospongoprunum* as a valid one.

Range (as published). *S. italicus* Radiolarian Zone (Kozur & Mostler 1994: 69).

Occurrence. Samples, Sb, Pm, M. Common.

Genus *Paroertlispongus* Kozur & Mostler, 1981

Type species: *Paroertlispongus multispinosus* Kozur & Mostler, 1981

Paroertlispongus multispinosus Kozur & Mostler, 1981

Pl. 9, figs 8-13

1981 *Paroertlispongus multispinosus* Kozur & Mostler, p. 48, pl. 44, fig. 2; pl. 45, fig. 1.

1984 *Paroertlispongus multispinosus* Kozur & Mostler – Lahm, p. 45, pl. 7, fig. 5.

1992 *Paleoeucyrtis elongata* Feng, p. 59, pl. 2, figs 13-14.

1993 *Paroertlispongus multispinosus* Kozur & Mostler – Dosztaly, pl. 2, fig. 2.

1994 *Paroertlispongus multispinosus* – Kozur & Mostler, p. 69, pl. 12, fig. 10; pl. 13, figs 4, 11.

1996 *Paroertlispongus multispinosus* – Kozur, p. 291, pl. 1, fig. 1.

1996 *Paroertlispongus multispinosus* – Kozur et al., p. 230, pl. 11, fig. 12.

2001 *Paroertlispongus multispinosus* – Feng et al., p. 192, pl. 6, figs 12, 14-18.

2001 *Paroertlispongus multispinosus* – Hauser et al., pl. 2, figs 2-3.

2001 *Oertlispongus multispinosus* Dumitrica, Kozur & Mostler – Hauser et al., pl. 2, fig. 16.

2003 *Paroertlispongus multispinosus* – Feng & Liang, p. 221, pl. 1, fig. 23.

2005 *Paroertlispongus multispinosus* – Gorican et al., pl. 1, figs 5-9.

2005 *Paroertlispongus multispinosus* – Feng et al., pl. 4, figs 15-16.

2009 *Paroertlispongus multispinosus* – Feng et al., p. 587, figs 4.2-4.3.

2009 *Paroertlispongus multispinosus* – Bortolotti et al., pl. 1, figs 6-7.

2011 *Paroertlispongus multispinosus* – Thassanapak et al., p. 193, figs 5l-M.

non 2011 *Paroertlispongus multispinosus* – Ozsvárt et al., fig. 9.5. (= *P. rarispinosus* Kozur & Mostler, 1981).

Description. Spongy spheroidal shell, 180-260 µm in diameter, with two opposite polar main spines with round cross section. The shell surface bears large tubercles. The primary spine is stout, 360-550 µm long and becomes wider distalwards. It is widest at three-fourth of its length, and then tapers over a short distance to a pointed end. Morphotypes occur in which this widening is just hinted at (Pl. 9, figs 11-13). The opposite secondary polar spine is usually broken off, however always being preserved at least in its proximal part. It is thinner than the primary spine but still distinctly larger than the numerous (around 40) needle-like by-spines covering the entire surface of the shell.

Remarks. According to Kozur et al. (1996: 230), Oertlispongidae (like *P. multispinosus* or other species described here further below) are mostly preserved as isolated main spines, likely because the shell is very vulnerable to HF dissolution procedure or due to dissolution during diagenesis. In our material, the shell is always present, this likely resulting from the more gentle extraction method used here, involving a buffered weak acid.

Range (as published). *T. florida* Subzone of the *S. transitus* Radiolarian Zone (Illyrian) to late Fassanian (Kozur et al. 1996: 230; Hauser et al. 2001: 37).

Occurrence. Samples Sb, S, Pm, M. Common.

Paroertlispongus rarispinosus Kozur & Mostler, 1981

Pl. 9, figs 14-15

1981 *Paroertlispongus rarispinosus* Kozur & Mostler, p. 48, pl. 1, fig. 3.

1993 *Paroertlispongus* aff. *rarispinosus* – Dosztaly, pl. 1, fig. 5.

1994 *Paroertlispongus rarispinosus* – Kozur & Mostler, p. 69, pl. 12, fig. 7.

1995 *Paroertlispongus rarispinosus* – Ramovs & Gorican, p. 187, pl. 1, fig. 9.

1996 *Paroertlispongus rarispinosus* – Kozur, pl. 1, fig. 2.

2001 *Paroertlispongus rarispinosus* – Feng et al., p. 192, pl. 7, fig. 8.

non 2009 *Paroertlispongus rarispinosus* – Feng et al., p. 587, fig. 4.1.

2011 *Paroertlispongus rarispinosus* – Thassanapak et al., p. 193, fig. 5N.

2011 *Paroertlispongus multispinosus* – Ozsvárt et al., fig. 9.5.

Description. Spongy spherical shell, 130-150 µm in diameter, with one polar needle-like main spine, 380-400 µm long, with round cross section. Owing to the poor preservation, the opposite secondary spines are missing.

Remarks. See under *P. multispinosus.*

Range (as published). *T. florida* Subzone of the *S. transitus* Radiolarian Zone to *L. annuloperforata* Subzone of *L. multiperforata* Radiolarian Zone (Kozur & Mostler 1994; Ramovs & Gorican 1995).

Occurrence. Samples Sb, S, M. Common.

Genus *Oertlispongus* Dumitrica, Kozur & Mostler, 1980

Type species: *Oertlispongus inaequispinosus* Dumitrica, Kozur & Mostler, 1980

Oertlispongus inaequispinosus Dumitrica, Kozur & Mostler, 1980

Pl. 9, figs 16-21

1980 *Oertlispongus inaequispinosus* Dumitrica, Kozur & Mostler, p. 5, pl. 10, fig. 7.

1982a *Oertlispongus inaequispinosus* – Dumitrica, p. 64, pl. 1, figs 6, 9.

1984 *Oertlispongus inaequispinosus* – Lahm, p. 48, pl. 8, fig. 2.

1989 *Oertlispongus inaequispinosus* Kozur & Mostler (sic) – Martini et al., pl. 3, fig. 14.

1990 *Oertlispongus inaequispinosus* – Gorican & Buser, p. 148, pl. 3, figs 10-11.

1990 *Oertlispongus inaequispinosus* – Kolar-Jurkovsek, pl. 7, fig. 8.

1993 *Oertlispongus inaequispinosus* – Dosztaly, pl. 2, figs 7-8, non 3-6.

1994 *Oertlispongus inaequispinosus inaequispinosus* Dumitrica, Kozur & Mostler – Kozur & Mostler, p. 59, pl. 10, figs 1, 4, 7, 13; pl. 47, fig. 6.

1994 *Oertlispongus inaequispinosus longispinosus* Kozur & Mostler, p. 59, pl. 10, figs?5, 11; pl. 11, figs 2, 6,?7,?11.

1995 *Oertlispongus inaequispinosus* – Kellici & De Wever, p. 150, pl. 3, fig. 9.

1995 *Oertlispongus inaequispinosus* – Halamic & Gorican, pl. 1, fig. 1.

1996 *Oertlispongus inaequispinosus* – Chiari et al., pl. 2, fig. 9.

1999 *Oertlispongus inaequispinosus* – Sashida et al., p. 772, figs 10.26-10.27.

1999 *Oertlispongus inaequispinosus* – Dumitrica, p. 35, pl. 1, figs 1, 3.

2001 *Oertlispongus inaequispinosus* – Hauser et al., pl. 2, fig. 18, non 19 (= *O. tumidospinosum* Kozur & Mostler, 1994).

2003 *Oertlispongus inaequispinosus* – Feng & Liang, p. 223, pl. 2, figs 5-6.

2005 *Oertlispongus inaequispinosus* – Gorican et al., pl. 1, figs 21-24, non 25-26 (= *O. tumidospinosum* Kozur & Mostler, 1994).

2009 *Oertlispongus inaequispinosus* – Feng et al., p. 589, figs 4.18-4.22.

Description. Spheroidal spongy shell with two opposite main polar spines round in cross section. Primary spine stout, long, sickle-like strongly curved and showing a high variability in shape and size. Proximal part of the primary polar spine shorter than the shell diameter. Opposite secondary polar spine straight and needle-like in shape. One or two by-spines are rarely observed; they lie in antapical position and are slighty smaller than the secondary spine.

Remarks. Kozur & Mostler (1994: 59-63) established 2 new *Oertlispongus* species (*O. aspinosus* including 2 subspecies, and *O. primitivus*) distinguished from *Oertlispongus inaequispinosus* Dumitrica, Kozur & Mostler, 1980 on the basis of the length of the stem (i.e. the proximal part of the primary polar spine). In both *O. aspinosus* and *O. primitivus* the stem is as long as or longer than the shell diameter instead of being shorter. However, the taxonomic significance of this character has not been accepted by all authors (see for instance specimens figured in Feng et al. 2009). In addition, Kozur & Mostler (1994) discriminated four *Oertlispongus inaequispinosus* subspecies with partly overlapping stratigraphical ranges (*O. inaequispinosus inaequispinosus*, *O. inaequispinosus longispinosus*, *O. inaequispinosus tumidospinosus*, and *O. inaequispinosus unispinosus*) based on features such as size and shape of the primary spine, occurrence of the secondary polar spine, occurrence, number, shape and position of by-spines. However, two years later, Kozur & Mostler themselves while describing a Longobardian radiolarian assemblage did not apply this subspecific taxonomic concept (Kozur & Mostler 1996b). Dumitrica (1999) could not prove the taxonomical value of some of the above characters regarded as subspecific but raised *O. inaequispinosus tumidospinosus* at specific rank. Partly due to the poor preservation of our material, partly to the questionable taxonomic significance of some of the features used at subspecific level, no distinction at a subspecific rank is applied here. All our morphotypes, however, likely fall into *O. inaequispinosus inaequispinosus* except for the specimen in Pl. 9, fig. 21 which probably better compares to *O. inaequispinosus longispinosus* characterized by strong by-spines in the lower hemisphere.

Range (as published). According to Kozur & Mostler (1996b: 109) *Oertlispongus inaequispinosus* is common from the middle *R. reitzi* Ammonoid Zone to the *E. curionii* Ammonoid Zone and then becomes rare up to the *P. priscus* Subzone of the *M. cochleata* Radiolarian Zone (correlatable with the lower part of the *P. archelaus* Ammonoid Zone).

