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MIDDLE AND LATE HETTANGIAN RADIOLARIANS FROM THE MT. CAMICIA SUCCESSION (GRAN SASSO, CENTRAL APENNINES - ITALY)

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Abstract. Well-preserved middle and late Hettangian radiolarians have been discovered S-E of Mt. Camicia (Central Apennines) in limestone beds that contain also Hettangian ammonites.

These beds are part of an Upper Triassic to Lower Jurassic carbonate succession, which crops out in the eastern part of the Gran Sasso range. This succession includes euxinic deposits (bituminous dolostone) and other pelagic sediments (mudstone and calcarenites) which developed in a basin rimmed by a carbonate platform. In the same time interval, the well-known formations of Dolomia Principale and Calcare Massiccio were forming on this platform.

In this paper we examine the radiolarian assemblages collected in three levels of the ammonite bearing beds, and we define two new genera (*Squinabolia* and *Turritus*) and eight new radiolarian species (*Anaticapitula parvireticulata*, *Anaticapitula triangularis, Farcus aquilensis, Farcus leonseveroi*, *Parahsuum vraddense*, *Squinabolia multispinata*, *Turritus venturii*, *Zhamoidellum sphaericus*), and we define twenty four other species, for a total of thirty eight identified species. The ammonites in the lowest level indicate a middle Hettangian age, those from the two upper levels a late Hettangian.

In the Western Tethys successions bearing Hettangian radiolarians are rare and have been found together with ammonites only in the Mt. Camicia section described in this paper. This section permits to correlate the radiolarian assemblages with the ammonite zonation.

Riassunto. Sul versante S-E del M. Camicia (Appennino Centrale), in strati calcarei contenenti ammoniti hettangiani, sono stati rinvenuti radiolari ben conservati di età Hettangiano medio e superiore. Questi livelli calcarei con ammoniti e radiolari fanno parte di una successione stratigrafica, di età Triassico Superiore-Giurassico Inferiore, che affiora sulla porzione orientale della catena del Gran Sasso. Questa successione include depositi euxinici (dolomie bituminose) ed altri depositi di origine pelagica (calcari pelitici e calcareniti). Tutto questo materiale si depose in un bacino bordato dalla piattaforma carbonatica che ha dato origine, nello stesso intervallo di tempo, alle ben note formazioni della Dolomia Principale e del Calcare Massiccio.

In questo lavoro sono state analizzate le associazioni a radiolari contenute in tre dei livelli ad ammoniti; sono stati definiti due nuovi generi (*Squinabolia* e *Turritus*) e otto nuove specie di radiolari (*Anaticapitula parvireticulata*, *Anaticapitula triangularis, Farcus aquilensis, Farcus leonseveroi*, *Parahsuum vraddense*, *Squinabolia multispinata*, *Turritus venturii*, *Zhamoidellum sphaericus*), mentre altre ventiquattro specie sono state soltanto descritte, per un totale di trentotto specie determinate. Gli ammoniti rinvenuti nel livello più basso sono stati riferiti all'Hettangiano medio, quelli trovati nei due livelli più alti sono dell'Hettangiano superiore.

Nelle successioni della Tetide Occidentale radiolari hettangiani sono rari: finora sono stati trovati insieme ad ammoniti soltanto nella successione del M. Camicia, descritta in questo lavoro. Questa sezione permette di correlare le associazioni a radiolari hettangiane con la zonazione ad ammoniti.

Introduction

Data on Early Jurassic radiolarians are relatively scarce. Radiolarians of this age have been described in the circum-Pacific area: in North-Eastern China (Yeh & Yang 2006), South-Western Japan (Hori & Yao 1988; Hori 1990; Shibutani & Hori 2008), Central Japan (Hattori 1987, 1988, 1989; Kishida & Hisada 1985; Sugiyama 1997), Busuanga Island in the Philippines (Yeh & Cheng 1998), New Zealand (Hori et al. 1996), Queen Charlotte Islands in British Columbia, North America (Pessagno & Whalen 1982; Tipper et al. 1991, 1994; Carter et al. 1998; Longridge et al. 2007), South America (Suzuki et al. 2002) and also in Bavaria (Kozur & Mostler 1990), Austria (Gawlick et al. 2001), Hungary (Palfy et al. 2007) and South-Western Turkey (Tekin 2002). The data from Bavaria, Austria, Hungary and Turkey, are the

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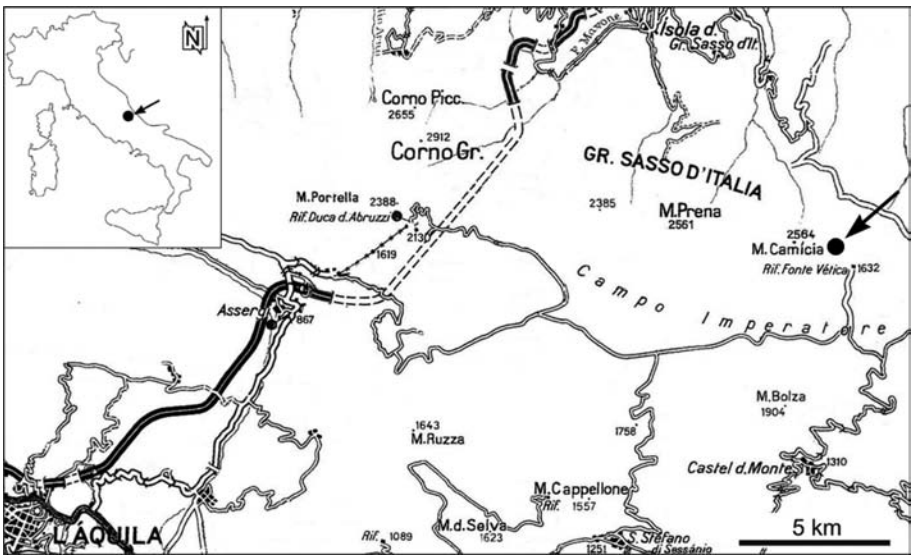


Fig. 1 - Location map of the Vradda section.

only ones available in the area corresponding to the Western Tethys.

In this paper, we describe rich and well-preserved radiolarian assemblages coming from a calcareous succession south-east of Mt. Camicia, in the Gran Sasso range (Fig. 1). These assemblages contain many new forms, some of them have been formally defined, for others it was given an informal description. This succession contains also ammonites of Hettangian age, and permits to correlate radiolarians with the ammonite zonation (Bertinelli et al. 2004).

The Mt. Camicia section is the second Hettangian locality found in the world with radiolarians and ammonites together, and the only one with ammonites in the Tethyan realm.

Geological setting

The Gran Sasso range consists of a complex stack of imbricate thrust sheets trending about E-W and dipping south. Adamoli (2002), Adamoli et al. (1981), Adamoli et al. (1990) and Ghisetti & Vezzani (1986) provided different interpretations regarding the number of sheets and their boundaries. The sheets form three larger units, which are separated from each other by two major thrust surfaces (Adamoli 2002). The lower surface is badly exposed, while the upper one is well visible along the eastern flank of the range.

The Gran Sasso range exposes a thick Triassic to Cenozoic sedimentary succession. The lowest portion of this succession is characterized by shallow-water carbonatic facies in the western part (Corno Grande area), with Dolomia Principale and Calcare Massiccio formations (Upper Triassic and Lower Jurassic respectively), and euxinic to open-pelagic facies of similar age in the eastern part (Mt. Camicia area) (Adamoli et al. 1978, 1981, 1984, 1990; Ciarapica 1990; Bigozzi et al. 1991; Damiani et al. 1991; Bertinelli et al. 2004; Passeri 2005).

The radiolarian assemblages described here come from a section in the lower part of the Mt. Camicia succession, which includes from bottom to top (Fig. 2): a) Upper Triassic bituminous dolostone and bituminous shale ("Bituminous Dolostones"; Scisti Bituminosi, Dolomie Bituminose Auctt.); b) Upper Triassic thin-bedded dolostone, cataclastic in their topmost part ("Vradda Dolostones"; Dolomie di Vradda Auctt.; c) uppermost Triassic – Lower Jurassic? nodular bioturbated limestone ("Spotted Limestones"; Calcari Maculati Auctt.); d) Hettangian – lowermost Sinemurian micritic limestone and calcarenites with ammonites ("Ammonitic Beds"; Strati Ammonitici di Vradda Auctt.); e) Sinemurian-Pliensbachian? cherty limestone with calcarenites and calcirudites (Corniola Fm).

Description of the examined section

The examined section crops out on the eastern flank of Mt. Camicia, at the left orographic side of a glen called Vallone di Vradda (Fig. 3). It consists of a well-exposed, 20 meter-thick succession of "Ammonitic Beds". The "Ammonitic Beds" (Fig. 2) include thin levels of micrite (wackestone) with ammonites, and well sorted, finely laminated calcarenites and micrite (ammonitic packstone), sometimes silicified in the upper part. The calcarenites were probably produced by bottom water circulation (contour-following bottom currents). They cannot be interpreted as either turbidites or tempestites, since they lack features such as graded bedding and hummocks and do not contain abundant bioclastic fragments.

Eight thin horizons with ammonites were found in the calcarenites and micritic limestone (Bertinelli et

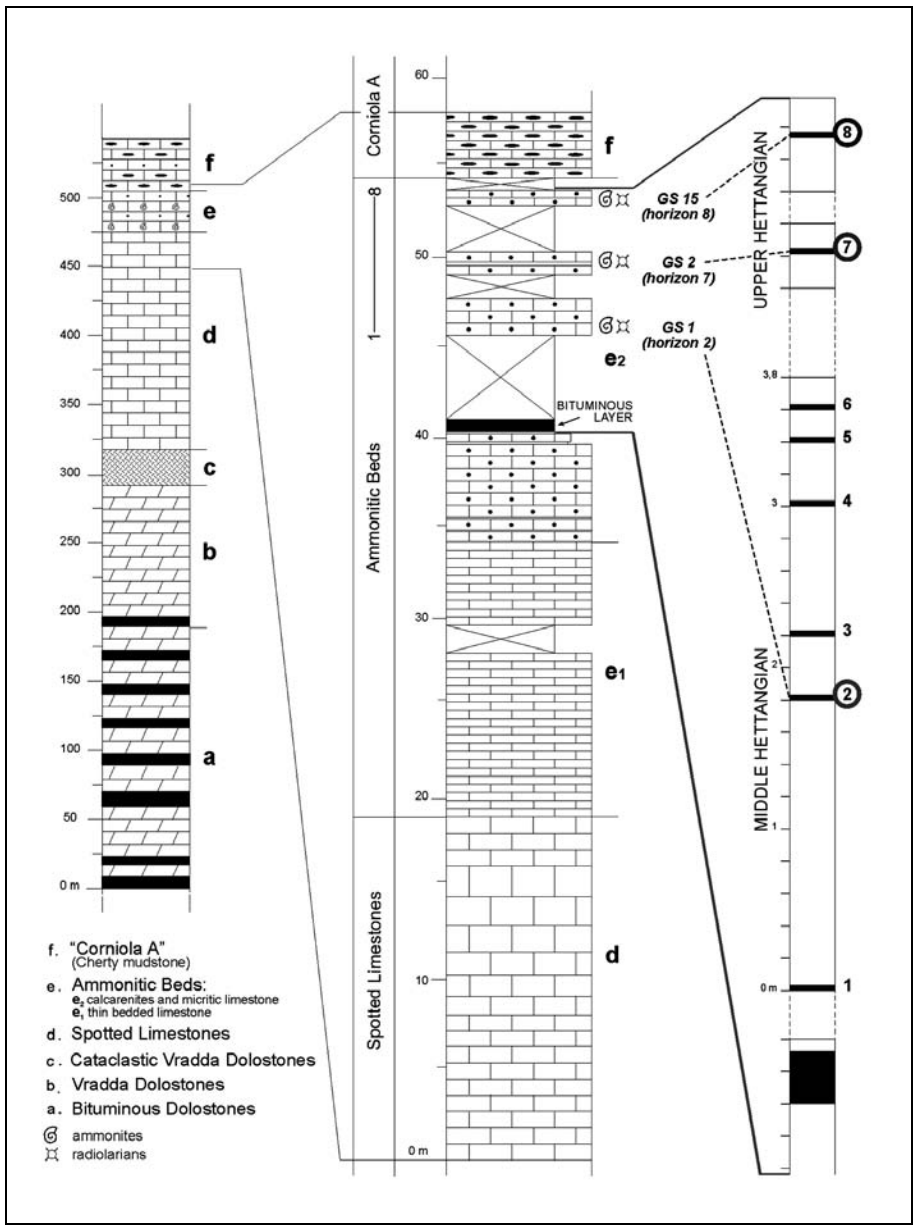


Fig. 2 - Mt. Camicia – Vradda stratigraphic section (after Bertinelli et al. 2004, slightly modified). To the right, detail of Ammonitic Beds with the examined samples (GS 1, GS 2, GS 15) and the ammonite-bearing horizons (1-8).

al. 2004), out of which three (horizons 2, 7 and 8 from bottom to top) yielded radiolarians. The radiolarians from horizons 7 and 8 are very well preserved. A bituminous layer (40-50 cm thick), rich in organic matter, lies below the lowest ammonitic horizon.

