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Buckeridge, J 2005, 'Ovulaster protodecimae, n. sp. (Echinoidea, Spatangoida) and associated epifauna (Cirripedia, Verrucidae) from the Danian of Northeastern Italy', *Rivista Italiana di Paleontologia e Stratigrafia*, vol. 111, no. 3, pp. 453-462.

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**OVULASTER PROTODECIMAE, N. SP. (ECHINOIDEA, SPATANGOIDA)
AND ASSOCIATED EPIFAUNA (CIRRIPEDIA, VERRUCIDAE)
FROM THE DANIAN OF NORTHEASTERN ITALY**

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Received: August 4, 2004; accepted: March 2, 2005

Key words: Danian, Echinoids, Spatangoida, New taxon, K/T boundary, Verrucid barnacles.

Abstract. A new species of irregular echinoid, *Ovulaster protodecimae*, is described from the Danian Scaglia Rossa Formation outcropping in the Venetian Prealps (Southern Alps, northeastern Italy). The new species, belonging to the order Spatangoida, is very distinctive because of its inflated, almost triangular test, the high-positioned periproct and the plate arrangement on the oral face. This is the first report of the genus *Ovulaster* in the Danian of Italy and the first description of an echinoid from the Early Palaeocene of Italy. One test has an epifauna of the sessile verrucid barnacle *Verruca* sp. cf. *V. prisca* Bosquet, 1854, attached on all except the oral surface.

Riassunto. Nel presente lavoro è istituita una nuova specie di echinide irregolare, *Ovulaster protodecimae* (Spatangoida), rinvenuta entro la Scaglia Rossa daniana nelle Prealpi Venete (Sudalpino, Italia nordorientale). Il nuovo taxon si distingue per la morfologia della teca (rigonfia e quasi triangolare), per la posizione elevata del periprocto e per la disposizione delle piastre nella faccia orale. Si tratta della prima segnalazione del genere *Ovulaster* nel Daniano dell'Italia e della prima descrizione di un echinide nel Paleocene Inferiore d'Italia. Uno degli esemplari studiati è incrostato su tutta la teca, a eccezione della faccia orale, da balani ascrivibili a *Verruca* sp. cf. *V. prisca* Bosquet, 1854.

Introduction

The Scaglia Rossa Formation (*s.l.*) is a well-known Late Cretaceous to early Palaeogene lithostratigraphic unit widely outcropping in the Veneto region (e.g. Antonelli et al. 1990; Braga et al. 1971; Costa et al. 1996). In the eastern part of the region it generally records the concluding phase of pelagic carbonate deposition in the Belluno Basin along the western margin of

the Friuli Platform (Miller & D'Alberto 2001). The Scaglia Rossa is mainly composed of deep-water reddish limestones and marly foraminiferal biomicrites (Channell & Medizza 1981). The deposition depth has generally been interpreted as more than 1000 metres below the "oxygen minimum zone", although the depositional environment of this formation may have been shallower, at least locally (e.g. Bosellini et al. 1978; Poletti et al. 2003). Macrofossils are generally rare, although remains of echinoids, bivalves and vertebrates have been known since the 19th Century (e.g. Catullo 1827; Da Rio 1844; De Zigno 1861; Airaghi 1903, 1904, 1907, 1931; Parona 1904, 1912; Piccoli & Traverso 1962; Cigala Fulgosi et al. 1980; Astolfi & Colombara 1990, 2003; Dhondt & Dieni 1990). These findings refer exclusively to the Cretaceous portion of the Scaglia Rossa Formation. The "Danian" echinoids of Seunes (1888) and Munier-Chalmas (1891) from the Vicenza province are Upper Cretaceous in terms of modern chronostratigraphy. The most recent, well-documented echinoids of Scaglia Rossa (*Stegaster sulcatus* Cotteau and *Stegaster dallagoi* Airaghi) were collected in Maastrichtian beds cropping out in quarries of the Euganei Hills, Padova province (e.g. Monte Ricco quarry, Astolfi & Colombara 1990, 2003). We are not aware of any corroborated findings of Palaeocene echinoids in the Scaglia Rossa Formation or in other equivalent units in Italy, except for a report on a questionable irregular echinoid from the Thanetian "Scaglia Cinerea" Formation at Pontenelle Alpi (Belluno) (Miller 2000, fig. 4 D). This record