Occurrence. Samples Sb, S, Pm, M. Abundant.

Oertlispongus tumidospinosus Kozur & Mostler, 1994

Pl. 9, fig. 22

1994 *Oertlispongus inaequispinosus tumidospinosus* Kozur & Mostler, p. 60, pl. 10, fig. 6; pl. 11, fig. 9.

1996b *Oertlispongus inaequispinosus* – Kozur & Mostler, p. 108, pl. 14, figs 10-11.

1999 *Oertlispongus tumidospinosus* – Dumitrica, p. 35, pl. 1, fig. 3.

2001 *Oertlispongus inaequispinosus* – Hauser et al., pl. 2, fig. 19.

2005 *Oertlispongus inaequispinosus* – Gorican et al., pl. 1, figs 25-26.

Description. Spheroidal spongy shell with two opposite main polar spines round in cross section. Pri-

PLATE 9

Scanning electron photomicrographs of radiolarians from the San Giorgio Dolomite (*E. curionii* Ammonoid Zone, early Ladinian). All material is from Val Porina. For each figure, sample/specimen number and value of scale bar are indicated.

Figs 1-3 - *Relindella mesotriassica* (Dumitrica, Kozur & Mostler), 1) Pm/15a, 120 μm, 2) M/b15a, 120 μm, 3) Sb/56, 120 μm.

Fig. 4 - *Spongopallium* sp. aff. *S. koppi* (Lahm) sensu Tekin & Sönmez, VP8-5, 100 μm.

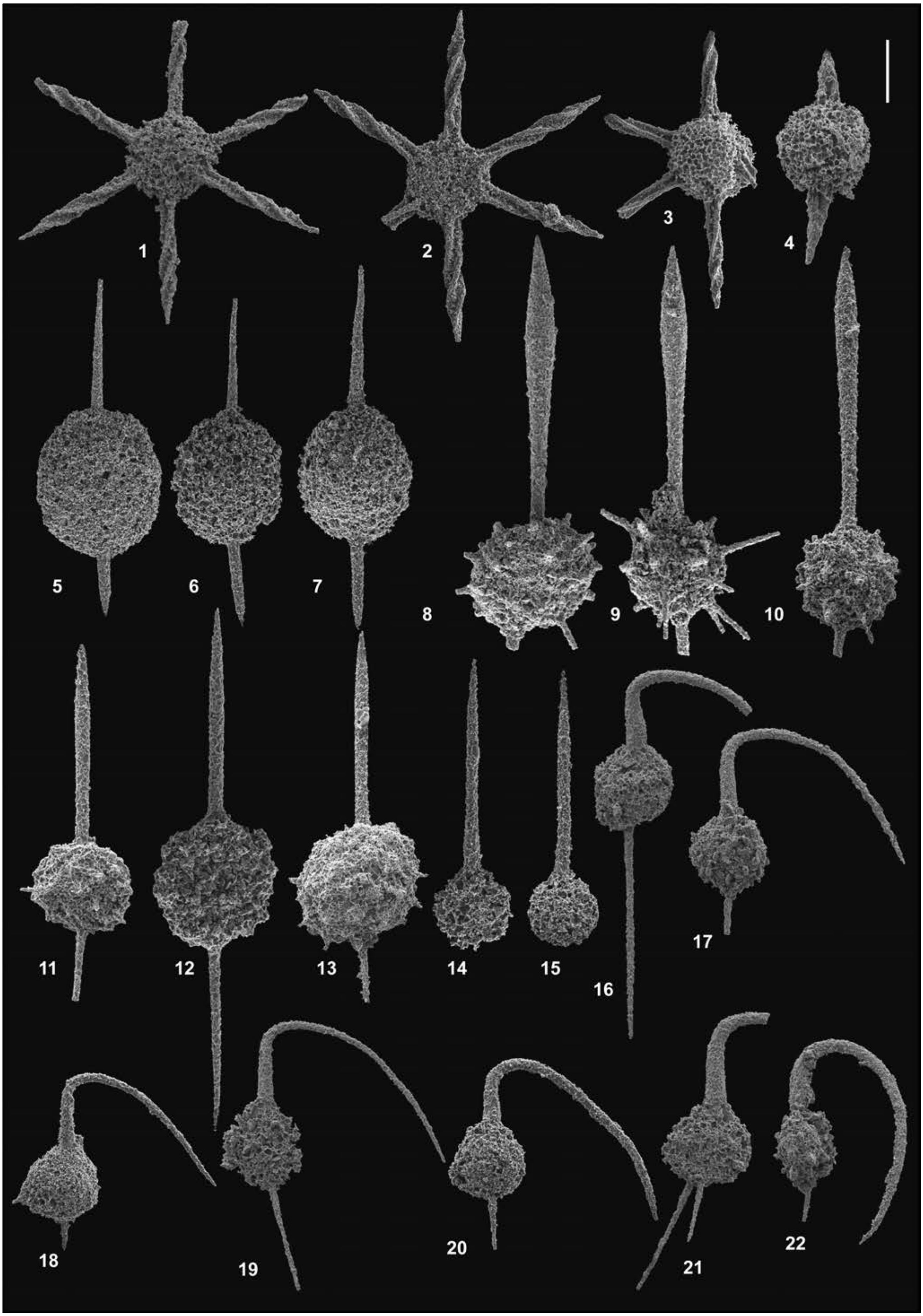
Figs 5-7 - *Pararchaeospongoprunum hermi* Lahm, 5) M/1a, 120 μm, 6) M/1b, 120 μm, 7) M/1c, 120 μm.

Figs 8-13 - *Paroertlispongus multispinosus* Kozur & Mostler, 8) Pm/23a, 120 μm, 9) Pm/23b, 120 μm, 10) M/13, 120 μm, 11) S/2, 120 μm, 12) M/8, 120 μm, 13) S/3, 120 μm.

Figs 14-15 - *Paroertlispongus rarispinosus* Kozur & Mostler, 14) M/7, 120 μm, 15) M/6, 120 μm.

Figs 16-21 - *Oertlispongus inaequispinosus* Dumitrica, Kozur & Mostler, 16) Pm/2c, 120 μm, 17) Pm/2f, 120 μm, 18) M/15a, 120 μm, 19) Pm/2b, 120 μm, 20) M/15c, 120 μm, 21) Pm/2e, 120 μm.

Figs 22 - *Oertlispongus tumidospinosus* Kozur & Mostler, Pm/2a, 120 μm.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mary spine stout, with a short and thick stem. Distal part long and recurved around the spongy test, its distal end reaching a level much lower than the shell itself. Secondary polar spine present, however poorly preserved in our samples.

Remarks. This species differs from *O. inaequispinosus* in having a strongly recurved long polar spine with a short tumid stem.

Range (as published). Uppermost part of the *S. italicus* Radiolarian Zone to lowermost part of the *L. multiperforata* Radiolarian Zone according to Kozur & Mostler (1994) but up to the *M. cochleata* Radiolarian Zone according to Dumitrica (1999: 35).

Occurrence. Sample Pm. Rare.

Genus *Baumgartneria* Dumitrica, 1982a

Type species: *Baumgartneria retrospina* Dumitrica, 1982a

Baumgartneria retrospina Dumitrica, 1982a

Pl. 10, figs 1-7

1982a *Baumgartneria retrospina* Dumitrica, p. 70, pl. 9, figs non 3 (= *B. lata* Kozur & Mostler, 1994), 4-5, non 6 (= *B. lata* Kozur & Mostler, 1994), 7-8; pl.10, figs 1-2; pl. 12, fig. 3.

non 1990 *Baumgartneria retrospina* – Gorican & Buser, p. 141, pl. 3, fig. 3 (= *B. yehae* Kozur & Mostler, 1994).

1991 *Baumgartneria retrospina* – Mandl & Ondrejickova, p. 311.

1994 *Baumgartneria retrospina* – Kozur & Mostler, p. 63, pl. 12, figs 1, 4, non 5 (= *B. yehae* Kozur & Mostler, 1994), 6, 8-9.

1994 *Baumgartneria retrospina hemicircularis* Kozur & Mostler, p. 63, pl. 12, fig. 3.

1995 *Baumgartneria retrospina* – Kellici & De Wever, p. 144, pl. 1, fig. 6.

1996 *Baumgartneria retrospina* – Chiari et al., pl. 1, fig. 8.

1999 *Baumgartneria retrospina* – Dumitrica, fig. 2.

2003 *Baumgartneria retrospina* – Feng & Liang, p. 224, pl. 1, figs 14, 16, 19, non 15 (= *B. yehae* Kozur & Mostler, 1994).

2005 *Baumgartneria retrospina* – Feng et al., p. 247, pl. 4, figs 6-7.

Description. Spherical spongy shell bearing a main spine circular in cross section. Distal part of the spine with a needle-like prolongation of the stem (axial spine) and two long, simple and recurved lateral branches. Stem only occasionally as long as, or shorter than, the shell diameter, usually distinctly longer than the shell diameter. Axial spine well developed and occasionally as long as the stem itself. Branches show a virtually perfect bilateral symmetry, as occuring in the holotype (Dumitrica 1982a, pl. 9, fig. 8) and distinguishing the species from *Baumgartneria yehae* Kozur & Mostler, 1994 and *B. ambigua* Dumitrica, 1999. Only a single specimen (Pl. 10, fig. 7) shows a slight asymmetry of lateral branches, however not as much pronounced as in *B. yehae* where lateral branches appear “as if arising from two levels of the stem” (Dumitrica 1999: 37).

Remarks. *B. retrospina* in Gorican & Buser (1990) and partly in Feng & Liang (2003), have lateral branches asymmetrical and arising from different levels as in *B. yehae* Kozur & Mostler and, accordingly, they are synonymized here with the latter species. The same has already been made by Dumitrica (1999: 37) as far as a specimen figured in Kozur & Mostler (1994, pl.12, fig. 5) is concerned. The initial evolutionary stages of *Baumgartneria* from *Oertlispongus* envisaged by Dumitrica (1999) is in fact not proven since the assemblage in which *B. yehae* and *B. ambigua* occurred was later determined by Dumitrica (not yet published) as belonging to the *M. firma* Zone.