Biostratigraphy

We adopt the radiolarian zonation and range charts proposed by Carter et al. (1998). We have considered also the ranges given by Pessagno & Poisson (1981), De Wever (1982a, b), Pessagno & Whalen (1982), Hori & Yao (1988), Yeh & Cheng (1998), Whalen & Carter (2002) and Tekin (2002) (Fig. 4).

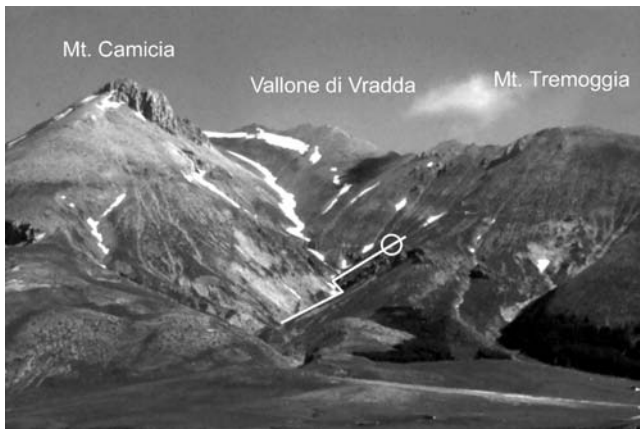


Fig. 3 - Panoramic view of the southern side of Mt. Camicia and Mt. Tremoggia. White line: Vradda section; sampled segment encircled.

age	MIDDLE HETTANGIAN	LATE HETTANGIAN	
taxa / samples	GS 1	GS 2	GS 15
Amuria macfarlanei Whalen & Carter, 1998		x	
Anaticapitula parvireticulata n. sp.			x
Anaticapitula triangularis n. sp.			x
Anaticapitula? sp.	x		
Archaeocenosphaera laseekensis Pessagno & Yang, 1989		x	
Ares? sp. A			x
Beatricea? sp. cf. *B. argescens* (Cordey, 1998)			x
Charlottea johnsoni Whalen & Carter, 1998		x	x
Charlottea sp. aff. *C. johnsoni* Whalen & Carter, 1998			x
Droltus laseekensis Pessagno & Whalen, 1982			x
Farcus aquilensis n. sp.			x
Farcus leonseveroi n. sp.			x
Farcus sp. cf. *F. graylockensis* Pessagno, Whalen & Yeh, 1986		x	x
Gorgansium blomei Kozur & Mostler, 1990			x
Haeckelicyrtium sp.			x
Kungalaria? sp. A			x
Kungalaria? sp. B			x
Napora sp. cf. *N. isa* (De Wever, 1982a)		x	
Nassellaria gen. and sp. indet. Z			x
Orbiculiformella sp. cf. *O. teres* (Hull, 1997)			x
Orbiculiformella sp. C			x
Pantanellium browni Pessagno & Blome, 1980			x
Pantanellium tanuense Pessagno & Blome, 1980			x
Parahsuum vraddaense n. sp.			x
Paronaella ravenensis Whalen & Carter, 1998		x	x
Paronaella skenaensis Whalen & Carter, 1998			x
Paronaella sp.			x
Praeconocaryomma decora Yeh, 1987	x	x	
Praeconocaryomma sarahae Carter, 2006	x	x	x
Protopsium sp. cf. P. *posinos* De Wever, 1981			x
Protopsium? sp. A			x
Saitoum sp. aff. *S. oculatus* (De Wever, 1982a)			x
Spongodiscid indet. C		x	x
Squinabolia multispinata n. sp.			x
Thurstonia timberensis Whalen & Carter, 1998		x	x
Thurstonia sp. cf. *T. timberensis* Whalen & Carter, 1998	x		
Thurstonia? sp.			x
Tozerium sp. A *sensu* Whalen & Carter, 1998		x	
Tozerium? sp. B			x
Tozerium? sp.		x	
Turritus venturii n. sp.			x
Tympaneides? sp. A			x
Udalia dennisoni Whalen & Carter, 1998			x
Udalia sp. cf. *U. dennisoni* Whalen & Carter, 1998	x		
Udalia sp. A			x
Zhamoidellum? *sphaericus* n. sp.		x	

Tab. 1 - Occurrence chart for the radiolarians from the Vradda section.

The radiolarian occurrence charts are presented in Tab. 1.

The ammonite biozonation is from Tipper & Guex (1994) and Mouterde & Corna (1997) (Fig. 5).

The ammonite and radiolarian assemblages in the "Ammonitic Beds", from bottom to top, are associated as follows:

- *Horizon 2*. Ammonites: Pleuroacanthitidae and *Discamphiceras* sp. indet.; radiolarians (sample GS 1, Fig. 6): *Anaticapitula*? sp., *Praeconocaryomma decora* Yeh, 1987, *Praeconocaryomma sarahae* Carter, 2006, *Thurstonia* sp. cf. *T. timberensis* Whalen & Carter, 1998, *Udalia* sp. cf. *U. dennisoni* Whalen & Carter, 1998.

The ammonites denote a middle Hettangian age (Bertinelli et al. 2004). Regarding radiolarians, *Praeconocaryomma decora* has been attributed to the early Sinemurian by Yeh & Cheng (1998) in Philippines and *Praeconocaryomma sarahae* to basal Pliensbachian by Carter (2006) in British Columbia. Their range could be extended to middle Hettangian (Fig. 4).

- *Horizon 7*. Ammonites: *Sunrisites* sp. indet. and *Paracaloceras* sp. indet.; radiolarians (sample GS 2, Fig. 6): *Amuria macfarlanei* Whalen & Carter, 1998, *Archaeocenosphaera laseekensis* Pessagno & Yang, 1989 in Pessagno et al. 1989, *Charlottea johnsoni* Whalen & Carter, 1998, *Farcus* sp. cf. *F. graylockensis* Pessagno, Whalen & Yeh, 1986, *Napora* sp. cf. *N. isa* De Wever, 1982a, *Paronaella ravenensis* Whalen & Carter, 1998, *Praeconocaryomma decora* Yeh, 1987, *Praeconocaryomma sarahae* Carter, 2006, Spongodiscid indet. C, *Thurstonia timberensis* Whalen & Carter, 1998, *Tozerium* sp. A sensu Whalen & Carter 1998, *Tozerium*? sp., *Zhamoidellum*? *sphaericus* n. sp.

The ammonites are of late Hettangian age (Bertinelli et al. 2004).

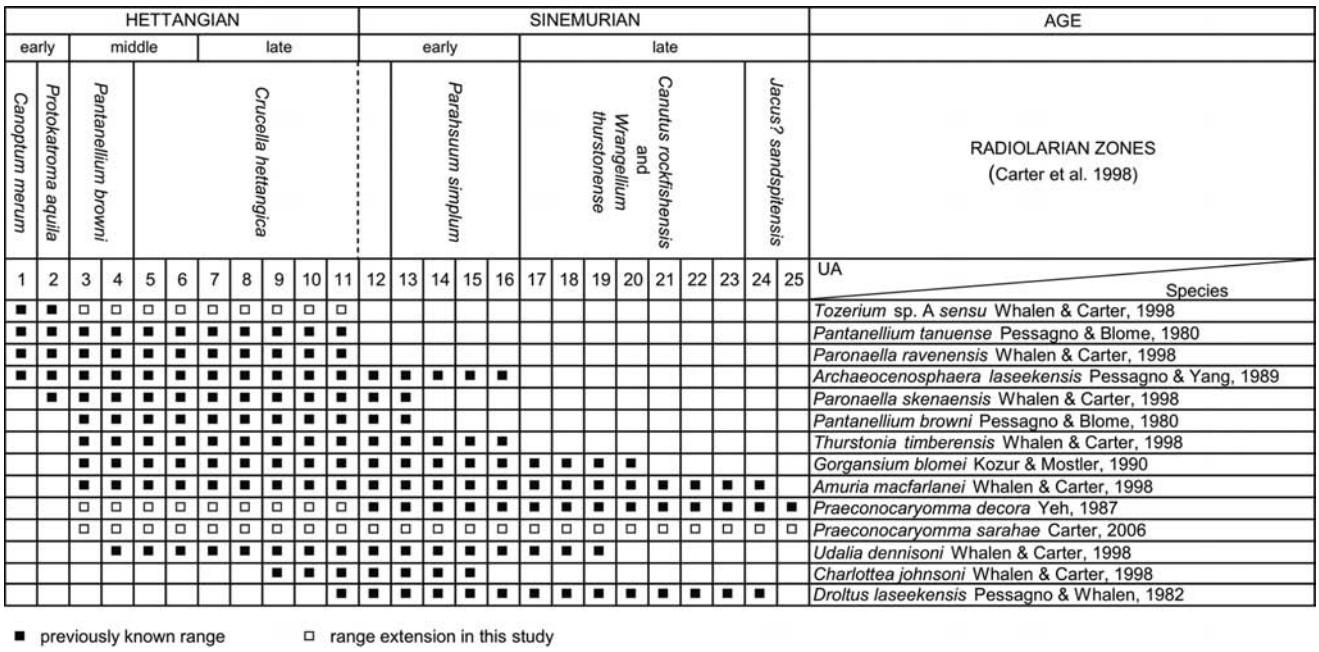


Fig. 4 - Range of radiolarian taxa after the radiolarian zonation proposed by Carter et al. (1998).

The radiolarian assemblage, according to Carter et al. (1998), is the upper part *Crucella hettangica* Zone, (U.A. 9-11, late Hettangian-latest Hettangian), on the basis of the coexistence of *Charlottea johnsoni* (U.A. 9-15, late Hettangian-early Sinemurian) with *Paronaella ravenensis* (U.A. 1-11, early Hettangian- latest Hettangian) (Fig. 4).

The dating of this horizon based on ammonites agrees with that based on radiolarians.