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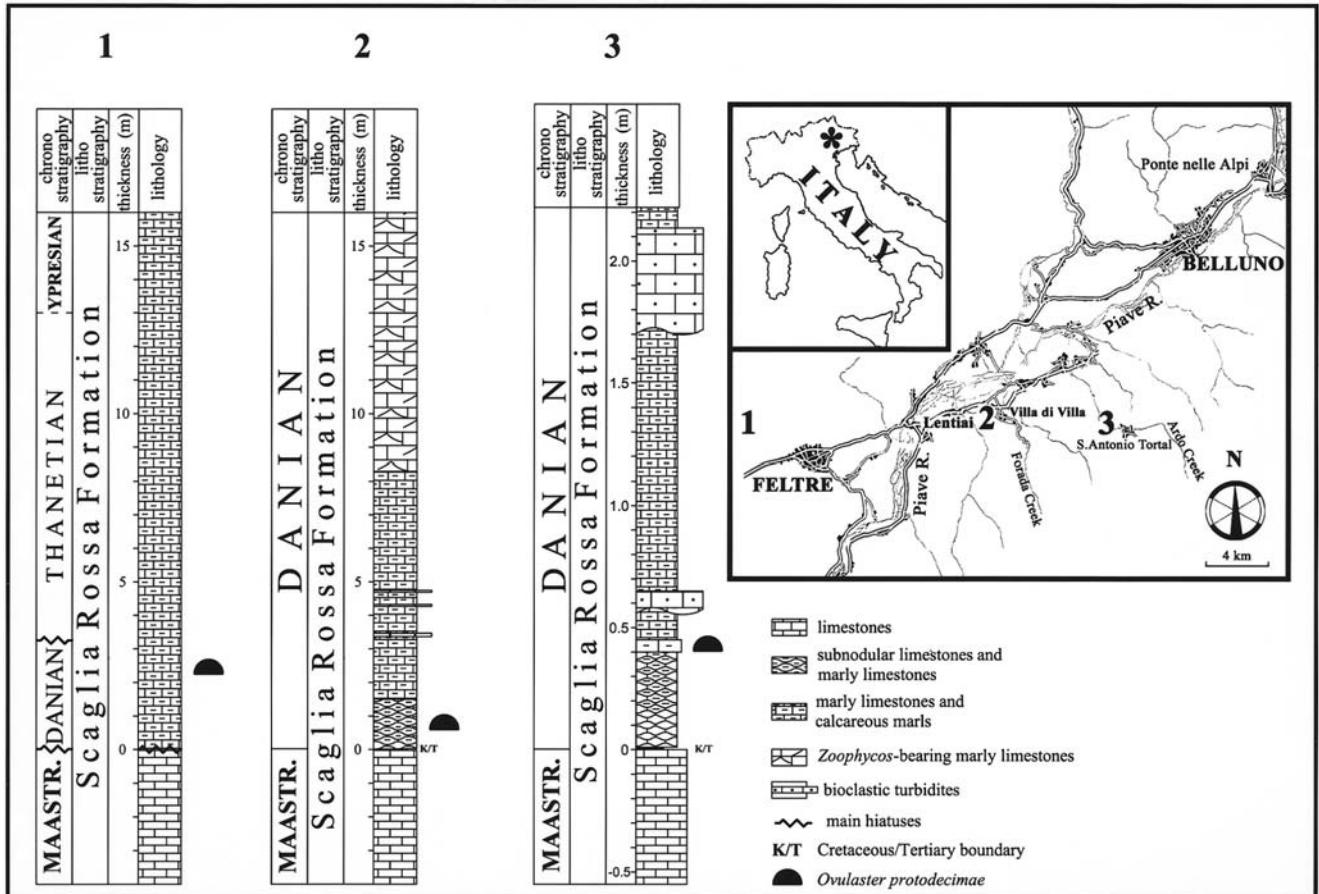


Fig. 1 - Location map and stratigraphic logs of the sections that yielded specimens of *Ovulaster protodecimae*. 1. Facen section; 2. Forada Section; 3. South Ardo section.

is particularly noteworthy because although the Palaeogene horizons of the Scaglia Rossa Formation contain very abundant trace fossils macrofossils are generally lacking (Miller 2000).

Here, we document the occurrence of a new species of spatangoid from the Danian Scaglia Rossa of Venetian Prealps (Southern Alps of northeastern Italy), the first description of an irregular echinoid from Early Palaeocene of Italy.

Sample localities and geological context

The studied material has been collected in different exposures of Scaglia Rossa of the Venetian Prealps of Belluno province (NE Italy; Fig. 1).

Locality 1: Facen. Advanced Danian marly limestones of the Scaglia Rossa in the locality of Facen (near Feltre, on the right side of Piave River valley), ca. 10 Km SW of Lentiai, yielded two specimens of the new taxon. The Palaeocene beds of this section have not been previously investigated so far. In fact, only the Eocene portion of the Facen succession has been considered in an overview on the western termination of Belluno Flysch (Grandesso & Stefani 1993). Preliminary data based on calcareous nannofossils analysis (Agnini e Fornaciari pers. com.) indicate that locally, the Palaeocene is very condensed (ca. 13 meters) with many hiatuses.