Range (as published). From the *O. primitivus* Subzone of the *S. italicus* Radiolarian Zone to the *L. annuloperforata* Subzone of the *L. multiperforata* Radiolarian Zone according to Kozur & Mostler (1994). Feng & Liang. (2003) reported abundant *B. retrospina* together with Muelleritortidae (*M. firma* and *M.* cf. *M. cochleata*) from China, assigning the corresponding assemblage to the late Ladinian *M. cochleata* Radiolarian Zone. The late Ladinian age suggested for an assemblage from Northwest Thailand (Feng et al. 2005) containing *B. retrospina* is inconsistent with the *O. inaequispinosus* Radiolarian Subzone (*S. italicus* Radiolarian Zone) to which the assemblage itself is assigned in the same paper.

Occurrence. Samples Sb, Pm, M. Abundant.

Genus *Falcispongus* Dumitrica, 1982a

Type species: *Falcispongus falciformis* Dumitrica, 1982a

Falcispongus falciformis Dumitrica, 1982a

Pl. 10, fig. 8

1982a *Falcispongus falciformis* Dumitrica, p. 66, pl. 1, fig. 5; pl. 2, figs 1, 3, 7; pl. 3, figs 2-3, 5-6.

1994 *Falcispongus falciformis* – Kozur & Mostler, p. 65, pl. 14, figs 2, 6, 12.

1994 *Falcispongus praefalciformis* Kozur & Mostler, p. 67, pl. 14, fig. 1.

1994 *Falcispongus priscus* Kozur & Mostler, p. 67, pl. 14, fig. 7, non 3-4, 11.

1994 *Falcispongus transitus* Kozur & Mostler, p. 67; pl. 2, fig. 1 in Dumitrica 1982a, according to Kozur & Mostler 1994.

2001 *Falcispongus falciformis* – Hauser et al., pl. 2, fig. 17.

2009 *Falcispongus falciformis* – Feng et al., p. 589, figs 4.13-4.16, 4.27-4.31.

Description. Spheroidal shell 120 μm in diameter. Primary spine sickle-shaped with only an outer hemicircular flattened wing arising from the distal part of the stem. Stem slender and slightly longer than the shell diameter. Angle between the stem and the distal part of the primary spine around 90°. Distal part of the main spine straigth. Neither secondary spine nor by-spines are present.

Remarks. *Falcispongus praefalciformis* Kozur & Mostler is clearly a junior synonym of *F. falciformis*. The holotype that Kozur & Mostler (1994) designated was chosen from the same assemblage (sample) from which *F. falciformis* was described and does not practically differ from the holotype of the latter species. The specimen illustrated herein differs from most specimens of the species in being very thin and in having a very narrow wing on the external part of the spine and no one on the internal part of the spine. It can be either an ontogenetically young specimen or a transitional morphotype between *Oertlispongus inaequispinosus* and *F. falciformis*.

Range (as published). *S. italicus* Radiolarian Zone to *L. multiperforata* Radiolarian Zone (Kozur & Mostler 1994: 65, 67).

Occurrence. Sample M. Very rare.

Falcispongus calcaneum Dumitrica, 1982a

Pl. 10, fig. 9

1982a *Falcispongus calcaneum* Dumitrica, p. 65, pl. 1, fig. 1; pl. 2, figs 2, 4-6, 8.

non 1984 *Falcispongus calcaneum* – De Wever, pl. 3, fig. 1.

non 1984 *Falcispongus calcaneum* – Lahm, p. 49, pl. 8, fig. 5.

1989 *Falcispongus calcaneum* – Martini et al., pl. 3, fig. 2.

1990 *Falcispongus calcaneum* – Gorican & Buser, p. 144, pl. 3, figs 4-6.

1994 *Falcispongus calcaneus* (sic) – Kozur & Mostler, p. 66.

1994 *Falcispongus postcalcaneus* (sic) Kozur & Mostler, p. 66, pl. 14, figs 5, 8-9.

1994 *Falcispongus priscus* Kozur & Mostler, p. 67, pl. 14, fig. 3,?11,?4, non 7.

1995 *Falcispongus calcaneum* – Kellici & De Wever, p. 145, pl. 1, fig. 10.

1999 *Falcispongus calcaneum* – Dumitrica, p. 38, pl. 2, fig. 1.

2001 *Falcispongus calcaneum* – Hauser et al., pl. 2, figs 21-22.

2003 *Falcispongus calcaneum* – Feng & Liang, p. 223, pl. 1, fig. 7.

Description. Spheroidal shell, strongly recrystallized. Primary spine sickle-shaped with only an outer wing arising from the distal part of the stem. Stem rather broad, shorter than shell diameter. Distal part of the main spine recurved. Neither secondary spine nor by-spines are present.

Remarks. Specimens figured in De Wever (1984) and Lahm (1984) have an additional wing along the inner side of the stem and, therefore, should be ascribed to other species (likely *Falcispongus hamatus* Dumitrica, 1980 and *Falcispongus falciformis* Dumitrica, 1980, respectively). Kozur & Mostler (1994) subdivided the specimens originally belonging to the type material of *Falcispongus calcaneum* Dumitrica, 1980 into two species, namely *Falcispongus calcaneum* Dumitrica, 1980 and *Falcispongus postcalcaneum* Kozur & Mostler, 1994, the latter being characterized by a shorter stem than the former. According to Dumitrica (1999), *Falcispongus postcalcaneum* Kozur & Mostler is a junior synonym of *Falcispongus calcaneum* Dumitrica; we follow here this interpretation. *Falcispongus priscus* Kozur & Mostler, by its holotype (Kozur & Mostler 1994, pl. 14, fig. 3), is a member (junior synonym) of the species *F. calcaneum* Dumitrica. Under *F. priscus* Kozur & Mostler (1994) illustrated specimens belonging to two species: *F. calcaneum* (pl. 14, fig. 3, and possibly 4 and 11) and *F. falciformis*, primitive stages (pl. 14, fig. 7). These two species are generally well distinguishable after the stem of the main spine (curved in the former and straight in the latter), curvature of the distal part of the spine, and the position of the blade; the latter is in the bending zone of the spine in *F. calcaneum* whereas it is closer to the proximal part of the stem in *F. falciformis*.

Range (as published). According to Kozur & Mostler (1994: 66) and Dumitrica (1999: 38-40, but see below), *Falcispongus calcaneum* (including *Falcispongus postcalcaneus* Kozur & Mostler, 1994 synonymized herein), ranges from the *O. primitivus* Subzone of *S. italicus* Radiolarian Zone to the late Fassanian, that is from the base of the *R. reitzi* Ammonoid Zone to the top of the *E. curionii* Ammonoid Zone (Kozur 2003: 64). According to Kozur & Mostler (1994: 66) morphotypes with broad and short stem (their *Falcispongus postcalcaneus*) like those described herein are the most advanced ones. The age of the sample I-623 in Dumitrica (1999) containing *Falcispongus calcaneum* and initially attributed to the *O. inaequispinosus* Radiolarian Subzone (Dumitrica 1999: 33) was later reassigned by Dumitrica (not yet published) to the *M. firma* Zone.

Occurrence. Sample Pm. Very rare.

Genus *Flexispongus* Lahm, 1984

Type species: *Oertlispongus cornubovis* Dumitrica,
Kozur & Mostler, 1980

Flexispongus cornubovis (Dumitrica, Kozur & Mostler, 1980)

Pl. 10, fig. 10

1980 *Oertlispongus cornubovis* Dumitrica, Kozur & Mostler, p. 5, pl. 10, figs 4, 9.

1984 *Flexispongus cornubovis* – Lahm, p. 47, pl. 8, fig. 1.

1994 *Oertlispongus cornubovis* – Kozur & Mostler, p. 59.

1995 *Oertlispongus cornubovis* – Kellici & De Wever, p. 150, pl. 1, fig. 7.

Description. Subellipsoidal spongy shell 150-180 µm in diameter with two opposite equal main polar spines round in cross section and needle-like in shape. Both spines are around 280 µm long and cow-horn-like curved. A straigth needle-like by-spine, also circular in cross section, lies on the equator of the shell perpendicularly to the main spines.

Remarks. Compared with the holotype, our specimens bear slenderer spines. A specimen with even slenderer spines is figured in Kellici & De Wever (1995). *Paurinella* Kozur & Mostler, 1981 shows similar main spines round in cross section which may be curved in the same way (*P. curvata* Kozur & Mostler, 1981) but this genus bears three main spines lying on the same plane instead of two main (polar) spines. Kozur & Mostler (1994) questioned the validity of the genus *Flexispongus* Lahm, regarding it as junior synonym of *Paroertlispongus* Kozur & Mostler, 1981. However, the genus *Flexispongus* is considered as valid by the revision of O'Dogherty et al. (2009b).

Range (as published). Middle Triassic (Dumitrica et al. 1980); late Anisian to early Ladinian (Lahm 1984; Kellici & De Wever 1995). O'Dogherty et al. (2009b; 2010) regard the genus *Flexispongus* Lahm as restricted to the late Anisian.

Occurrence. Sample M. Rare.

Family Pseudohagiastridae Dumitrica et al. (in press)

Genus *Acanthotetrapaurinella* Kozur & Mostler, 2006

Type species: *Acanthotetrapaurinella variabilis* Kozur & Mostler, 2006

Acanthotetrapaurinella vrielyncki (Kellici & De Wever, 1995) n. comb.

Pl. 10, fig. 11

1995 *Pararchaeospongoprunum? vrielyncki* Kellici & De Wever, p. 152, pl. 3, figs 12-14.

Description. Subspheroidal to inflated discoidal spongy shell, 160-180 µm in diameter, with four thin straigth spines, circular in cross section and needle-like in shape. Spines are tetrahedrally arranged, with three spines lying on the same plane and the fourth perpendicular to the others.

Remarks. The original diagnosis of the genus is too restricted. It mentions as taxonomic characters a spongy tetrahedral shell, 4 tetrahedrally arranged cylindrical spines bearing a crown of spinules. Of all these characters we exclude the crown of spinules that are characteristic of only the type species because, in our opinion, the three species originally described under this genus most likely are synonyms, *A. subovalis* Kozur & Mostler and *A.? bifida* Kozur & Mostler being nothing else than anomalies of *A. variabilis* Kozur & Mostler. The species described by Kellici & De Wever (1995) has a sligthy larger shell (220-260 µm) but it is otherwise very similar to our specimens which conform to the diagnosis of genus *Acanthotetrapaurinella* Kozur & Mostler, 2006.