- *Horizon 8.* Ammonites: *Gyrophioceras, Schlotheimia* sp. indet. and *Kammerkaroceras*? sp. indet.; radiolarians (sample GS 15, Fig. 5): *Anaticapitula parvireticulata* n. sp., *Anaticapitula triangularis* n. sp., *Ares*? sp. A, *Beatricea*? sp. cf. *B. argescens* (Cordey, 1998), *Charlottea johnsoni* Whalen & Carter, 1998, *Charlottea* sp. aff. *C. johnsoni* Whalen & Carter, 1998, *Haeckelicyrtium* sp., *Droltus laseekensis* Pessagno & Whalen, 1982, *Farcus aquilensis* n. sp., *Farcus leonseveroi* n. sp., *Farcus* sp. cf. *F. graylockensis* Pessagno, Whalen & Yeh, 1986, *Gorgansium blomei* Kozur & Mostler, 1990, *Kungalaria*? sp. A, *Kungalaria*? sp. B, Nassellaria gen. and sp. indet. Z, *Orbiculiformella* sp. cf. *O. teres* (Hull, 1997), *Orbiculiformella* sp. C, *Pantanellium browni* Pessagno & Blome, 1980, *Pantanellium tanuense* Pessagno & Blome, 1980, *Parahsuum vraddaense* n. sp., *Paronaella ravenensis* Whalen & Carter, 1998, *Paronaella skenaensis* Whalen & Carter, 1998, *Paronaella* sp., *Praeconocaryomma sarahae* Carter, 2006, *Protopsium* sp. cf. *P. posinos* De Wever, 1981, *Protopsium*? sp. A, *Saitoum* sp. aff. *S. oculatus* (De Wever, 1982a), Spongodiscid indet. C, *Squinabolia multispinata* n. sp., *Thurstonia timberensis* Whalen & Carter, 1998, *Thurstonia*? sp., *Tozerium*? sp. B, *Turritus venturii* n. sp., *Tympaneides*? sp. A, *Udalia dennisoni* Whalen & Carter, 1998, *Udalia* sp. A. The ammonites are late Hettangian in age (Bertinelli et al. 2004).

The radiolarian assemblage, according to Carter et al. (1998), is the uppermost part of *Crucella hettangica* Zone (U.A. 11, latest Hettangian) on the basis of the coexistence of *Pantanellium tanuense* and *Paronaella ravenensis* (U.A. 1-11, early Hettangian – latest Hettangian) with *Droltus laseekensis* (U.A. 11-24, latest Hettangian-late Sinemurian) (Fig. 4).

The radiolarian assemblages, contained in the same levels of ammonites, can be attributed to middle Hettangian (lowest level) and late Hettangian (two upper levels). This suggests to extend the ranges of some radiolarians species on the base of ammonoid zonation of North America (Tipper & Guex 1994) and of North-Eastern Alps (Mouterde & Corna 1997) (Fig. 4).

Description and comparison of radiolarian assemblages

The radiolarian assemblages of the lowest and middle level (horizons 2 and 7), show a dominance of spumellarians (praeconocaryommids) over nassellarians and entactinarians, and are rich in spherical and irregularly spinose often tuberculated forms. The relative abundance of spumellarians, however, decreases progressively from the lowest level upwards. In the highest level (horizon 8) spumellarians, entactinarians and nassellarians are equally abundant. The spumellarian fauna is dominated by pantanelliids, patulibracchiids and praeconocaryommids, the entactinarian fauna is rich in

	AGE		AMMONOID ZONES					RADIOLARIAN ZONES
			NORTH AMERICA (Tipper & Guex 1994)	NE ALPS (Mouterde & Corna 1997)	MT. CAMICIA, GRAN SASSO CENTRAL APENNINES (Bertinelli et al. 2004) ammonoids		(this paper) radiolarian samples	QUEEN CHARLOTTE ISLANDS, BRITISH COLUMBIA (Carter et al. 1998)
EARLY JURASSIC	Sinem.		Coroniceras					
	Hettangian	late	Canadensis	*Schlotheimia marmorea*	*Gyrophioceras*	horizon 8	GS 15	Crucella hettangica
					Paracaloceras	horizon 7	GS 2	
					Trachyphyllites			
		middle	Doetzkircheri	*Kammerkarites megastoma*	*Pseudaetomoceras*			
			Franziceras		Pleuroacanthitidae	horizon 2	GS 1	Pantanellium browni
					Protocymbites			
		early	Euphyllites	*Psiloceras calliphyllum*				Protokatroma aquila
			Psiloceras					Canoptum merum

Fig. 5 - Correlation of radiolarian zones for Hettangian and Sinemurian (Carter et al. 1998) with ammonoid zones (Tipper & Guex 1994; Mouterde & Corna 1997).

charlotteids and the nassellarian fauna in archaeodictyomitrids and ultranaporids.

The presence of abundant pantanelliids suggests high fertility of the water masses (Baumgartner 1987, 1992, 1993). The genus *Pantanellium* is considered opportunistic (Pessagno & Blome 1980; Carter 1993, 1994; Hull 1995; Carter et al. 1998; Carter & Hori 2005). Diversity increases rapidly during the late Hettangian.

The radiolarian assemblages described above are characterised by abundant pantanelliids and charlotteids while canoptids, saturnalids and syringocapsids are absent. They are similar to the coeval ones that have been found in Queen Charlotte Islands (British Columbia) by Carter et al. (1998) with 12 common species: *Amuria macfarlanei* Whalen & Carter, 1998, *Archaeocenosphaera laseekensis* Pessagno & Yang, 1989, *Charlottea johnsoni, Droltus laseekensis* Pessagno & Whalen, 1982, *Pantanellium browni* Pessagno & Blome, 1980, *Pantanellium tanuense* Whalen & Carter, 1998, *Paronaella ravenensis* Whalen & Carter, 1998, *Paronaella skenaensis* Whalen & Carter, 1998, *Orbiculiformella* sp. cf. *O. teres* (Hull, 1997) (see Spongodiscid indet. B sensu Whalen & Carter, 1998), *Thurstonia timberensis* Whalen & Carter, 1998, *Tozerium* sp. A sensu Whalen & Carter, 1998, *Udalia dennisoni* Whalen & Carter, 1998. The assemblages of Queen Charlotte Islands, as our assemblages, are rich in pantanelliids and charlotteids. They contain only scarce canoptids and saturnalids, or lack them at all (Carter et al. 1998); this, again, approaches them to our assemblages where these forms are absent. The Hettangian faunas from Turkey (Tekin 2002) and our faunas contain 6 common species but differ in having abundant saturnalids and canoptids. The Mt. Camicia radiolarian assemblages have scarce affinities (1 to 4 common species) also with other assemblages of different yet not very distant ages: *Protopsium posinos, Saitoum oculatus* (see *Poulpus oculatus*) in the late Sinemurian-early Pliensbachian (Pessagno & Poisson 1981; De Wever 1981, 1982a, b) from Turkey; *Praeconocaryomma decora* in the Pliensbachian-Toarcian (Yeh 1987) from Oregon; *Charlottea johnsoni, Praeconocaryomma sarahae* (see *Praeconocaryomma parvimamma*) at the Hettangian-Sinemurian boundary (Suzuki et al. 2002) from Peru; *Pantanellium browni, Paronaella ravanensis*, *Praeconocaryomma decora* in the early Sinemurian (Yeh & Cheng 1998) from Philippines.

Systematic Paleontology

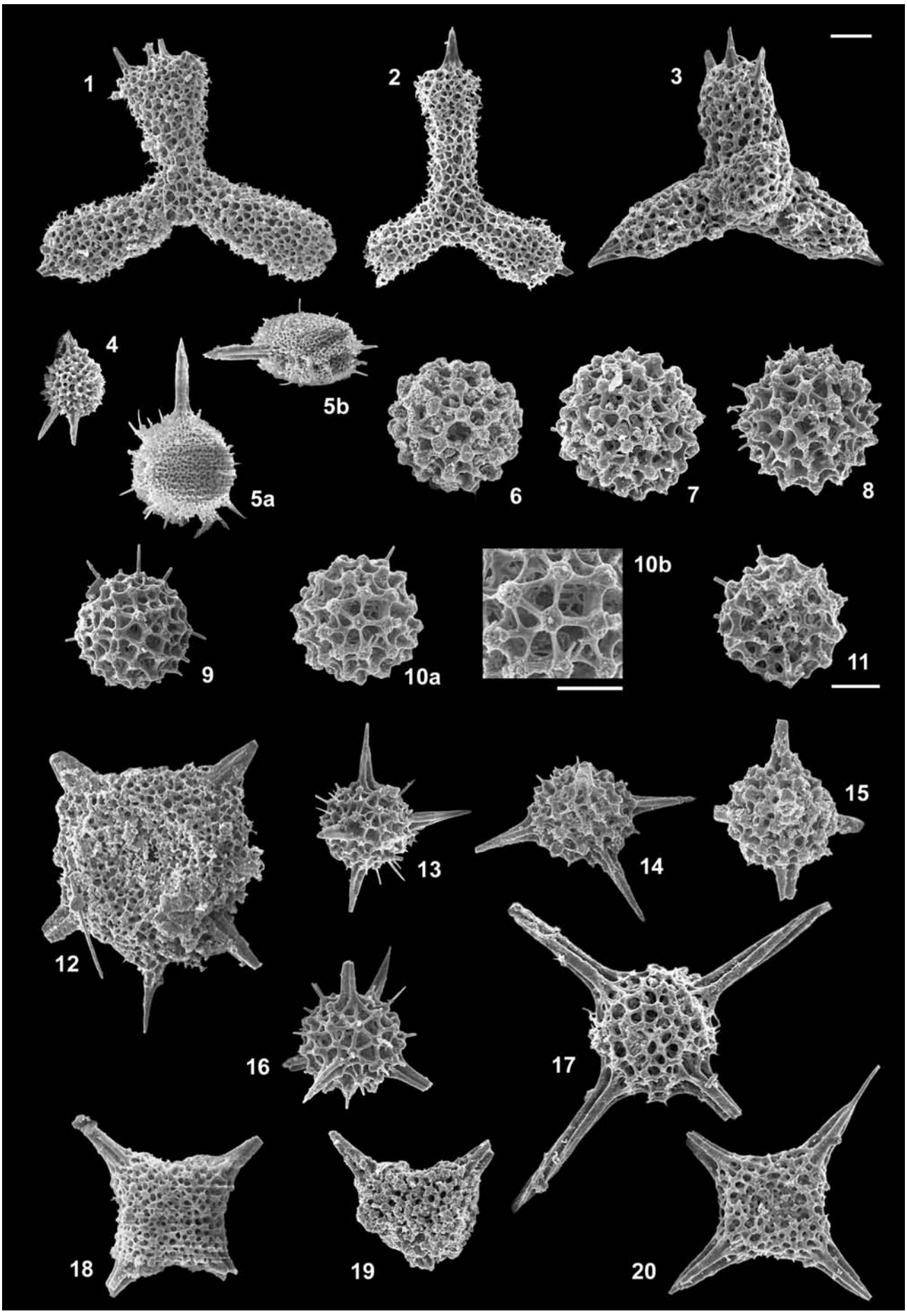
The family assignment follows chiefly the classification of De Wever et al. (2001) and O'Dogherty et al. (2009). Families are discussed in alphabetical order.