Locality 2: Forada Creek. At a previously undescribed exposure outcropping along the gorge of the Forada Creek, on the left side of the Piave River valley two kilometres from Lentiai, near the village of Villa di Villa, at an apparently complete K/T boundary (Giusberti 2002; Fornaciari et al. 2003, in prep.). Here the Scaglia Rossa Formation is 200-250 meters thick (Costa et al. 1996) and spans from Lower Turonian to Lower Eocene. Three specimens were found within a 150 cm-thick package of reddish subnodular micritic limestones and marly limestones, immediately above the 1.5 cm-thick clay layer marking the K/T boundary (Fig. 1). Further intensive collecting from the site yielded only few small specimens of poorly preserved irregular echinoids and rare crinoid columnals.

Locality 3: South Ardo Creek. Here, the upper portion of the Scaglia Rossa (including the K/T transition and the Danian beds) contains numerous light-coloured calciturbidites; it is known locally as "Cugnan Formation" (Di Napoli Alliata et al. 1970; Costa et al. 1996). One specimen of *O. protodecimae* has been collected in the basal Danian marly limestones, ca. 40 cm above the K/T boundary, outcropping close to the spectacular gorge of the South Ardo Creek (known in the local dialect as "Brent Grande"), about 8 km to the east of the Forada Creek (Fig. 1). A strongly crushed echinoid, doubtfully ascribed to the genus *Ovulaster*, has been also collected at the base of a thick calciturbiditic bed, ca. 9 meters above the K/T boundary.

In terms of palaeogeography, the Facen succession accumulated in the western part of the Belluno Basin, whereas the Forada and South Ardo successions were deposited in the central and eastern part of the Belluno Basin respectively. The sedimentation in the South Ardo area was strongly influenced by the vicinity of the Friuli Platform that shed abundant bioterritris into the basin.

Systematic palaeontology

The specimens illustrated and described are housed in the collection of the Dipartimento di Geologia, Paleontologia e Geofisica, Università degli Studi di Padova, Museo di Geologia e Paleontologia, via Giotto 1, Padova, Italy (numbers with the prefix MGPD). The classification followed herein mainly follows Smith & Jeffery (2000) with subsequent modifications (Smith et al. 2003).

Class **Echinoidea** Leske, 1778

Order **Spatangoida** Claus, 1876

Suborder **Micrasterina** Fischer in Moore, 1966

Family **Micrasteridae** Lambert, 1920

Genus **Ovulaster** Cotteau, 1884

Type species: *Ovulaster gauthieri* Cotteau, 1884.

Diagnosis. See Smith & Jeffery (2000, p. 310).

Occurrence. Upper Cretaceous to Palaeocene (e.g. Wagner & Durham 1966; Smith & Jeffery 2000; Smith et al. 2003; present paper).

Discussion. Prior to this paper, the genus *Ovulaster* included five species: *O. zignoanus* (d’Orbigny, 1854), *O. gauthieri* Cotteau, 1884, *O. auberti* Gauthier, 1892, *O. obtusus* Cotteau in Blayac & Cottreau, 1909 and *O. reticulatus* Smith & Gallemi in Smith et al., 1999. *Ovulaster zignoanus* a poorly known, small species originally described from the “Senonian” Scaglia Rossa of Vicenza province (northeastern Italy) has been proposed as a senior synonym of the type *O. gauthieri* by Gauthier (1892). This has been followed by authors such as Airaghi (1903) and Lambert & Thiéry (1924). However, Blayac & Cottreau (1909) and Mortensen (1950) rejected this decision on the basis of the original illustrations. Unfortunately, the material from Italy was never investigated in detail and simply listed or briefly

described with poor quality figures (e.g. Airaghi 1903, 1931; De Zigno 1861; Piccoli & Traverso 1962; Astolfi & Colombara 1990, 2003). On the basis of this evidence, it becomes clear that a careful redescription of type material of *O. zignoanus* is badly needed.

Ovulaster reticulatus is known from the Early Maastrichtian of Spain (Smith et al. 1999), and *O. auberti* and *O. obtusus* from the Late Cretaceous of North Africa.

Ovulaster protodecimae n. sp.

Figs 2a,b; Pl. 1; Pl. 2, figs 6-9

Material. Total: 6 specimens. 3 specimens from the section of the Forada Creek (MGPD 28877; MGPD 28878; MGPD 28941), 2 specimens from the Facen section (MGPD 29013, 29014) and 1 specimen (MGPD 29015) from South Ardo section. Specimens MGPD 28877 and MGPD 28878 are well preserved with slight abrasion partly obliterating the tubercle arrangement on the plates. Specimen MGPD 28877 shows a faint ventral compression around the peristome. Twelve small verrucid barnacles are attached to the test of paratype MGPD 28877. The third specimen (MGPD 28941) is crushed. The specimens from Facen (MGPD 29013, 29014) are moderately well preserved and show similar surface abrasion to that of the Forada specimens. The specimen from South Ardo (MGPD 29015) is weakly deformed and encrusted by heavily worn serpulid and undetermined bivalves. Specimens MGPD 28941 and 29015 are too deformed for detailed morphological analysis.