Range (as published). Late Anisian to early Ladinian (Kellici & De Wever 1995).

Occurrence. Sample M. Very rare.

Genus *Cantalum* Pessagno, 1979 in Pessagno et al., 1979

Type species: *Cantalum holdsworthi* Pessagno, 1979 in Pessagno et al., 1979

Remarks. *Cantalum* was originally considered a pantanelliid genus with 4 tetrahedrally arranged three-bladed spines. Dumitrica et al. (in press) interpreted it as a genus with spongy test rather similar to that of *Acanthotetrapaurinella* Kozur & Mostler.

Cantalum? sp. ind.

Pl. 10, fig. 12

Description. Spherical cortical shell, around 130 µm in diameter, with latticed framework. Four equal slender spines in irregular tetrahedral arrangement, up to 150 µm long. Spines are proximally three-bladed then distalwards becoming needle-like and circular in cross section. Internal skeleton not known.

Remarks. A single specimen. Owing to the poor preservation, the attribution to the genus *Cantalum* is highly tentative. In the species of *Cantalum* so far known the spines are usually equal and arranged in a regular tetrahedral pattern whereas in the species/specimen illustrated here the upward directed spines seems to be smaller and the arrangement of spines is not perfectly tetrahedral. Moreover, the test has a surely latticed cortical shell, whereas in *Cantalum* the latter is spongy. Given the position and length of the upward directed spine, it is possible that this specimen is a four-spined anomaly of a normally three-spined species possibly belonging to the genus *Sepsagon*.

Range (this study). Lower *E. curionii* Ammonoid Zone, early Ladinian.

Occurrence. Sample M. Rare.

Spumellaria incertae sedis

Genus *Thaisphaera* Sashida & Igo, 1992

Type species: *Thaisphaera minuta* Sashida & Igo, 1992

Thaisphaera? sp. cf. **T. minuta** Sashida & Igo, 1992

Pl. 10, figs 13-15

? 1992 *Thaisphaera minuta* Sashida & Igo, p. 1306, figs 4.8, 4.11-4.14, 4.16-4.17.

Description. Spherical shell, 170-190 µm in diameter, with latticed framework made up of variably-sized pore frames with small nodes on the vertices. 8 (10?) short spines; conical in shape with a proximal part triangular in cross section.

Remarks. Due to their poor preservation, the attribution of our specimens to this species is only tentative.

Range (this study). Lower *E. curionii* Ammonoid Zone, early Ladinian. *Thaisphaera minuta* is known from the late Spatian to the early Anisian (Sashida & Igo 1992). According to O'Dogherty et al. (2009b; 2010) the genus *Thaisphaera* ranges from the late Induan to the early Anisian.

Occurrence. Samples S, M, VP8. Common.

Genus *Pessagnollum* Kozur, Krainer & Mostler, 1996

Type species: *Pessagnollum multispinosus* Kozur, Krainer & Mostler, 1996

Pessagnollum? hexaspinosum n. sp.

Pl. 10, figs 16-19

Etymology: According to the occurrence of six spines.

Holotype: The specimen MCSN 8362 (sample Sb), Pl. 10, figs 16-18.

Paratypes: The specimen MCSN 8363 (sample Sb), Pl. 10, fig. 19.

Type locality: Val Porina, Monte San Giorgio, Canton Ticino, Southern Switzerland.

Type horizon: Basal section of the San Giorgio Dolomite, lower part of the *E. curionii* Ammonoid Zone (= uppermost part of the *L. multiperforata* Radiolarian Zone), early Ladinian, Middle Triassic.

Description. Test with spherical cortical shell with six spines. Wall of cortical shell consisting of large and high polygonal pore frames, mostly hexagonal. Six short stout pyramidal spines, arranged along three axes almost mutually orthogonal to each other. Spines are tricarinate with very wide grooves each ending in a pore of the cortical shell. The distal end of the spines is pointed and circular in cross section. Inner structure unknown.

Measurements. Diameter of the cortical shell = 180-186 μm, length of the spines = 52-56 μm, width of the base of the spines = 32 μm.

Comparisons. Genus *Pessagnollum* was introduced by Kozur et al. (1996) to include spherical morphotypes with short pyramidal spines and cortical pore frames "typical for the Pantanelliidae" Pessagno, 1977, the family to which the genus was firstly attributed (Kozur et al. 1996: 226). The inner structure is however unknown and according to the revision of O'Dogherty et al. (2009b) the genus has to be regarded as incertae sedis. In fact, the original description of the genus and type species that made the authors to include this taxon under the Pantanellidae is not correct. It mentions that the shell has "two short, broad, pyramidal tricarinate polar spines and several smaller by-spines of similar shape concentrated to the equatorial plane", but the only photo illustrating these characters shows three bigger spines, and the so-called polar spines are not at all polar (coaxial): whereas the upper one is in the plane of the photo, the lower one is obliquely upward directed. In this situation, we assigned questionably this new species to the genus *Pessagnolum*. *P. multispinosum* Kozur, Krainer & Mostler, 1996 has two polar spines of comparable size and shape but differs in having somewhat smaller pore frames and 6-8 shorter spines on the equatorial plane.

Range. Lower *E. curionii* Ammonoid Zone, early Ladinian (this study). According to O'Dogherty et al (2009b; 2010), the genus *Pessagnollum* is restricted to the middle Anisian.

Occurrence. Sample Sb. Rare.

Genus *Carinaheliosoma* Kozur & Mostler 1981

Type species: *Carinaheliosoma densiporata* Kozur & Mostler, 1981.

Carinaheliosoma? sp. ind.

Pl. 10, fig. 20

Description. Spherical, likely latticed shell around 160-170 μm in diameter bearing 14 short three-bladed, pyramidal spines with a broad base and gently tapering distalwards. Most blades are interconnected on the test surface by ridges outlining polygonal areas.

Remarks. The poor preservation of these specimens precludes a definitive investigation of the shell structure which, however, most likely appears as having been constituted by medium- to large-sized pore frames. The genus *Carinaheliosoma* seems to be the only one to which we could tentatively assign this species.

Range (this study). Lower *E. curionii* Ammonoid Zone, early Ladinian.

Occurrence. Sample M. Very rare.

Genus *Ticinosphaera* gen. n.

Type species: *Helioentactinia mesotriassica* Kozur & Mostler, 1981 in Lahm 1984

Etymology: From the Canton Ticino, the region to which the Monte San Giorgio belongs.

Diagnosis: Test spherical consisting of two latticed shells, a small microsphere and a spherical cortical shell, interconnected by more than seven radial bars that are extended outside into three-bladed spines. Initial spicule quite probably absent.

Remarks. This new genus is erected to comprise Triassic species assigned until present to the Paleozoic genus *Helioentactinia* Nazarov and partly to the Triassic genus *Parentactinosphaera* Kozur & Mostler (see discussion under this genus). It differs from the genus *Astrocentrus* Kozur & Mostler, 1979, that also shows a spherical shell with many three-bladed spines, in having a latticed instead of a spongy shell.

Range. Anisian to Carnian so far as known.

Ticinosphaera mesotriassica (Kozur & Mostler, 1981) n. comb.

Pl. 10, figs 21-25; Pl. 11, figs 1-4

1981 *Helioentactinia mesotriassica* Kozur & Mostler, p. 17, pl. 55, fig. 3.

1984 *Helioentactinia mesotriassica* – Lahm, p. 19, pl. 2, fig. 4.

1984 *Helioentactinia oertlii* – Lahm, p. 19, pl. 2, fig. 2, non 3.

1995 *Helioentactinia oertlii* – Kellici & De Wever, p. 148, pl. 2, fig. 10.

Description. Spherical latticed cortical shell 220-320 µm in diameter with irregular polygonal meshwork. Twelve main three-bladed spines with very sharp and high ridges separated by wide grooves. Spines are 30-38 µm wide proximally and seemengly they do not taper distalwards. Very numerous needle-like by-spines are usually visible, even in poorly preserved specimens. They are evenly distributed over the shell surface and may branch distally.

Remarks. Shell diameter of our specimens usually exceeds that of the type material (140-210 µm). We included in the synonymy list only one of the two specimens illustrated by Lahm as *H. oertlii* because the other one (Lahm 1984, pl. 2, fig. 3) clearly shows only six internal radial bars.

Range (as published). Late Anisian? to early Carnian (Lahm 1984).

Occurrence. Samples Sb, S, Pm, M. Abundant.

Genus *Lahmosphaera* gen. n.

Type species: *Stauracontium? alpinum* Dumitrica, Kozur & Mostler, 1980.

Etymology: The genus is dedicated to Dr. Bernhard Lahm, Germany, in honour of his contribution to the knowledge of Triassic Radiolaria.

Diagnosis: Test consisting of two concentric latticed shells, a globular microsphere and a spherical to lens-shaped cortical shell, interconnected by 6 three-bladed radial bars of which four, lying crosswisely in the equatorial plane, are prolonged outside into four three-bladed spines. The other two radial spines have a polar position and stop in the cortical shell. Cortical shell with or without additional three-bladed spines arranged more or less regularly on its surface. Microsphere seemingly without initial spicule.

Remarks. Besides the type species, we include in this genus late Anisian and Ladinian species with the characters mentioned in the diagnosis. It seems to include *Plafkerium? muelleri* Dumitrica, Kozur & Mostler, 1980, *Stauracontium? granulosum* Dumitrica, Kozur & Mostler, 1980, *Staurosphaera trispinosa* Kozur & Mostler, 1979, and maybe other species. Owing to the poor preservation of the microsphere in the type material, the presence of an initial spicule inside it could not be ascertained.

Range. Late Anisian to early Ladinian so far as known.

Lahmosphaera alpina (Dumitrica, Kozur & Mostler, 1980) n. comb.

Pl. 11, figs 5-8

1980 *Stauracontium? alpinum* Dumitrica, Kozur & Mostler, p. 17, pl. 2, fig. 3; pl. 14, fig. 1.