In the radiolarian assemblages of the Vradda section we describe two new genera, eight new species and

PLATE 1

Scanning electron micrographs of Hettangian radiolarians from Vradda section, Mt. Camicia. Scale bar = 50 μm

Fig. 1 - *Paronaella ravenensis* Whalen & Carter, GS 15; Fig. 2 - *Paronaella skenaensis* Whalen & Carter, GS 15; Fig. 3 - *Paronaella* sp., GS 15; Fig. 4 - *Protopsium* sp. cf. *P. posinos* De Wever, GS 15; Fig. 5a-b - *Protopsium*? sp. A, GS 15:a. general view; b. side view; Fig. 6, 7 - *Praeconocaryomma decora* Yeh, GS 1; Fig. 8 - *Praeconocaryomma decora* Yeh, GS 2; Fig. 9 - *Praeconocaryomma sarahae* Carter, GS 2; Fig. 10a-b - *Praeconocaryomma sarahae* Carter, GS 15:a. entire specimen; b. detail of the shell; Fig. 11 - *Praeconocaryomma sarahae* Carter, GS 15; Fig. 12 - *Beatricea*? sp. cf. *B. argescens* (Corday), GS 15; Fig. 13, 14 - *Thurstonia timberensis* Whalen & Carter, GS 15; Fig. 15 - *Thurstonia* sp. cf. *T. timberensis* Whalen & Carter, GS 1; Fig. 16 - *Thurstonia*? sp., GS 15; Fig. 17 - *Tympaneides*? sp. A, GS 15; Fig. 18 - *Udalia dennisoni* Whalen & Carter, GS 15; Fig. 19 - *Udalia* sp. cf. *U. dennisoni* Whalen & Carter, GS 1; Fig. 20 - *Udalia* sp. A, GS 15.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twenty four forms in open nomenclature. Holotypes and paratypes of the new species are deposited at the Department of Earth Sciences, Section of Geology and Paleontology, University of Perugia (Italy); Bertinelli collection, catalogue numbers from AB-VR 0001 to AB-VR 0027.

Order **Spumellaria**, Ehrenberg, 1875

Family Angulobracchiidae Baumgartner, 1980

Genus *Paronaella* Pessagno, 1971, emend. Baumgartner, 1980

Type species: *Paronaella solanoensis* Pessagno, 1971

Paronaella ravenensis Whalen & Carter, 1998

Pl. 1, fig. 1

1998 *Paronaella ravenensis* Whalen & Carter, p. 51, pl. 13, fig. 1, 2, 6, 9, 12, 16

Occurrence. Samples GS 2, GS 15, Vradda section (Mt. Camicia, Gran Sasso, Central Apennines). Upper Hettangian.

Paronaella skenaensis Whalen & Carter, 1998

Pl. 1, fig. 2

1998 *Paronaella skenaensis* Whalen & Carter, p. 52, pl. 13, fig. 4, 5, 8, 11, 15.

Occurrence. Sample GS 15, Vradda section (Mt. Camicia, Gran Sasso, Central Apennines). Upper Hettangian.

Paronaella sp.

Pl. 1, fig. 3

Material: One specimen.

Remarks. This specimen, with four arms, is an aberrant form of genus *Paronaella*.

Occurrence. Sample GS 15, Vradda section (Mt. Camicia, Gran Sasso, Central Apennines). Upper Hettangian.

Family Archaeospongoprunidae Pessagno, 1973

Genus *Protopsium* Pessagno & Poisson, 1981

Type species: *Protopsium ehrenbergi* Pessagno & Poisson, 1981

Protopsium sp. cf. **P. posinos** De Wever, 1981

Pl. 1, fig. 4

cf. 1981 *Protopsium posinos* De Wever, p. 146, pl. 5, fig. 21-25.

Material: One specimen.

Remarks. This specimen differs from *Protopsium posinos* in having less stout spines.

Occurrence. Sample GS 15, Vradda section (Mt. Camicia, Gran Sasso, Central Apennines). Upper Hettangian.

Protopsium ? sp. **A**

Pl. 1, fig. 5a-b

Material: Two specimens.

Description. Circular discoidal spongy test, with a lateral furrow, one massive three bladed spine and numerous thin short secondary spines.

Remarks. This form differs from genus *Protopsium* in having only one massive spine and numerous short secondary spines. It differs also from the genus *Orbiculiformella* in lacking the depressed central cavity and by having only one principal spine.

Occurrence. Sample GS 15, Vradda section (Mt. Camicia, Gran Sasso, Central Apennines). Upper Hettangian.

Family Conocaryommidae Lipman, 1969 emend. De Wever et al., 2001

(syn.: Praeconocaryommidae Pessagno, 1976)

Genus *Praeconocaryomma* Pessagno, 1976

Type species: *Praeconocaryomma universa* Pessagno, 1976

Praeconocaryomma decora Yeh, 1987

Pl. 1, fig. 6, 7, 8

1987 *Praeconocaryomma decora* Yeh, p. 39, pl. 6, fig. 15, pl. 20, fig. 1, 2, 16.

1987 *Praeconocaryomma* sp. A Yeh, p. 40, pl. 2, figs. 17, 22, pl. 20, fig. 4.

1990 *Praeconocaryomma decora* Yeh – Nagai, pl. 6, fig. 6.

1998 *Praeconocaryomma decora* Yeh – Yeh & Cheng, p. 15, pl. 11, fig. 1, 5.

2002 *Praeconocaryomma* sp. A Yeh – Whalen & Carter, p. 108, pl. 8, fig. 5.

2003 *Praeconocaryomma* spp. Goričan et al., p. 291, pl. 1, fig. 10 only.

2006 *Praeconocaryomma decora* gr. Yeh – Goričan et al., p. 324, pl. PRY01, fig. 1 (H), 2.

Occurrence. Samples GS 1, GS 2, Vradda section (Mt. Camicia, Gran Sasso, Central Apennines). Middle-Upper Hettangian.

Praeconocaryomma sarahae Carter, 2006

Pl. 1, fig. 9, 10a-b, 11

? 1987 *Praeconocaryomma* sp. B Hattori, pl. 20, fig. 18.

? 1997 *Praeconocaryomma* ? sp. D0 Yao, pl. 1, fig.36.

2001 *Praeconocaryomma media* Pessagno & Poisson – Gawlick et. al., pl. 6, fig. 2.

2002 *Praeconocaryomma media* Pessagno & Poisson – Suzuki et al., pl. 172, fig. 4-A.

2002 *Praeconocaryomma parvimamma* Pessagno & Poisson – Suzuki et al., pl. 172, fig. 4-B.

2006 *Praeconocaryomma sarahae* Carter n. sp. in Goričan et al., p. 328, pl. PRY07, fig. 1(H)-11.

Occurrence. Samples GS 1, GS 2, GS 15, Vradda section (Mt. Camicia, Gran Sasso, Central Apennines). Middle-Upper Hettangian.

Family Emiluviidae Dumitrica, 1995

Genus *Beatricea* Whalen & Carter, 1998

Type species: *Beatricea christovalensis* Whalen & Carter, 1998

Beatricea? sp. cf. **B. argescens** (Cordey, 1998)

Pl. 1, fig. 12

cf. 1998 *Orbiculiforma argescens* Cordey, p. 94, pl. 21, fig. 6, 9, 11.

cf. 2006 *Beatricea*? *argescens* (Cordey) – Goričan et al., p. 60, pl. ORB04, fig. 2-4.

Material: Two specimens.

Description. Test circular to sub-quadrangular with irregular small pores, depressed central cavity surrounded by a prominent rim, four primary three bladed short peripheral spines and few secondary thinner spines.

Remarks. It differs from *Beatricea*? *argescens* (Cordey, 1998) in having very short primary spines and some secondary. It differs from *Beatricea sanpabloensis* (Whalen & Carter, 2002), in having a more sub-quadrangular test.

Occurrence. Sample GS 15, Vradda section (Mt. Camicia, Gran Sasso, Central Apennines). Upper Hettangian.

Genus *Thurstonia* Whalen & Carter, 1998

Type species: *Thurstonia minutaglobus* Whalen & Carter, 1998

Thurstonia timberensis Whalen & Carter, 1998

Pl. 1, fig. 13, 14

1989 Genus 4 spp., Hattori, pl. 17, fig. B, C.

1990 *Beturiella*? sp. Nagai, pl. 6, fig. 1, 2.

1998 *Thurstonia timberensis* Whalen & Carter, p. 43, pl. 6, fig. 3, 4, 5, 10.

1998 *Thurstonia* sp. B Yeh & Cheng, p. 11, pl. 8, fig. 8.

2006 *Thurstonia timberensis* Whalen & Carter - Goričan et al., p. 380, pl. THU04, fig. 1(H).

Occurrence. Sample GS 2, GS 15, Vradda section (Mt. Camicia, Gran Sasso, Central Apennines). Upper Hettangian.

Thurstonia sp. cf. **T. timberensis** Whalen & Carter, 1998

Pl. 1, fig. 15

cf. 1998 *Thurstonia timberensis* Whalen & Carter, p. 43, pl. 6, fig. 3, 4, 5, 10.

Material: One specimen.

Remarks. This is very similar to *T. timberensis* Whalen & Carter, 1998, but the spines are broken.

Occurrence. Sample GS 1, Vradda section (Mt. Camicia, Gran Sasso, Central Apennines). Middle Hettangian.

Thurstonia? sp.

Pl. 1, fig. 16

Material: One specimen.

Remarks. This differs from genus *Thurstonia* in having five instead of six main spines. Two of these are polar spines, and three are disposed in the equatorial plane at 120°. This specimen is similar to *T. timberensis* Whalen & Carter, 1998 for the shape of the spines but not for the number.

Occurrence. Sample GS 15, Vradda section (Mt. Camicia, Gran Sasso, Central Apennines). Upper Hettangian.

Genus *Tympaneides* Carter, 1988

Type species: *Tympaneides charlottensis* Carter et al., 1988

Tympaneides? sp. **A**

Pl. 1, fig. 17

Material: One specimen.

Remarks. This species differs from genus *Tympaneides* Carter, 1988 in lacking the typical drum-shape of the cortical shell. It differs from genus *Thurstonia* Whalen & Carter, 1998, in having a less spherical shape and in having only four spines.

Occurrence. Sample GS 15, Vradda section (Mt. Camicia, Gran Sasso, Central Apennines). Upper Hettangian.

Genus *Udalia* Whalen & Carter, 1998

Type species: *Udalia dennisoni* Whalen & Carter, 1998

Udalia dennisoni Whalen & Carter, 1998

Pl. 1, fig. 18

1998 *Udalia dennisoni* Whalen & Carter, p. 59, pl. 6, fig. 11, 13, 14, 17-19, 21, 22.

2002 *Udalia dennisoni* Whalen & Carter – Tekin, p. 185, pl. 3, fig. 2.

Occurrence. Sample GS 15, Vradda section (Mt. Camicia, Gran Sasso, Central Apennines). Upper Hettangian.

Udalia sp. cf. **U. dennisoni**

Pl. 1, fig. 19

cf. 1998 *Udalia dennisoni* Whalen & Carter, p. 59, pl. 6, fig. 11, 13, 14, 17-19, 21, 22.

Material: One specimen.

Remarks. This specimen is poorly preserved and broken, but it is similar to *Udalia dennisoni.*

Occurrence. Sample GS 1, Vradda section (Mt. Camicia, Gran Sasso, Central Apennines). Middle Hettangian.

Udalia sp. **A**

Pl. 1, fig. 20

Material: Three specimens.

Description. Sub-quadrangular shell with four short triradiate spines, pointed distally, emerging from the corners. Irregular polygonal pore frame with small nodes at pore frame vertices of the meshwork of the cortical shell.

Remarks. This form differs from *Udalia dennisoni* in having shorter and stouter spines, and less numerous and smaller nodes. It differs from *Udalia plana* in having shorter spines and a less thick cortical shell.

Occurrence. Sample GS 15, Vradda section (Mt. Camicia, Gran Sasso, Central Apennines). Upper Hettangian.

Family Pantanelliidae Pessagno, 1977

Subfamily Pantanelliinae Pessagno, 1977

Genus *Gorgansium* Pessagno & Blome, 1980

Type species: *Gorgansium silviense* Pessagno & Blome, 1980

Gorgansium blomei Kozur & Mostler, 1990

Pl. 2, fig. 1

1980 *Gorgansium* sp. C Pessagno & Blome, p. 236, pl. 4, fig. 8.