1984 *Hexacontium mesotriassicum* Dumitrica, Kozur & Mostler – Lahm, p. 77, pl. 13, fig. 11.

? 1984 *Stauracontium alpinum* – Lahm, p. 77, pl. 13, fig. 10.

Description. Spherical large-pored latticed cortical shell, 200-220 µm in diameter, with rounded hexagonal, less frequently pentagonal, pore frames. Usually ten pores on the diameter of the shell. Spiny vertices of the pore frames. Four coplanar, crosswisely arranged, equal main spines. Their proximal part is broad and tricarinate, with high blades and deep and wide grooves each ending in a pore of the cortical shell. The distal part is rod-like and longer than the proximal one. From the base on, the ridges of the spines run laterally along the shell forming concave-upward ribs. After having

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PLATE 10

Scanning electron photomicrographs of radiolarians from the San Giorgio Dolomite (*E. curionii* Ammonoid Zone, early Ladinian). All material is from Val Porina. For each figure, sample/specimen number, catalogue number (for type material) and value of scale bar are indicated.

Figs 1-7 - *Baumgartneria retrospina* Dumitrica, 1) Pm/1e, 120 µm, 2) Pm/1b, 120 µm, 3) M/b31b, 120 µm, 4) Pm/1a, 120 µm, 5) Pm/1f, 120 µm, 6) M/b31a, 120 µm, 7) Pm/1c, 120 µm.

Fig. 8 - *Falcispongus falciformis* Kozur & Mostler, M/b24, 120 µm.

Fig. 9 - *Falcispongus calcaneum* Dumitrica, Pm/3, 120 µm.

Fig. 10 - *Flexispongus cornubovis* (Dumitrica, Kozur & Mostler), M/9, 120 µm.

Fig. 11 - *Acanthotetrapaurinella vrielyncki* (Kellici & De Wever), M/23, 100 µm.

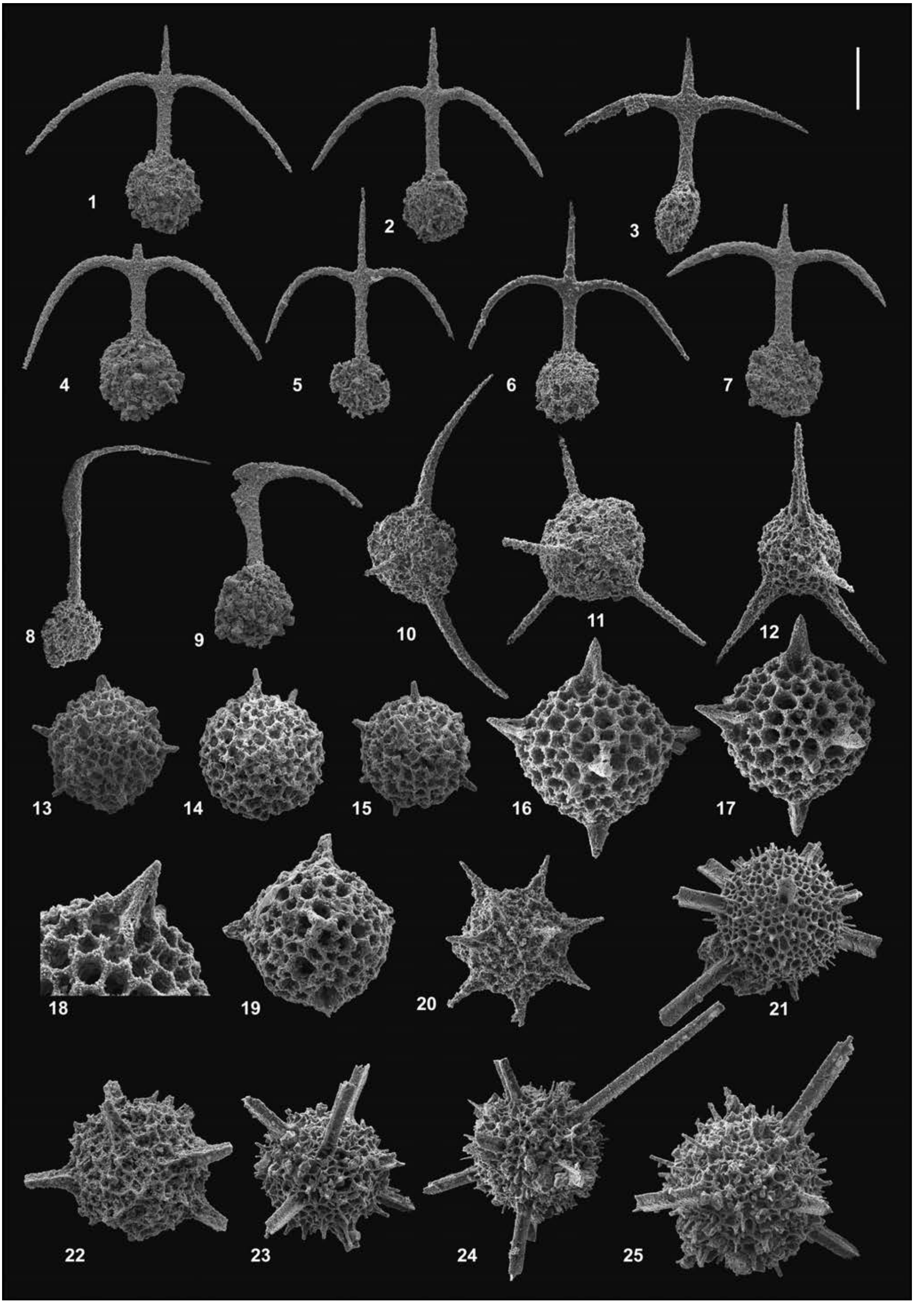
Fig. 12 - *Cantalum?* sp. ind., M/b19, 100 µm.

Figs 13-15 - *Thaisphaera?* sp. cf. *T. minuta* Sashida & Igo, 13) VP8/18, 100 µm, 14) VP8/12, 100 µm, 15) M/14, 100 µm.

Figs 16-19 - *Pessagnollum? hexaspinosum* n. sp., 16-17) MCSN 8362, holotype, total view, 80 µm, 18) MCSN 8362, holotype, detail of cortical shell and spines, 50 µm, 19) MCSN 8363, paratype, 80 µm.

Fig. 20 - *Carinaheliosoma?* sp. ind., M/20, 100 µm.

Figs 21-25 - *Ticinosphaera mesotriassica* (Kozur & Mostler), 21) Sb/40a, 120 µm, 22) Pm/32d, 120 µm, 23) S/21, 120 µm, 24) S/23, 120 µm, 25) S/40, 120 µm.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separated two couple of pores on each side, ribs distally end into a tricarinate, less frequently tetracarinate, short spine. These are stout, wider than high, with very broad grooves and sharp ridges extending to tips. Length of carinate proximal part of the four main spines= 28-38 µm, maximal preserved length of rod-like distal part of the four main spines = 82 µm, width of the base of the four main spines = 35 µm, length of the shorter spines = 30 µm, width of the shorter spines= 34-40 µm.

Remarks. *Lahmosphaera trispinosa* has branched spines, *L. muelleri* and *L. granulosa* have twisted spines. In addition, all these species lack the stout additional spines typical of *L. alpina*.

Range (as published). Late Anisian to early Ladinian (Dumitrica et al. 1980; Lahm 1984).

Occurrence. Samples S, Sb. Rare.

Lahmosphaera trispinosa (Kozur & Mostler, 1979) n. comb.

Pl. 11, figs 9-15

1979 *Staurosphaera trispinosa* Kozur & Mostler, p. 58, pl. 21, fig. 3.

1979 *Staurosphaera triloba* Nakaseko & Nishimura, p. 72, pl. 5, figs 1-2.

1980 *Stauracontium? trispinosum ladinicum* Dumitrica, Kozur & Mostler, p. 17, pl. 1, fig.? 5; pl. 2, fig. 4; pl. 3, figs 6-7; pl. 5, fig. 4; pl. 14, fig. 5.

1984 *Stauracontium? trispinosum* – Lahm, p. 76, pl. 13, fig. 8.

1989 *Stauracontium? trispinosum ladinicum* – Yeh, p. 68, pl. 3, fig. 7.

1990 *Stauracontium? trispinosum* – Gorican & Buser, p. 158, pl. 1, fig. 2.

1990 *Staurocontinum?* (sic) *trispinosum ladinicum* – Kolar-Jurkovsek, pl. 4, figs 1a-1b, 2.

1995 *Stauracontium? trispinosum* – Kellici & De Wever, p. 162, pl. 5, fig. 19; pl. 6, figs 1-2.

1995 *Stauracontium? trispinosum* – Chiari et al., pl. 3, fig. 8.

1995 *Stauracontium? trispinosum* – Ramovs & Gorican, p. 196.

1996 *Staurolonche trispinosum trilobum* (Nakaseko & Nishimura) – Kozur et al., p. 228, pl. 10, fig. 16.

1999 *Staurolonche trispinosum trilobum* – Sashida et al., p. 771, fig. 8.18.

2001 *Staurolonche trispinosa* – Feng et al., p. 198, pl. 8, fig. 3.

2006 *Staurolonche trispinosa* – Marquez et al., pl. 6, fig. 7.

2010 *Staurolonche trispinosa* – Tekin & Sönmez, fig. 6F.

2011 *Stauracontium trispinosum* – Ozsvárt et al., fig. 10.6.

Description. Spheroidal latticed shell 140-180 µm in diameter, with well-defined polygonal pore frames. Very short by-spines arise from the nodal points. Four stout main spines crosswisely arranged and shorter than the shell diameter. Spines three-bladed with sharp ridges and wide grooves. The distal part of each spine branches forming a verticil of three lateral triangular spinules, short and aligned with the ridges of the spines. Behind the verticils, a needle-like prolongation of the spines always occurs.

Remarks. Two subspecies have been proposed for morphotypes similar to the present one, based on features and position of the distal spinules composing the verticils (Kozur et al. 1996), namely *Staurolonche trispinosum trispinosum* (Kozur & Mostler, 1979 = *Staurosphaera trispinosa* Kozur & Mostler, 1979) and *Staurolonche trispinosum trilobum* (Nakaseko & Nishimura, 1979 = *Staurosphaera triloba* Nakaseko & Nishimura, 1979). *Staurolonche trispinosum ladinicum* Dumitrica, Kozur & Mostler, 1980 is a junior synonym of the latter subspecies (Kozur et al. 1996). In our specimens the three distal spinules composing the verticiles are usually poorly developed and distinctly shorter than the proximal part of the main spines before the verticiles. Following the subdivision of Kozur et al. (1996), this would be suggestive of an assignment to "*Staurolonche*" *trispinosum trilobum* (Nakaseko & Nishimura, 1979). However, differentiation to a subspecific rank has been questioned because of the occurrence of transitional morphotypes in the same populations (Lahm 1984) and usually it was not applied (Gorican & Buser 1990; Feng et al. 2001; Marquez 2006; Tekin & Sönmez 2010). Such a subspecific subdivision is avoided here as well. *Staurolonche* Haeckel, 1881 (as well as *Staurosphaera* Haeckel, 1881) is a nomen dubium (O'Dogherty et al. 2009a,c). *Stauracontium* Haeckel, 1881 is a valid genus name but erroneously used for Mesozoic occurrences (O'Dogherty et al. 2009a).

Range (as published). Illyrian to Carnian (Kozur et al. 1996). Kozur et al. (1996) suggested a gradual transition from morphotypes with short lateral spinules (*S. trispinosum trilobum*), which dominates in the Illyrian, to morphotypes with long lateral spinules (*S. trispinosum trispinosum*), which are the only ones occurring in Carnian assemblages. However, the occurrence

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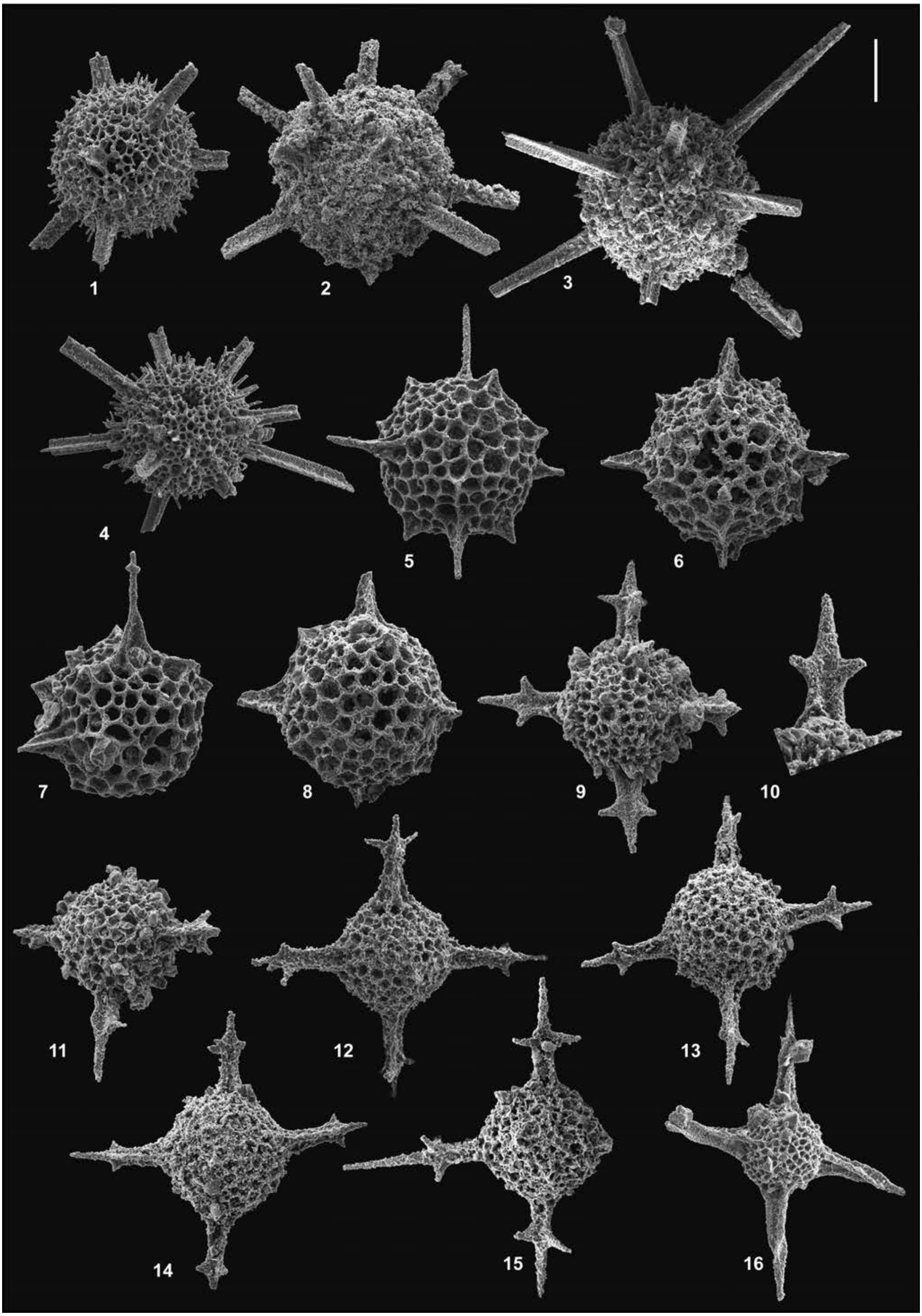
PLATE 11

Scanning electron photomicrographs of radiolarians from the San Giorgio Dolomite (*E. curionii* Ammonoid Zone, early Ladinian). All material is from Val Porina. For each figure, sample/specimen number and value of scale bar are indicated.

Figs 1-4	- *Ticinosphaera mesotriassica* (Kozur & Mostler), 1) Sb/40b, 120 µm, 2) Pm/32a, 120 µm, 3) S/39, 120 µm, 4) Sb/28, 120 µm.
Figs 5-8	- *Lahmosphaera alpina* (Dumitrica, Kozur & Mostler), 5) Sb/51b, 80 µm, 6) S31, 80 µm, 7) Sb/53a, 80 µm, 8) Sb/51a, 80 µm.
Figs 9-15	- *Lahmosphaera trispinosa* (Kozur & Mostler), 9) S/15b, total view, 80 µm, 10) S/15b, detail of a spine, 50 µm, 11) S/15a, 80 µm, 12) M/b20, 80 µm, 13) Pm/25c, 80 µm, 14) Pm/25d, 80 µm, 15) Pm/25b, 80 µm.
Fig. 16	- *Lahmosphaera muelleri* (Dumitrica, Kozur & Mostler), Sb/40b, 120 µm.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of morphotypes with short lateral spinules at least up to the late Ladinian *M. cochleata* Radiolarian Zone has been recently confirmed (Tekin & Sönmez 2010).

Occurrence. Samples S, Pm, M. Abundant.

Lahmosphaera muelleri (Dumitrica, Kozur & Mostler, 1980) n. comb.

Pl. 11, fig. 16

1980 *Plafkerium ? muelleri* Dumitrica, Kozur & Mostler, p. 14, pl. 1, fig. 3.

1990 *Stauracontium? granulosum* Dumitrica, Kozur & Mostler – Gorican & Buser, p. 158, pl. 1, fig. 1.

1995 *Plafkerium? muelleri* – Kellici & De Wever, p. 156, pl. 4, fig. 6.

Description. Spherical cortical shell, around 100-110 µm in diameter, with latticed framework. Small pores irregularly framed. Four main spines destrally torsioned except in their short proximal part, coplanar and crosswisely arranged. Spines are three-bladed with high ridges and wide grooves, around 140-150 µm long. They gently taper to the distal part which can bear a needle-like prolongation.

Remarks. The specimen illustrated in Gorican & Buser (1990) cannot be assigned to *Lahmosphaera granulata*, which bears sinistrally-torsioned spines.

Range (as published). Anisian to Ladinian according to Sashida et al. (1999).

Occurrence. Sample S. Rare.

Entactinaria or Spumellaria incertae sedis

"Entactinosphaera"? sp. cf. "E". triassica Kozur & Mostler, 1979

Pl. 12, fig. 1

cf. 1979 *Entactinosphaera triassica* Kozur & Mostler, p. 70, pl. 6, fig. 2.

cf. 1984 *Entactinosphaera? triassica* – Lahm, p. 18, pl. 1, fig. 12.

Description. Spherical to subellipsoidal cortical shell around 200 µm in diameter with six long main spines along three mutually perpendicular axes. Main spines three-bladed, with sharp and high ridges and wide grooves. As far as they are preserved, main spines do not appear to taper distalwards. Numerous long needle-like by-spines are visible, even in poorly preserved specimens.

Remarks. The general morphology of our specimens resembles that of *Entactinosphaera triassica* Kozur & Mostler, but given their poor preservation and their occurrence in the early Ladinian we doubt of their assignation to this species originally described from Carnian sediments. By-spines never occur in similar species, such as "*Entactinosphaera*"? *simoni* Kozur & Mostler, 1979 and "*E.*" *zapfei* Kozur & Mostler, 1979 (see also Lahm 1984). Genus *Entactinosphaera* Foreman, 1967 is a junior synonym of *Trilonche* Hinde, 1899 (family Entactiniidae Riedel, 1967a; De Wever et al. 2001: 180) which was erroneously used for Mesozoic occurrences (O'Dogherty et al. 2009a). However, preservation of our material precludes any re-assignment at generic level of the species originally included in *Entactinosphaera.*

Range (as published). Late Anisian? to early Carnian (Lahm 1984).

Occurrence. Sample Pm. Rare.

"Entactinosphaera"? zapfei Kozur & Mostler, 1979

Pl. 12, fig. 2

1979 *Entactinosphaera? zapfei* Kozur & Mostler, p. 71, pl. 14, fig. 2.

1984 *Entactinosphaera? zapfei* – Lahm, p. 16, pl. 1, fig. 9.

Description. Latticed spherical cortical shell around 160 µm in diameter with large pore frames and with six long main spines along three mutually perpendicular planes. Spines three-bladed, with sharp ridges and wide grooves. As far as they are preserved, main spines do not appear to taper distalwards and are sometimes slightly twisted. The vertices of the pore frames bear exclusively small nodes, by-spines are absent.