1990 *Gorgansium blomei* Kozur & Mostler, p. 216, pl. 16, fig. 13.

2002 *Gorgansium blomei* Kozur & Mostler - Tekin, p. 179, pl. 1, fig. 3.

Occurrence. Sample GS 15, Vradda section (Mt. Camicia, Gran Sasso, Central Apennines). Upper Hettangian.

Genus *Pantanellium* Pessagno, 1977

Type species: *Pantanellium riedeli* Pessagno, 1977

Pantanellium browni Pessagno & Blome, 1980

Pl. 2, fig. 2, 3, 4

1980 *Pantanellium browni* Pessagno & Blome, p. 239, pl. 4, fig. 5-7, 12, 14, 16, 19, 20.

1990 *Ellipsoxiphus browni* (Pessagno & Blome) - Kozur & Mostler, p. 214, pl. 14, fig. 14; pl. 15, fig. 11, 14.

1991 *Pantanellium browni* Pessagno & Blome - Tipper et al., p. 225, pl. 8, fig. 13.

1998 *Pantanellium browni* Pessagno & Blome – Whalen & Carter, p. 47, pl. 1, fig. 6, 16.

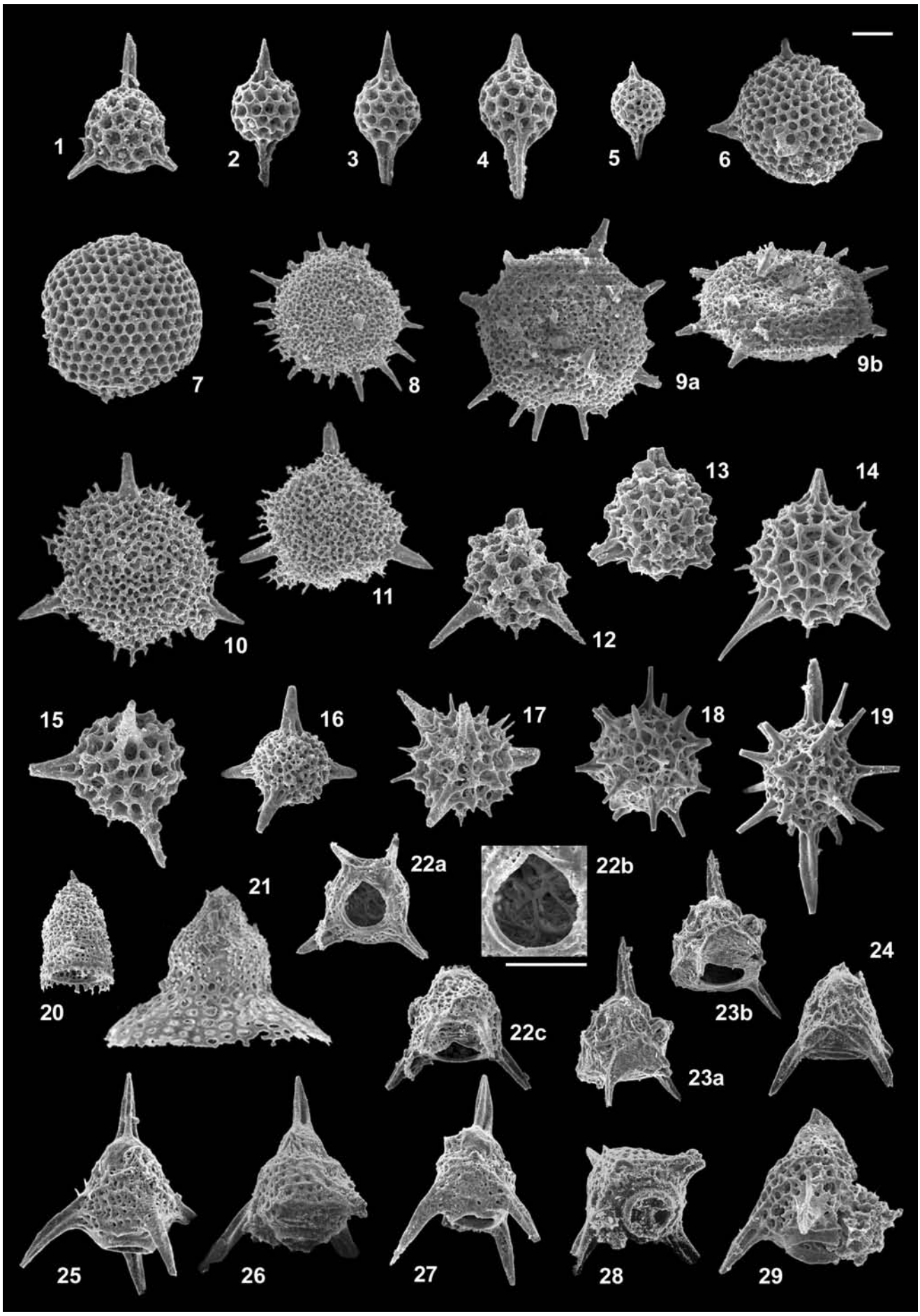
2002 *Pantanellium browni* Pessagno & Blome – Tekin, p. 180, pl. 1, fig. 5.

Occurrence. Sample GS 15, Vradda section (Mt. Camicia, Gran Sasso, Central Apennines). Upper Hettangian.

PLATE 2

Scanning electron micrographs of Hettangian radiolarians from Vradda section, Mt. Camicia. Scale bar = 50 μm

Fig. 1 - *Gorgansium blomei* Kozur & Mostler, GS 15; Fig. 2-4 - *Pantanellium browni* Pessagno & Blome, GS 15; Fig. 5 - *Pantanellium tanuense* Pessagno & Blome, GS 15; Fig. 6 - *Amuria macfarlanei* Whalen & Carter, GS 2; Fig. 7 - *Archaeocenosphaera laseekensis* Pessagno & Yang, GS 2; Fig. 8 - *Orbiculiformella* sp. cf. *O. teres* (Hull), GS 15; Fig. 9a-b - *Orbiculiformella* sp. C, GS 15:a. general view; b. oblique view; Fig. 10 - Spongodiscid indet. C, GS 2; Fig. 11 - Spongodiscid indet. C, GS 15; Fig. 12 - *Charlottea johnsoni* Whalen & Carter, GS 2; Fig. 13 - *Charlottea johnsoni* Whalen & Carter, GS 15; Fig. 14 - *Charlottea* sp. aff. *C. johnsoni* Whalen & Carter, GS 15; Fig. 15 - *Tozerium* sp. A (*sensu* Whalen & Carter, 1998), GS 2; Fig. 16 - *Tozerium*? sp. B, GS 15; Fig. 17- *Tozerium*? sp., GS 2; Fig. 18 - *Kungalaria*? sp. A, GS 15; Fig. 19 - *Kungalaria*? sp. B, GS 15; Fig. 20 - *Droltus laseekensis* Pessagno & Whalen, GS 15; Fig. 21 - *Haeckelicyrtium* sp., GS 15; Fig. 22a-c - *Farcus aquilensis* n. sp. (paratype, AB-VR 0002), GS 15: a. basal view; b. detail of the internal structure c. side view; Fig. 23a-b - *Farcus aquilensis* n. sp. (holotype, AB-VR 0001), GS 15: a. lateral view; b. oblique view; Fig. 24 - *Farcus aquilensis* n. sp. (paratype, AB-VR 0003), GS 15; Fig. 25 - *Farcus leonseveroi* n. sp. (holotype, AB-VR 0004), GS 15; Fig. 26, 27 - *Farcus leonseveroi* n. sp. (paratypes, AB-VR 0005, AB-VR 0006), GS 15; Fig. 28 - *Farcus leonseveroi* n. sp. (paratype, AB-VR 0007), basal view, GS 15; Fig. 29 - *Farcus* sp. cf. *F. graylockensis* Pessagno, Whalen & Yeh, GS 2.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Pantanellium tanuense Pessagno & Blome, 1980

Pl. 2, fig. 5

1980 *Pantanellium tanuense* Pessagno & Blome, p. 259, pl. 4, fig. 3, 4, 24.
1988 *Pantanellium* sp. aff. *P. tanuense* Pessagno & Blome - Spörli & Aita, pl. 4, fig. 2.
1989 *Pantanellium* sp. aff. *P. tanuense* Pessagno & Blome - Spörli, Aita & Gibson, fig. 5, n. 6.
1991 *Pantanellium tanuense* Pessagno & Blome - Tipper et al., pl. 8, fig. 5.
1994 *Pantanellium tanuense* Pessagno & Blome - Goričan, pl. 1, fig. 14-18.
1998 *Pantanellium tanuense* Pessagno & Blome - Whalen & Carter, p. 49, pl. 1, fig. 4, 11, 26.

Occurrence. Sample GS 15, Vradda section (Mt. Camicia, Gran Sasso, Central Apennines). Upper Hettangian.

Family Xiphostylidae Haeckel, 1881, sensu Pessagno & Yang, 1989 in Pessagno et al., 1989, emend. De Wever et al., 2001

Genus *Amuria* Whalen & Carter, 1998

Type species: *Amuria impensa* Whalen & Carter, 1998

Amuria macfarlanei Whalen & Carter, 1998

Pl. 2, fig. 6

1998 *Amuria macfarlanei* Whalen & Carter, p. 56, pl. 11, fig. 7.
2001 *Amuria macfarlanei* Whalen & Carter – Gawlick et al., Fig. 5 n. 3.

Occurrence. Sample GS 2, Vradda section (Mt. Camicia, Gran Sasso, Central Apennines). Upper Hettangian.

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

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

Archaeocenosphaera laseekensis Pessagno & Yang, 1989

Pl. 2, fig. 7

1989 *Archaeocenosphaera laseekensis* Pessagno & Yang - Pessagno et al., p. 203, pl. 2, fig. 18, 21,22, 25.
1998 *Archaeocenosphaera laseekensis* Pessagno & Yang - Whalen & Carter, p. 57, pl. 11, fig. 1, 5, 9, 21.

Occurrence. Sample GS 2, Vradda section (Mt. Camicia, Gran Sasso, Central Apennines). Upper Hettangian.

Family Veghicycliidae Kozur & Mostler, 1972

Genus *Orbiculiformella* Kozur & Mostler, 1978

Type species: *Orbiculiforma railensis* Pessagno, 1977

Orbiculiformella sp. cf. **O. teres** (Hull, 1997)

Pl. 2, fig. 8

cf. 1997 *Orbiculiforma teres* n. sp., Hull, p. 16, fig. 10, 11, 15, 19.
1998 Spongodiscid indet. B Whalen & Carter, p. 61, pl. 9, fig.18.

Material: Four specimens.

Description. Large and spongy discoidal test, without central depression, with numerous thin small peripheral spines.

Remarks. This form differs from *Orbiculiformella teres* (Hull, 1997) in having thinner peripheral spines and a less lenticular test.

Occurrence. Sample GS 15, Vradda section (Mt. Camicia, Gran Sasso, Central Apennines). Upper Hettangian.

Orbiculiformella sp. **C**

Pl. 2, fig. 9a-b

1987 *Orbiculiforma* sp. B Yeh, pl. 2, fig. 23.

Material: Four specimens.

Description. They are attributed to genus *Orbiculiformella* in having a discoidal shell, a rounded marginal zone with large pores and a depressed central zone with about 10 principal smooth spines (circular in cross section).

Remarks. They differ from genus *Orbiculiformella* in having not a sub quadrangular shell, and in particular from the species *Orbiculiforma multifora* Pessagno & Poisson, 1981, in having less numerous, larger, smoother and more irregular spines. It differs from *Orbiculiformella callosa* (Yeh, 1987) in having a small and less deep central cavity and a less vertical margin, with thicker peripheral spines. It differs from *Orbiculiformella teres* (Hull, 1997) in having a larger and deeper central depression, with less numerous peripheral spines.