Remarks. The general morphology of our specimens resembles that of *Entactinosphaera*? *zapfei* Kozur & Mostler but owing to their poor preservation and their occurrence in the early Ladinian the assignation to this Carnian species appears as questionable. In "*Entactinosphaera*"? *triassica* Kozur & Mostler, 1979 by-spines are always present whereas "*E.*"? *simoni* Kozur & Mostler, 1979 shows smaller pore frames (Kozur & Mostler 1979; Lahm 1984). About the validity of the generic attribution see also remarks under "*E.*"? *triassica.*

Range (as published). Early Carnian (Lahm 1984).

Occurrence. Sample S. Rare.

Gen. et sp. ind.

Pl. 12, fig. 3

Description. Spheroidal latticed shell, subhexagonal in equatorial outline, 150 µm in diameter, with polygonal pore frames of irregular size. Eight tricarinate stout spines with sharp ridges and wide and deep longitudinal grooves. Spines unequal, all branching at a short distance from the cortical shell, forming three more or less complete lateral spinules at each verticil. Lateral spinules are medium-sized and aligned with the ridges of the spines. After the verticils a (tricarinate?) prolongation of the spines occurs.

Remarks. Poorly preserved. The specimen figured in Kozur et al. (1996, pl. 7, fig. 8) and described as *Livinallongella* aff. *lahmi* Kozur, Krainer & Mostler, 1996 looks very similar to our specimens; *Livinallongella* Lahm, 1984 (junior synonim of *Parentactinosphaera* Kozur & Mostler, 1979; O'Dogherty et al. 2009b), however, has 7 spines.

Range (this study). Lower *E. curionii* Ammonoid Zone, early Ladinian.

Occurrence. Sample Sb. Rare.

Order **Nassellaria** Ehrenberg, 1875

Family Poulpidae De Wever, 1981

Genus *Poulpus* De Wever, 1979

Type species: *Poulpus piabyx* De Wever, 1979

Poulpus curvispinus Dumitrica, Kozur & Mostler, 1980

Pl. 12, figs 4-5

1980 *Poulpus curvispinus* Dumitrica, Kozur & Mostler, p. 22, pl. 2, fig. 1; pl. 15, figs 5-6.

1987 *Poulpus curvispinus* – Kojima & Mizutani, p. 261, fig. 2.16.

1989 *Poulpus curvispinus* – Yeh, p. 73, pl. 14, fig. 1.

1990 *Poulpus curvispinus* – Gorican & Buser, p. 153, pl. 9, figs 1-2.

1994 *Poulpus curvispinus curvispinus* Dumitrica, Kozur & Mostler – Kozur & Mostler, p. 116, pl. 32, figs 5, 8.

1994 *Poulpus curvispinus praecurvispinus* Kozur & Mostler, p. 116, pl. 32, figs 3, 6-7.

1999 *Poulpus curvispinus cuvispinus* (sic) – Tekin, p. 160, pl. 38, figs 1-2.

Description. Hemiglobular cephalis with three long tricarinate feet sharply bent downwards. Total shell height around 240 μm, width of cephalis 88 μm, height of cephalis 78 μm, length of feet 175-185 μm. The two external blades of the feet enclose a rounded groove (which, according to the original diagnosis, should correspond to a large pore in the cephalis wall).

Remarks. Kozur & Mostler (1994) distinguished the two subspecies *Poulpus curvispinus curvispinus* Dumitrica, Kozur & Mostler, 1980 and *Poulpus curvispinus praecurvispinus* Kozur & Mostler, 1994 on the basis of, respectively, presence or absence of distinct nodes on the cephalis. The poor preservation of our material precludes the observation of this feature, thus hindering the determination at a subspecific level.

Range (as published). According to Kozur & Mostler (1994: 116) and Tekin (1999: 160) *Poulpus curvispinus* (cumulated range of both subspecies) ranges from the *O. primitivus* Subzone of *S. italicus* Radiolarian Zone to the *S. fluegeli* Subzone of the *M. cochleata* Radiolarian Zone.

Occurrence. Samples S, Pm. Very rare.

Genus *Hozmadia* Dumitrica, Kozur & Mostler, 1980

Type species: *Hozmadia reticulata* Dumitrica, Kozur & Mostler, 1980

Hozmadia sp. cf. **H. reticulata** Dumitrica, Kozur & Mostler, 1980

Pl. 12, fig. 6

cf. 1980 *Hozmadia reticulata* Dumitrica, Kozur & Mostler, p. 21, pl. 9, figs 9-10.

cf. 1990 *Hozmadia reticulata* – Gorican & Buser, p. 147, pl. 9, figs 8-10.

cf. 1994 *Hozmadia reticulata* – Kozur & Mostler, p. 114, pl. 31, fig. 4.

cf. 1995 *Hozmadia reticulata* – Kellici & De Wever, p. 148, pl. 2, figs 17-18.

cf. 1995 *Hozmadia reticulata* – Ramovs & Gorican, p. 186, pl. 7, figs 1-4.

cf. 2000 *Hozmadia reticulata* – Wenchen & Ning, p. 82, pl. 3, fig. 4.

Description. Hemiglobular cephalis crossed by ridges. Apical horn excentrical. Three carinate feet slightly bent downwards. Total shell height around 200 μm, width of cephalis 85 μm, height of cephalis 100 μm, length of feet 105 μm.

Remarks. A single specimen with broken-off apical horn, whose poor preservation precludes a definitive discrimination between *Hozmadia reticulata* Dumitrica, Kozur & Mostler 1980 and its forerunner *H. costata* Kozur & Mostler, 1994.

Range (this study). Lower *E. curionii* Ammonoid Zone, early Ladinian. *Hozmadia reticulata* occurs in the *S. transitus* and S. *italicus* Radiolarian Zones (Kozur & Mostler 1994; Ramovs & Gorican 1995). Wenchen & Ning (2000: 82) extended the range up to the Late Triassic.

Occurrence. Sample M. Very rare.

Hozmadia sp. ind.

Pl. 12, fig. 7

Description. Large, hemiglobular cephalis covered with ridges and bearing a stout, three-bladed apical horn. Three long three-bladed and proximally four bladed feet, curved downwards. Total shell height around 310 μm, width of cephalis 100 μm, height of cephalis 120 μm, length of feet 135-145 μm.

Remarks. A single, poorly preserved specimen. It differs from both *H. reticulata* Dumitrica, Kozur & Mostler and *H. costata* Kozur & Mostler, with which it resembles most, by having longer feet and a rather blunt apical horn. Morphologically, the species could also be assigned to the genus *Eonapora*, but the absence of a distal thoracic skirt and the presence of four blades in the proximal part, resulted by the prolongation of the apertural bord and of the crests of the arches VL, Ll and lD, substantiates the assignment to the genus *Hozmadia*.

Range (this study). Lower *E. curionii* Ammonoid Zone, early Ladinian.

Occurrence. Sample M. Very rare.

Genus *Eonapora* Kozur & Mostler, 1979

Type species: *Eonapora pulchra* Kozur & Mostler, 1979

Eonapora? sp. cf. **E. longispinosa** Kozur & Mostler, 1994

Pl. 12, fig. 8

cf. 1980 *Eonapora* sp. Dumitrica, Kozur & Mostler, p. 21, pl. 9, figs 3-4.

cf. 1994 *Eonapora longispinosa* Kozur & Mostler, p. 112, pl. 30, figs 6, 9.

Description. Large, hemiglobular cephalis covered with ridges and bearing a very long, stout, three-bladed apical horn. Three long three-bladed feet, straigth or only very sligthly curved. Total shell height around 390 µm, width of cephalis 150 µm, height of cephalis 120 µm, length of feet 170-180 µm.

Remarks. A single, uncomplete specimen.

Range (this study). Lower *E. curionii* Ammonoid Zone, early Ladinian. According to Kozur & Mostler (1994), *Eonapora longispinosa* ranges from the *O. inaequispinosus* Subzone of the *S. italicus* Radiolarian Zone to the *L. multiperforata* Radiolarian Zone.

Occurrence. Sample S. Very rare.

Family Ultranaporidae Pessagno, 1977

Genus *Silicarmiger* Dumitrica, Kozur & Mostler, 1980

Type species: *Silicarmiger costatus* Dumitrica, Kozur & Mostler, 1980

Silicarmiger costatus Dumitrica, Kozur & Mostler, 1980

Pl. 12, figs 9-13

1980 *Silicarmiger costatus* Dumitrica, Kozur & Mostler, p. 23, pl. 7, figs 1-6; pl. 14, fig. 4; pl. 15, fig. 2.

1990 *Silicarmiger costatus* – Gorican & Buser, p. 156, pl. 10, fig. 8.

1994 *Silicarmiger costatus costatus* Dumitrica, Kozur & Mostler – Kozur & Mostler, p. 118, pl. 33, figs 6, 15-16; pl. 34, fig. 8.

1994 *Silicarmiger costatus magnicornus* Kozur & Mostler, p. 118, pl. 33, fig 10; pl. 34, fig. 7.

1995 *Silicarmiger costatus* – Kellici & De Wever, p. 160, pl. 5, figs 11-14.

Description. Pyramidal nassellarian with globular cephalis; total shell height 370-400 µm. Stout three-bladed apical horn, 80-120 µm long, sometimes with needle-like distal end. Thorax with irregular pores formed by short bars extending between 5-7 irregular transverse ribs. Feet up to 170 µm long; they are needle-like with round cross-section except for the tricarinate proximal part.