Occurrence. Sample GS 15, Vradda section (Mt. Camicia, Gran Sasso, Central Apennines). Upper Hettangian.

Spumellaria incertae sedis

Spongodiscid indet. C

Pl. 2, fig. 10, 11

Material: Three specimens.

Description. Large and spongy discoidal test, with three massive primary, coplanar spines divergent at 120° and thin small secondary spines. The primary spines are bladed at the base and circular distally.

Remarks. This form differs from Spongodiscid indet. A Whalen & Carter, 1998 in having three spines instead of four and a finer and spongy meshwork, and from *Orbiculiformella* Spongodiscid indet. B Whalen & Carter, 1998 in having only three large primary spines. It differs from genus *Orbiculiformella* in lacking the depressed central cavity and in having three short and stout primary spines.

Occurrence. Sample GS 2, GS 15, Vradda section (Mt. Camicia, Gran Sasso, Central Apennines). Upper Hettangian.

Order **Entactinaria** Kozur & Mostler, 1982

Family Eptingiidae Dumitrica, 1978

Genus *Charlottea* Whalen & Carter, 1998

Type species: *Charlottea amurensis* Whalen & Carter, 1998

Charlottea johnsoni Whalen & Carter, 1998

Pl. 2, fig. 12, 13

1998 *Charlottea johnsoni* Whalen & Carter, p. 38, pl. 3, fig. 5, 10, 13, 14.

2002 *Charlottea johnsoni* Whalen & Carter - Tekin, p. 188, pl. 3, fig. 2.

2002 *Charlottea johnsoni* Whalen & Carter - Suzuki et al., p.168, Fig. 4G.

Occurrence. Sample GS 2, GS 15, Vradda section (Mt. Camicia, Gran Sasso, Central Apennines). Upper Hettangian.

Charlottea sp. aff. **C. johnsoni** Whalen & Carter, 1998

Pl. 2, fig. 14

aff. 1998 *Charlottea johnsoni* Whalen & Carter, p. 38, pl. 3, fig. 5, 10, 13, 14.

Material: Three specimens.

Remarks. They differ from *Charlottea johnsoni* Whalen & Carter, 1998 in having a multilayered cortical shell and thin and short spines arising from small nodes.

Occurrence. Sample GS 15, Vradda section (Mt. Camicia, Gran Sasso, Central Apennines). Upper Hettangian.

Genus *Tozerium* Whalen & Carter, 1998

Type species: *Tozerium nascens* Whalen & Carter, 1998

Tozerium sp. **A** Whalen & Carter, 1998

Pl. 2, fig. 15

1998 *Tozerium* sp. A Whalen & Carter, p. 44, pl. 1, fig. 2.

Occurrence. Sample GS 2, Vradda section (Mt. Camicia, Gran Sasso, Central Apennines). Upper Hettangian.

Tozerium? sp. **B**

Pl. 2, fig. 16

Material: Three specimens.

Description. Subspherical test with four primary spines, with two layered shells: the outer one with small subcircular pores of variable sizes and with secondary thin small spines emerging from the nodes of the pore frame.

Remarks. This species differs from other species of genus in having smaller and irregular pores, more massive spines which are triradiate at the base and in possessing thin, short secondary spines.

Occurrence. Sample GS 15, Vradda section (Mt. Camicia, Gran Sasso, Central Apennines). Upper Hettangian.

Tozerium? sp.

Pl. 2, fig. 17

Material: One specimen.

Remarks. This differs from *Tozerium*? sp. B in having large and round pores and many secondary spines arising from the nodes. It differs from the genus *Thurstonia* in having only four spines.

Occurrence. Sample GS 2, Vradda section (Mt. Camicia, Gran Sasso, Central Apennines). Upper Hettangian.

Family Kungalariidae Dumitrica & Carter, 1999

Genus *Kungalaria* Dumitrica & Carter, 1999

Type species: *Kungalaria newcombi* Dumitrica & Carter, 1999

Kungalaria? sp. **A**

Pl. 2, fig. 18

Material: Three specimens.

Description. Subcircular shell with two layers: the outer one with a large polygonal to triangular pore frame and many short thin spines.

Remarks. They are assigned to genus *Kungalaria* only doubtfully because it is not possible to see the initial spicule. They differ from *Kungalaria newcombi* Dumitrica & Carter, 1999, in having many thin and short spines, circular in cross section.

Occurrence. Sample GS 15, Vradda section (Mt. Camicia, Gran Sasso, Central Apennines). Upper Hettangian.

Kungalaria? sp. **B**

Pl. 2, fig. 19

Material: Three specimens.

Description. Subcircular shell with two layers, the outer one with large irregularly shaped pore frame. Two primary three bladed polar spines and numerous secondary spines, circular in cross section.

Remarks. They are assigned to genus *Kungalaria* only doubtfully because it is not possible to see the initial spicule. They differ from *Kungalaria newcombi* Dumitrica & Carter, 1999, in having two primary polar spines, which are three bladed and larger that the secondary ones.

Occurrence. Sample GS 15, Vradda section (Mt. Camicia, Gran Sasso, Central Apennines). Upper Hettangian.

Order **Nassellaria** Ehrenberg, 1875

Family Bagotidae Pessagno & Whalen, 1982

Genus *Droltus* Pessagno & Whalen, 1982

Type species: *Droltus lyellensis* Pessagno & Whalen, 1982

Droltus laseekensis Pessagno & Whalen, 1982

Pl. 2, fig. 20

1982 *Droltus laseekensis* Pessagno & Whalen, p. 122, pl. 2, fig. 5, 6, 11, 16, pl. 12, fig. 8, 15.

1998 *Droltus laseekensis* Pessagno & Whalen - Whalen & Carter, p. 63, pl. 15, fig. 8, pl. 26, fig. 4.

2006 *Droltus laseekensis* Pessagno & Whalen - Goričan et al., p. 138, pl. DRO03, fig. 1-5.

Occurrence. Sample GS 15, Vradda section (Mt. Camicia, Gran Sasso, Central Apennines). Upper Hettangian.

Family Deflandrecyrtiidae Kozur & Mostler, 1979

Genus *Haeckelicyrtium* Kozur & Mostler, 1979

Type species: *Haeckelicyrtium austriacum* Kozur & Mostler, 1979

Haeckelicyrtium sp.

Pl. 2, fig. 21

Material: One specimen.

Remarks. It differs from *Haeckelicyrtium* sp. B Whalen & Carter, 2002 in having rather equal and radially aligned pores and without visible spines on the edge of the skirt. It differs from *H. subcircularis* Tekin, 1999, in having larger pores on the thorax and rather equal and radially aligned pores on the abdominal skirt.

Occurrence. Sample GS 15, Vradda section (Mt. Camicia, Gran Sasso, Central Apennines). Upper Hettangian.

Family Foremanellinidae Dumitrica, 1982

Genus *Farcus* Pessagno, Whalen & Yeh, 1986

Type species: *Farcus graylockensis* Pessagno, Whalen & Yeh, 1986

Farcus aquilensis n. sp.

Pl. 2, fig. 22a-c, 23a-b, 24

Etymology: This species is named for L'Aquila town, located close to the Gran Sasso range.

Type locality: Sample GS 15, Vradda section (Mt. Camicia, Gran Sasso, Central Apennines).

Types: Holotype Pl. 2, fig. 23a-b (AB-VR 0001), paratypes Pl. 2, fig. 22a-c (AB-VR 0002), Pl. 2, 24 (AB-VR 0003), from type locality.

Description: Test dicyrtid, with large, hemispherical, poreless cephalis with a long triradiate apical horn; thorax large with small irregular pores, irregular network of ridges on the proximal portion and four moderately short feet, triradiate, with three large longitudinal grooves and three narrow ridges tapering distally. Base of thorax hemispherical with a central peary to circular aperture bounded by a thin and not prominent imperforate rim.

Remarks. *F. aquilensis* differs from *F. graylockensis* Pessagno, Whalen & Yeh, 1986 in having cephalis larger with a less massive horn, smaller pores, irregular transversal ridges and shorter feet. It differs from *F. kozuri* Yeh, 1987, in lacking three to four well-developed transverse ridges on the distal portion of the thorax. It differs from *F.* sp. A Carter et al., 1998 in having larger thorax with irregular transversal ridges instead small and regular pores, shorter and straight feet.

The oldest *Farcus* known so far is *Farcus* sp. A in Carter et al. 1998 (upper Sinemurian). The coexistence of *Farcus aquilensis* with *Pantanellium tanuense* and *Paronaella ravenensis* (U.A. 1-11, early Hettangian- latest Hettangian) and *Droltus laseekensis* (U.A. 11-24, latest Hettangian-late Sinemurian) extends the FOD of this genus to the latest Hettangian.

Measurements (μm) based on five specimens.

	Holotype	Min.	Max.	Avg.
Total height	175	137	187	160
Apical horn	75	62.5	75	69
Feet	57	50	78	62
Max. width	100	100	134	114

Occurrence. Sample GS 15, Vradda section (Mt. Camicia, Gran Sasso, Central Apennines). Upper Hettangian.

Farcus leonseveroi n. sp.

Pl. 2, fig. 25, 26, 27, 28

Etymology: This species is named in honour of Prof. Leonsevero Passeri for his contributions to the geology of the Apennines.

Type locality: Sample GS 15, Vradda section (Mt. Camicia, Gran Sasso, Central Apennines).

Types: Holotype Pl. 2, fig. 25 (AB-VR 0004), paratypes Pl. 2, fig. 26 (AB-VR 0005), Pl. 2, 27 (AB-VR 0005), Pl. 2, fig. 28 (AB-VR 0007), from type locality.

Description. Test dicyrtid, large hemispherical poreless cephalis with a triradiate apical horn, thorax subovoidal in outline, with small irregular pores, sub-horizontal ridges, not prominent, four long triradiate curved feet. Base of thorax with a circular and prominent aperture bounded by a large imperforate rim.

Remarks. It differs from *F. sinemurus* Yeh & Yang, 2006 in having large cephalis, sub-horizontal ridge on the thorax, not polygonal pore frames and prominent aperture with a large imperforate rim. It differs from *F. aquilensis* n. sp. in having less evident and more regular ridges, a prominent circular aperture with a large imperforate rim. It differs also from *F.* sp. A Carter et al., 1998 by the presence of a larger thorax, with sub-horizontal ridges and a prominent circular aperture bounded by a large imperforate rim.

Measurements (μm) based on five specimens.

	Holotype	Min.	Max.	Avg.
Total height	210	170	225	201
Apical horn	77	67	83	78
Feet	100	87	100	96
Max. width	117	100	125	116

Occurrence. Sample GS 15, Vradda section (Mt. Camicia, Gran Sasso, Central Apennines). Upper Hettangian.

Farcus sp. cf. **F. graylockensis** Pessagno, Whalen & Yeh, 1986

Pl. 2, fig. 29

cf. 1986 *Farcus graylockensis* Pessagno, Whalen & Yeh, p. 24, pl. 2, fig. 4, 6-8, 12, 15.

Material: One specimen.

Remarks. This form differs from *F. graylockensis* Pessagno, Whalen & Yeh, 1986, in having conical rather than hemispherical cephalis, evident ridges on the conical thorax, circular and prominent aperture, curved and more massive feet.

Occurrence. Sample GS 2, GS 15, Vradda section (Mt. Camicia, Gran Sasso, Central Apennines). Upper Hettangian.

Family Hsuidae Pessagno & Whalen, 1982

Genus *Parahsuum* Yao, 1982

Type species: *Parahsuum simplum* Yao, 1982

Parahsuum vraddaense n. sp.