Remarks. Kozur & Mostler (1981, 1994) lowered *Silicarmiger costatus* Dumitrica, Kozur & Mostler 1980 to a subspecific rank (*S. costatus costatus*) and introduced two new subspecies: *S. costatus anisicus* Kozur & Mostler, 1981 and *S. costatus magnicornus* Kozur & Mostler, 1994. Gorican & Buser (1990) and Kellici & De Wever (1995) regarded *S. costatus anisicus* Kozur & Mostler, characterized by a low number of ribs (3-4) and strong feet, as a synonym of *S. costatus costatus* Dumitrica, Kozur & Mostler 1980. However, this is questionable because even though *S. costatus anisicus* is similar to the juvenile specimen of *S. costatus* figured in Dumitrica et al. 1980 (pl. 15, fig. 2), Kozur & Mostler (1981: 104) clearly stated that the morphotype they attributed to *S. costatus anisicus* is the only one occuring in their Anisian material (*P. trinodosus* Ammonoid Zone) together with juveniles which, in turn, differ from the juvenile specimen of *S. costatus* Dumitrica, Kozur & Mostler, 1980 cited above. This observation of Kozur & Mostler (1981) is corroborated by the composition of the Pelsonian radiolarian assemblages from Cristian, Romania (unpublished) which contain only the morphotype of *S. costatus anisicus*. Our material compares well with *S. costatus costatus* Dumitrica, Kozur & Mostler, 1980 and partly with *S. costatus magnicornus* Kozur & Mostler, 1994, also including transitional morphotypes between the two subspecies. According to Kozur & Mostler (1994: 118) *S. costatus magnicornus* bears a very large, stout apical horn with a broad straight proximal part (Pl. 12, figs 9, 12; compare with Kozur & Mostler 1994, pl. 33, fig. 10). Conversely, in *S. costatus costatus* the apical horn continuously tapers from the broad base to the distal part (Pl. 12, figs 10-11; compare with Kozur & Mostler 1994, pl. 33, fig. 16).

Range (as published). According to Kozur & Mostler (1994) *S. costatus costatus* ranges from the early to the middle Fassanian, whereas *S. costatus magnicornus* occurs in the middle Fassanian.

Occurrence. Samples Sb, Pm, M. Rare.

Family Ruesticyrtiidae Kozur & Mostler, 1979

Genus *Pararuesticyrtium* Kozur & Mock in Kozur & Mostler, 1981

Type species: *Pararuesticyrtium densiporatum* Kozur & Mock in Kozur & Mostler, 1981

Pararuesticyrtium? sp. aff. **P. eofassanicum** Kozur & Mostler, 1994

Pl. 12, fig. 14

aff. 1994 *Pararuesticyrtium eofassanicum* Kozur & Mostler, p. 109, pl. 28, figs 5-6, 10, 12; pl. 43, fig. 13.

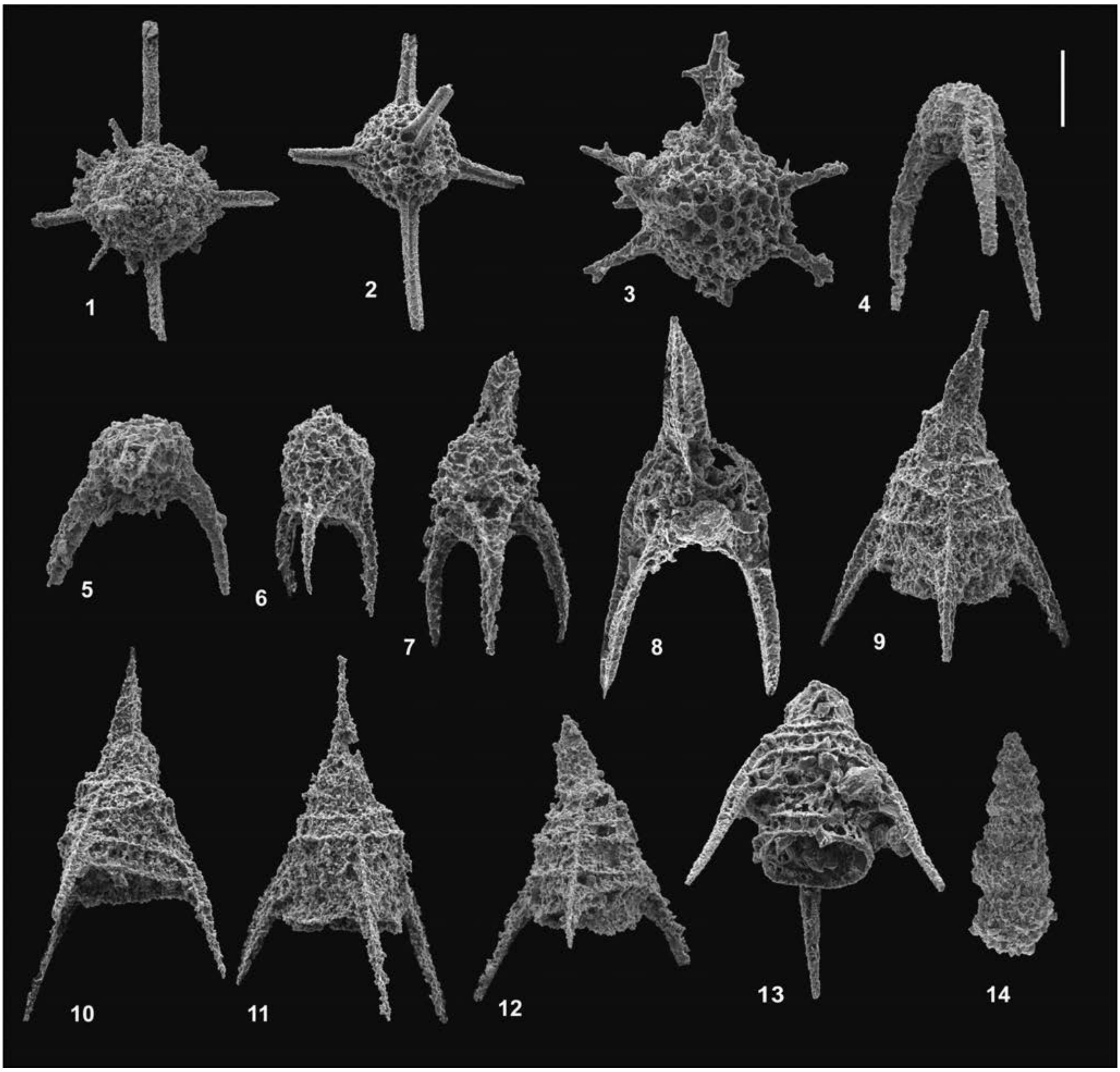

PLATE 12

Scanning electron photomicrographs of radiolarians from the San Giorgio Dolomite (*E. curionii* Ammonoid Zone, early Ladinian). All material is from Val Porina. For each figure, sample/specimen number and value of scale bar are indicated.

Fig. 1 - *“Entactinosphaera”?* sp. cf. *E. triassica* Kozur & Mostler, Pm/36g, 120 µm.

Fig. 2 - *‘Entactinosphaera”? zapfei* Kozur & Mostler, S/44, 120 µm.

Fig. 3 - Gen. et sp. ind., Sb/25, 80 µm.

Figs 4-5 - *Poulpus curvispinus* Dumitrica, Kozur & Mostler, 4) Pm/48a, 80 µm, 5) Pm/48b, 80 µm.

Fig. 6 - *Hozmadia* sp. cf. *H. reticulata* Dumitrica, Kozur & Mostler, Mb/30, 80 µm.

Fig. 7 - *Hozmadia* sp. ind., Mb/29, 80 µm.

Fig. 8 - *Eonapora?* sp. cf. *E. longispinosa* Kozur & Mostler, S/13, 80 µm.

Figs 9-13 - *Silicarmiger costatus* Dumitrica, Kozur & Mostler, 9) Mb/28a, 80 µm, 10) M/3a, 80 µm, 11) Mb/28b, 80 µm, 12) Pm/47a, 80 µm, 13) S/24, 80 µm.

Fig. 14 - *Pararuesticyrtium?* sp. aff. *P. eofassanicum* Kozur & Mostler, Pm/49, 80 µm.

Remarks. Because of the very poor preservation, the taxonomic status of these specimens is very difficult to assess. However, it seems to be morphologically close to some species of the genus *Pararuesticyrtium* Kozur & Mostler, 1981, and especially to *P. eofassanicum* Kozur & Mostler.

Range (as published). According to Kozur & Mostler (1994) *P. eofassanicum* occurs in the *O. inaequispinosus* Subzone of the *S. italicus* Radiolarian Zone of the European Tethys.

Occurrence. Sample Pm. Very rare.

Conclusions

For the first time, a radiolarian assemblage unquestionably belonging to the *E. curionii* Ammonoid Zone (earliest Ladinian) has been described, thus supplementing new information about the taxa occurring in the so far poorly defined uppermost *L. multiperforata* Radiolarian Zone. The assemblage, including 73 species, overall shows typical late Anisian features ("Fassanian" according to the traditional pre-2005 radiolarian literature), highlighting the absence of major changes in the radiolarian fauna across the Anisian/Ladinian boundary officially ratified in spring 2005 (= base of the *Eoprotrachyceras curionii* Ammonoid Zone; Brack et al. 2005). Anyway, seven species have been recognized as new taxa; their biostratigraphic significance, however, needs further confirmation through the future study of coeval sections. The taxonomic status of the recovered species has been reassessed and four new genera have been introduced. Lithofacies and features of the organic matter content (Bernasconi 1994; Stockar et al. accepted) point to a depositional environment represented by an intraplatform basin with restricted bottom water circulation. Based on structural considerations, maximum basin depth never exceeded 130 m (Bernasconi 1994). To the east, the depositional area was separated from the deep-marine environments of the "Buchenstein" facies by shallow-water barriers only a few meters deep (Gaetani et al. 1992). The observed development of additional spines in some genera such as *Eptingium* and *Pentactinocarpus* is interpreted as reflecting anomalies within these populations; together with the extremely low nassellarian abundance and diversity, this feature may reflect some degree of restriction of the basin described above. Nassellaria, in particular, regarded as being the first affected by decreasing oxygen levels rising from bottom waters upwards, may be here virtually absent due to restricted circulation, water stratification and ensuing oxygen depletion in the deeper parts of the Monte San Giorgio basin. The recovered radiolarian assemblage, however, doubtlessly testifies to the existence in early Ladinian times of open-marine connections between the basin of the Monte San Giorgio and the "Buchenstein" basins of the central and eastern South-Alpine domain and farther away throughout the Tethys.

The extraction of the fragile radiolarian tests, molded by dolomite rombohedra growing on and cross-cutting the shell surface during an early phase of dolomitization affecting the embedding carbonate, was only possible by using a particular time-consuming procedure. This included long-term dissolution of productive dolostones in a buffered solution of formic acid, followed by cleaning of single tests in dilute hydrochloric acid solution under a stereoscopic microscope.

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