Pl. 3, fig. 1a-b, 2, 3, 4a-b

Etymology: From the Vradda valley.

Type locality: Sample GS 15, Vradda section (Mt. Camicia, Gran Sasso, Central Apennines).

Types: Holotype Pl. 3, fig. 1a-b (AB-VR 0008), paratypes Pl. 3, fig. 2 (AB-VR 0009), Pl. 3, 3 (AB-VR 0010), Pl. 3, fig. 4a-b (AB-VR 0011), from type locality.

Description. Test conical, with 6 segments, without well-developed strictures. Cephalis poreless, rounded, with a very small and short pointed lateral horn. Thorax and the proximal segments with rare pores irregularly arranged. Distal segments with circular to elliptical pores arranged in a single longitudinal line between irregular longitudinal costae (from 16 to 22).

Remarks. This species differs from *P. ovale* Hori & Yao, 1988, for the presence of a small pointed horn and less numerous irregular costae.

Measurements (μm) based on seven specimens.

	Holotype	Min.	Max.	Avg.
Total height	137.5	120	170	135
Max. width	75	70	92	77

Occurrence. Sample GS 15, Vradda section (Mt. Camicia, Gran Sasso, Central Apennines). Upper Hettangian.

Family Neosciadiocapsidae Pessagno, 1969

Genus *Squinabolia* n. gen.

Type species: *Squinabolia multispinata* n. sp.

Etymology: Named for Senofonte Squinabol, pioneer of Mesozoic radiolarian research.

Description. Hat-shaped dicyrtid test composed of two or more layers with very irregular meshwork. Cephalis small, conical with an apical triradiate short

horn. Thorax large, conical, with a distal narrow skirt and with or without short spines on the rim. Thoracic velum well developed, almost planiform or directed downward, composed of irregular meshwork similar to that of thorax. Circular aperture.

Remarks. Differs from genus *Nabolella* Petrushevskaya, 1981 in lacking a large globular cephalis and thorax with 4-8 long marginal spines. It differs also in having large thorax, with a distal narrow skirt, and a well developed thoracic velum with a circular aperture. Differs from the multicyrtid genus *Palinandromeda* Pessagno, Blome & Hull 1993 in having only cephalis and thorax. Carter (1993) described new Rhaetian species of genus *Squinabolella* Pessagno, 1969 from Queen Charlotte Islands (British Columbia). According to O'Dogherty et al. (2009), *Squinabolella* Pessagno, 1969 is a junior synonym of *Microsciadiocapsa* Pessagno, 1969, a Cretaceous genus. For this reason the species of *Squinabolella* in Carter 1993 should be attributed to *Squinabolia* n. gen.

Range. Upper Triassic: Rhaetian. Lower Jurassic: upper Hettangian-lower Sinemurian.

Occurrence. Vradda section (Mt. Camicia, Gran Sasso, Central Apennines); Nadanhada Terrane NE China; Queen Charlotte Islands, British Columbia.

Squinabolia multispinata n. sp.

Pl. 3, fig. 5, 6a-b, 7, 8

2006 Nassellarian ind. sp. C Yeh & Yang, p. 345, 346, pl. V, fig. 23, 26, 27, 29.

Etymology: From Latin *multispinata*: with numerous spines.

Type locality: Sample GS 15, Vradda section (Mt. Camicia, Gran Sasso, Central Apennines).

Types: Holotype Pl. 3, fig. 6a-b (AB-VR 0012), paratypes Pl. 3, fig. 5 (AB-VR 0013), Pl. 3, 7 (AB-VR 0014), Pl. 3, fig. 8 (AB-VR 0015), from type locality.

Description. Hat-shaped dicyrtid test composed of two or more layers with very irregular meshwork. Cephalis small, conical with an apical triradiate short horn. Thorax large, conical to subconical, with a distal narrow skirt and 13-18 thin pointed spines on the rim, circular in cross section. Thoracic velum planiform with irregular meshwork of circular and subcircolar large pores and a large circular aperture. Outer layer with, distally, large rounded irregularly arranged pores.

Remarks. This form differs from *Squinabolella* sp. C Carter, 1993, in having a short apical horn and spines on the rim of the skirt that are more numerous, thin and pointed. Differs from *Deflandrecyrtium* sp. B Tekin, 2002 in having a dicyrtid test and short spines on the rim of the skirt.

Measurements (μm) based on eleven specimens.

	Holotype	Min.	Max.	Avg.
Total height	294	225	300	270
Diameter of thoracic skirt	323	243	323	286

Range. Lower Jurassic, upper Hettangian-lower Sinemurian.

Occurrence. Sample GS 15, Vradda section (Mt. Camicia, Gran Sasso, Central Apennines); sample MZ90-027, Nadanhada Terrane NE China.

Family Poulpidae De Wever, 1981

Genus: *Saitoum* Pessagno, 1977

Type species: *Saitoum pagei* Pessagno, 1977

Saitoum sp. aff. **S. oculatus** (De Wever, 1982a)

Pl. 3, fig. 9

aff. 1982a *Poulpus oculatus* De Wever, p. 191, pl. 1, fig. 6-10.

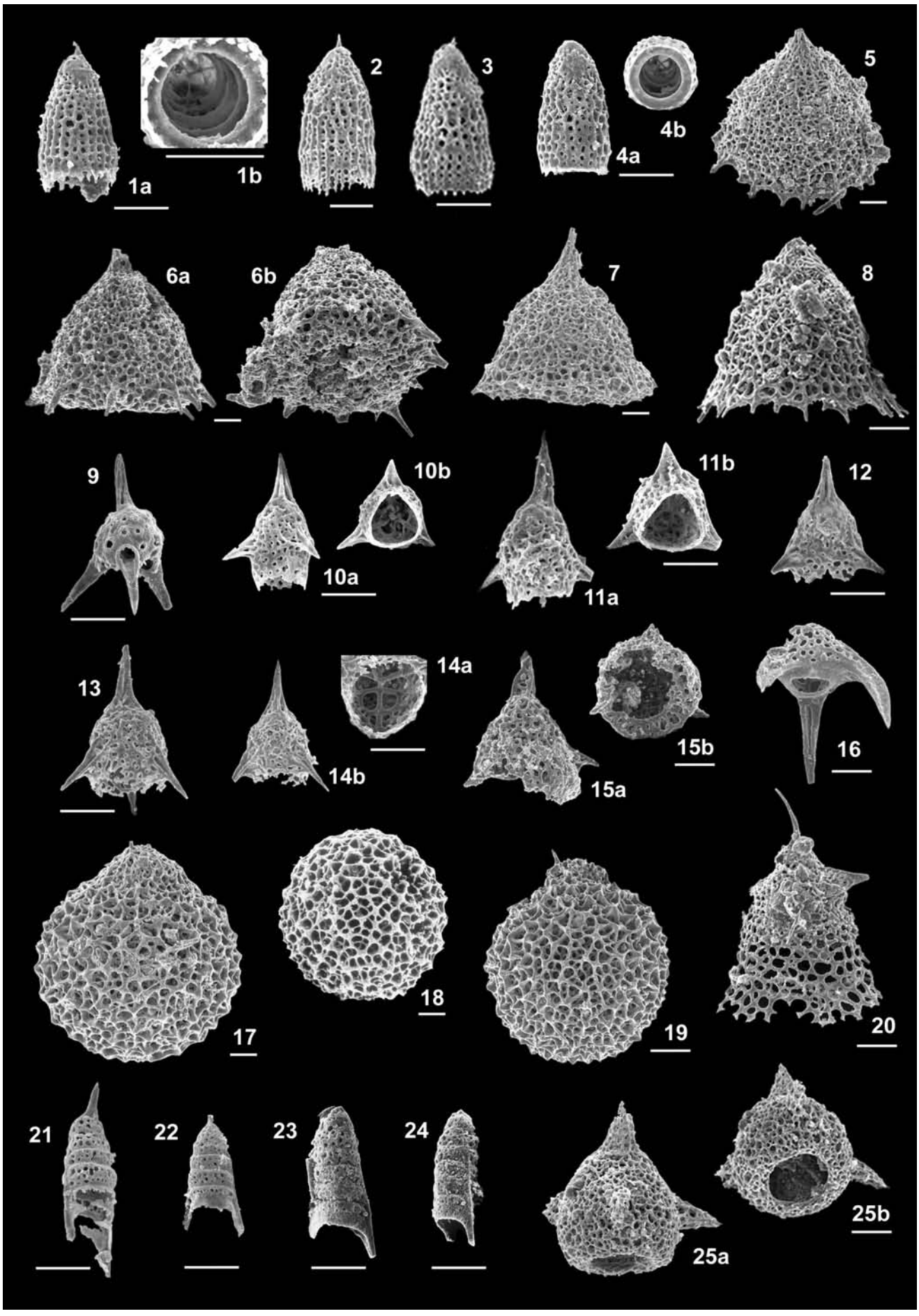
2011 *Saitoum* sp. cf. *S. coronarium* Whalen & Carter - Yeh, p. 14, pl. 6, fig. 18, 23.

Material: Ten specimens.

PLATE 3

Scanning electron micrographs of Hettangian radiolarians from Vradda section, Mt. Camicia. Scale bar = 50 μm

Fig. 1a-b - *Parahsuum vraddaense* n. sp. (holotype AB-VR 0008), GS 15: a. lateral view; b. internal view showing the cephalic structure; Fig. 2, 3 - *Parahsuum vraddaense* n. sp. (paratypes, AB-VR 0009, AB-VR 0010), GS 15; Fig. 4a-b - *Parahsuum vraddaense* n. sp (paratype, AB-VR 0011), GS 15: a. lateral view; b. basal view; Fig. 5 - *Squinabolia multispinata* n. sp. (paratype, AB-VR 0013), GS 15; Fig. 6a-b - *Squinabolia multispinata* n. sp. (holotype, AB-VR 0012), GS 15: a. lateral view; b. basal view; Fig. 7, 8 - *Squinabolia multispinata* n. sp. (paratypes, AB-VR 0014, AB-VR 0015), GS 15; Fig. 9 - *Saitoum* sp. aff. *S. oculatus* (De Wever), GS 15; Fig. 10a-b - *Anaticapitula parvireticulata* n. sp. (holotype, AB-VR 0016), GS 15: a. lateral view; b. basal view; Fig. 11a-b - *Anaticapitula parvireticulata* n. sp. (paratype, AB-VR 0017), GS 15: a. lateral view; b. basal view; Fig. 12 - *Anaticapitula triangularis* n. sp. (paratype, AB-VR 0019), GS 15; Fig. 13 - *Anaticapitula triangularis* n. sp. (holotype, AB-VR 0018), GS 15; Fig. 14a-b - *Anaticapitula triangularis* n. sp. (paratype, AB-VR 0020), GS 15: a. lateral view; b. basal view; Fig. 15a-b - *Anaticapitula*? sp. (lateral and basal view), GS 1: a. lateral view; b. basal view; Fig. 16 - *Napora* sp. cf. *N. isa* (De Wever), GS 2; Fig. 17 - *Zhamoidellum*? *sphaericus* n. sp. (holotype, AB-VR 0021), GS 2; Fig. 18 - *Zhamoidellum*? *sphaericus* n. sp. (paratype, AB-VR 0022), basal view, GS 2; Fig. 19 - *Zhamoidellum*? *sphaericus* n. sp. (paratype, AB-VR 0023), GS 2; Fig. 20 - *Ares*? sp. A, GS 15; Fig. 21 - *Turritus venturii* n. sp. (holotype, AB-VR 0024), GS 15; Fig. 22, 23, 24 - *Turritus venturii* n. sp. (paratypes, AB-VR 0025, AB-VR 0026, AB-VR 0027), GS 15; Fig. 25a-b - Nassellaria gen. et sp. indet. Z, GS 15: a. general view; b. basal view.


1a
1b
2
3
4a
4b
5
6a
6b
7
8
9
10a
10b
11a
11b
12
13
14a
14b
15a
15b
16
17
18
19
20
21
22
23
24
25a
25b

Remarks. We use the genus *Saitoum* Pessagno, 1977 instead *Poulpus* De Wever, 1982 because *Poulpus* lacks the prominent cephalic spine. In addition genus *Poulpus* became extinct in the Triassic (O'Dogherty et al. 2011). This form differs from *Poulpus oculatus* in having smaller pores and mostly of the same size except for those at feet. It differs also from *Poulpus* sp. N sensu Hattori (1987) in having less numerous pores and short straight feet.

Occurrence. Sample GS 15, Vradda section (Mt. Camicia, Gran Sasso, Central Apennines). Upper Hettangian.

Family Ultranaporidae Pessagno, 1977, emend. Pessagno, Whalen & Yeh, 1986

Genus *Anaticapitula* Dumitrica & Zugel, 2003

Type species: *Anaticapitula clauda* Dumitrica & Zugel, 2003

Anaticapitula parvireticulata n. sp.

Pl. 3, fig. 10a-b, 11a-b

Etymology: The name is from Latin *parvus*: small, and *reticulus*: network.

Type locality: Sample GS 15, Vradda section (Mt. Camicia, Gran Sasso, Central Apennines).

Types: Holotype: Pl. 3, fig. 10a-b (AB-VR 0016), paratype Pl. 3, fig. 11a-b (AB-VR 0017), from type locality.

Description. Ovoid dicyrtid test with a massive pointed three-bladed apical horn. Hemispherical big cephalis; thorax open, short, subcircular to triangular in cross section, with a tubular free velum. Cephalis and thorax without collar stricture. Three feet representing external extensions of primary lateral (L) and dorsal (D) cephalic spines. Short divergent feet, with two lateral blades and a central one. Test with irregular pores, rare and small on the cephalis and increasing in size and density on the thorax.

In basal view (Pl. 3, fig. 13b, 14b) the initial cephalic structure seems to show a small Ax.

Remarks. This species differs from *A. anatiformis* (De Wever), in having a bigger hemispherical cephalis, thorax without strong longitudinal edges extending in three feet, and shorter, divergent and straight feet. The surface of the test differs from *A. anatiformis* in having less numerous and irregular pores.

Measurements (μm) based on eight specimens.

	Holotype	Min.	Max.	Avg.
Total height	125	125	182	150
Apical horn	40	40	63	48
Feet length	37	28	47	36
Thorax width	45	45	68	54

Occurrence. Sample GS 15, Vradda section (Mt. Camicia, Gran Sasso, Central Apennines). Upper Hettangian.

Anaticapitula triangularis n. sp.

Pl. 3, fig. 12, 13, 14a-b

Etymology: The name is from Latin *triangularis*: triangular.

Type locality: Sample GS 15, Vradda section (Mt. Camicia, Gran Sasso, Central Apennines).

Types: Holotype Pl. 3, fig. 13 (AB-VR 0018), paratypes Pl. 3, fig. 12 (AB-VR 0019), Pl. 3, fig. 14a-b (AB-VR 0020), from type locality.

Description. Dicyrtid triangular test, with a massive pointed three-bladed apical horn. Cephalis smooth or with rare and small pores. Cephalis and thorax without stricture. Thorax roughly tetrahedral in form, with irregular pores and wrinkles. Large velum partially connected with the three short straight feet.

Remarks. Differs from *A. parvireticulata* n. sp. in having a triangular shape of the test, larger and irregular pores on the thorax, larger size of the velum, connected with the longer straight feet.

Measurements (μm) based on six specimens.

	Holotype	Min.	Max.	Avg.
Total height	149	110	151	134
Apical horn	69	46	65	59
Feet length	55	46	55	50
Thorax width	83	70	83	76

Occurrence. Sample GS 15, Vradda section (Mt. Camicia, Gran Sasso, Central Apennines). Upper Hettangian.

Anaticapitula? sp.

Pl. 3, fig. 15a-b

2004 Nassellaria indet. Bertinelli et al., fig. 6, n. 25.

Material: One specimens.

Remarks. It differs from genus *Anaticapitula* in having cephalic horn with pores between the ridges and lacking strong ridges on cephalis and thorax.

Occurrence. Sample GS 1, Vradda section (Mt. Camicia, Gran Sasso, Central Apennines). Middle Hettangian.

Genus *Napora* Pessagno, 1977

Type species: *Napora bukryi* Pessagno, 1977

Napora sp. cf. **N. isa** (De Wever, 1982a)

Pl. 3, fig. 16

cf. 1982a *Jacus isa* De Wever, p. 212, pl. 12, fig. 10-14, pl. 13, fig. 1-4.

2004 Nassellaria indet. Bertinelli et al., fig. 6, n. 11.

Material: One specimen.

Remarks. Thorax very similar to that of *Napora isa* (De Wever, 1982a) and feet that, equally, are pronouncedly curved. Its attribution is uncertain since the cephalis with the horn is broken.

Occurrence. Sample GS 2, Vradda section (Mt. Camicia, Gran Sasso, Central Apennines). Upper Hettangian.

Family Williriedellidae Dumitrica, 1970

Genus *Zhamoidellum* Dumitrica, 1970

Type species: *Zhamoidellum ventricosum* Dumitrica, 1970

Zhamoidellum? sphaericus n. sp.

Pl. 3, fig. 17, 18, 19

Etymology: The name is from Latin *sphaericus*: spherical, for the shape of the abdomen.

Type locality: Sample GS 2, Vradda section (Mt. Camicia, Gran Sasso, Central Apennines).

Types: Holotype Pl. 3, fig. 17 (AB-VR 0021), paratypes Pl. 3, fig. 18 (AB-VR 0022), Pl. 3, fig. 19 (AB-VR 0023), from type locality.

Description. Shell large, inflated, with three segments. Cephalis hemispherical with a needle-like small, apical lateral horn. Cephalis and thorax with an irregular frame of small pores. Test with a stricture between thorax and abdomen. The shell presents two layers, the inner one with small irregular pores, the outer one with larger irregular sized, polygonal pore frame and small nodes at the pore frame vertices. Abdomen inflated, globular and closed.

Remarks. This form is attributed to genus *Zhamoidellum* doubtfully due to an irregular meshwork instead of circular or polygonal pore frames. It differs from *Stichocapsa* sp. A (sensu Whalen & Carter, 2002) in having cephalis with irregular pores and a tiny apical spine.

Measurements (μm) based on six specimens.

	Holotype	Min.	Max.	Avg.
Total height (excl. horn)	413	326	515	394
Max. width	400	305	461	363

Occurrence. Sample GS 2, Vradda section (Mt. Camicia, Gran Sasso, Central Apennines). Upper Hettangian.

Nassellaria incertae sedis

Genus *Ares* De Wever, 1982a

Type species: *Ares armatus* De Wever, 1982a

Ares? sp. **A**

Pl. 3, fig. 20

Material: Two specimens.

Description. Test dicyrtid; small cephalis with one thin smooth curved horn and thorax with three or four massive triradiate spines and large subconical velum. Cephalis and thorax with small pores, velum with large subcircular pores.

Remarks. These specimens are doubtfully attributed to the genus *Ares* De Wever, 1982 in having only one thin smooth curved horn and three-four short thorax spines. They differ from genus *Riedelius* in having only one thin curved horn, three (or four) visible massive short triradiate spines arising from the collar stricture and in lacking longitudinal and transversal ridges on the cephalis and thorax.

Occurrence. Sample GS 15, Vradda section (Mt. Camicia, Gran Sasso, Central Apennines). Upper Hettangian.

Genus *Turritus* n. gen.

Type species: *Turritus venturii* n. sp.

Etymology: The name is from Latin *turritus*: like a tower.

Description. Test multicyrtid, sub-conical, with five or six segments. Cephalis with a small pointed apical horn, triradiate in cross section at the base and circular distally. Thorax, abdomen and post-abdominal segments perforated by irregular circular to ovate pores. Distal segment with two long straight downward feet, circular in cross section.

Remarks. Differs from genus *Bipedis* De Wever, 1982 in having more than two segments, a thin apical horn, and lacks the V spine outside; feet thinner and straight downward. Differs from genus *Cuniculiformis* De Wever, 1982 in having five or more segments, only a single thin apical horn, circular instead triradiate in section, and two feet.

Some specimens assignable to this genus were illustrated by Hattori (1987) as Gen. 2 sp. B, Hattori (1988) as Gen. 10 sp., Hattori (1989) as Gen. 1 spp. and Gen. sp. ind., and by Hori et al. (1996) as *Bipedis* (?) sp. A.

Range. Lower Jurassic: upper Hettangian-Sinemurian to Toarcian-Aalenian (?).

Occurrence. Sample GS 15, Vradda section (Mt. Camicia, Gran Sasso, Central Apennines, Italy); Nanjo

Massif (Fukui Prefecture, Central Japan); Kawhia coast (New Zealand).

Turritus venturii n. sp.

Pl. 3, fig. 21, 22, 23, 24

1987 Gen. 2 sp. B Hattori, pl. 21, fig. 7.
1988 Gen. 10 sp. Hattori, pl. 9, fig. G.
1989 Gen. 1 sp. A Hattori, pl. 16, fig. G.
1989 Gen. 1 spp. Hattori, pl. 21, fig. L.
1989 Gen. sp. indet. Hattori, pl. 36, fig. F.
1996 *Bipedis* (?) sp. A Hori et al., pl. 2, fig. 17.

Etymology: Named in honour of Prof. Federico Venturi for his contributions to the study of ammonoids of Vradda section.

Type locality: Sample GS 15, Vradda section (Mt. Camicia, Gran Sasso, Central Apennines).

Description. Test multicyrtid, sub-conical, with five or six segments. Cephalis with a small pointed apical horn triradiate in cross section at the base and circular distally. Thorax, abdomen and post-abdominal segments slightly narrowing distally, with relatively deep strictures. All the segments perforated by irregular circular to ovate pores. Distal segment with two long feet circular in cross section. Distal velum with large circular pores.

Remarks. It differs from Gen. 2 sp. A Hattori, 1987, Gen. 10 sp. Hattori, 1988, Gen. 1 spp. and Gen. sp. indet. Hattori, 1989 in having more conical test and the two feet more divergent with the external thick blades emerging from the thorax.

Measurements (μm) based on nine specimens.

	Holotype	Min.	Max.	Avg.
Total height	75	58	125	105
Apical horn	half broken	23	33	28
Feet	28	25	45	32
Max. width	42	42	58	55

Occurrence. Sample GS 15, Vradda section (Mt. Camicia, Gran Sasso, Central Apennines). Upper Hettangian.

Types. Holotype Pl. 3, fig. 21 (AB-VR 0024), Paratypes Pl. 3, fig. 22 (AB-VR 0025), Pl. 3, fig. 23 (AB-VR 0026), Pl. 3, fig. 24 (AB-VR 0027), from type locality.

Nassellaria gen. and sp. indet. Z

Pl. 3, fig. 25a-b

Material: Four specimens.

Description. Test dicyrtid with an apical horn (A), covered by pores, and three latticed large tubular spines (D and L). Shell with two layers, the outer one with large polygonal irregular pore frame. The tip of the spines is triradiate.

Remarks. This form differs from Nassellaria indet. B Whalen & Carter, 2002 in having three latticed tubular spines and an apical horn with pores and for lacking small basal poreless distal spines.

Occurrence. Sample GS 15, Vradda section (Mt. Camicia, Gran Sasso, Central Apennines). Upper Hettangian.

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