Type series. 4 specimens.

Holotype. MGPD 28877, the specimen figured in Fig. 2a and Pl. 1 (Figs 1-5).

Paratypes. MGPD 28878, the specimen figured in Fig. 2b, Pl. 1 (Figs 6-10) and Pl. 2 (Figs 8, 9); MGPD 29013, figured in Pl. 1 (Figs 11, 12); MGPD 29014, figured in Pl. 2 (Figs 6, 7).

Etymology. Patronymic. The new species is dedicated to Professor Franca Proto Decima in recognition of her great contribution to the study of the Palaeogene of the Veneto region (Italy).

Type horizon. A 150 cm-thick red subnodular marly biomicritic limestone that overlies the clay layer marking the K/T boundary (Fig. 1). This horizon lies within the Scaglia Rossa Formation, lowermost Danian. Age based on calcareous nannofossil assemblage (lowermost part of NP 1 Zone of Martini, 1971 within the acme of *Braarudosphæra* spp.). The calcareous nannofossil content of the matrix infilling the periproct of the holotype MGPD 28877 is the same as the enclosing sediment.

Type locality. The gorge of Forada Creek, near the village of Villa di Villa, Lentiai, Belluno, Venetian Prealps, NE Italy.

Diagnosis. Test inflated, almost triangular in outline without anterior indentation. All ambulacra non-petaloid with small, round pores; ambulacral plates high. Apical system ethmophract with four gonopores. Mouth anteriorly positioned. Mesamphisternous plastron with long labral plate and symmetrical sternal plates.

Dimensions. Holotype L = 36,1 mm; W = 35,4 mm; H 30,0 mm; H periproct = 12, 7 mm. Paratypes MGPD 28878 L = 31, 3 mm; W = 30, 2 mm; H = 27, 2 mm; H periproct = 11, 2 mm. MGPD 29014 L = 30 mm; W = 30, 5 mm; H = 28, 1 mm; H periproct = 9,7 mm; MGPD 29013 L = 35, 7 mm; W = 34, 6 mm; H = 30, 3 mm; H periproct = 12, 5 mm

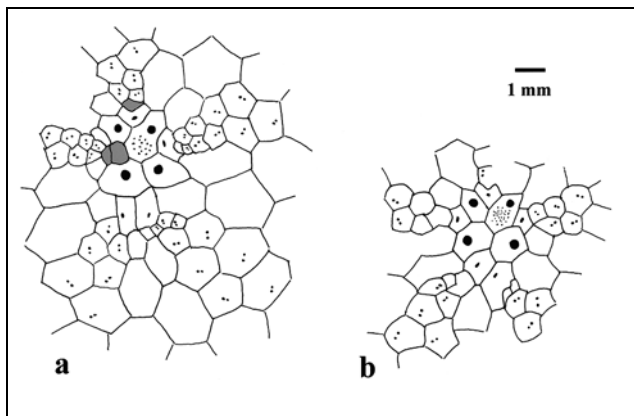


Fig. 2 - Apical system of *Ovulaster protodecimae*. a) holotype MGPD 28877; b) paratype MGPD 28878.

Description. Medium-sized spatangoid with ambulacral and interambulacral plates swollen centrally.

Shape. Test width and length approximately equal (width = 97-101% of length). Widest point of test slightly anterior (37-41% of test length from anterior border). Test height 83-94% of length, tallest point coincides with apical disc. Frontal sulcus absent; test triangular in profile, posterior truncated vertically. The oral surface gently convex curving gradually towards peristome. Ambitus is low, about 1/3 of total height.

Apical disc. Apical disc tetrabasal and ethmophract; compact and roughly circular in outline; lies anterior of tallest point, is slightly sunken below adjacent interambulacral zones. The four genital plates in contact with one another centrally, similar in size but with genital plate 3 smallest (Fig. 2a, b). Gonopores are large and circular, lying towards outer edge of genital plates. Madreporite gonopore noticeably smaller than others. Ocular plates II, III and IV small, triangular, separated from one another; oculars I and V quadrangular, in contact posteriorly. Hydropores confined to genital plate 2.

Ambulacra. Frontal non-petaloid ambulacrum not differentiated from other ambulacra. Ambulacral pores small, circular in outline; near the apical system they lie at centre of the plates, adambitally ambulacral pores become minute unipores, shifting towards lower margin of plates. Phylloides weakly developed.

Lateral and posterior ambulacra pairs very similar and non-petaloid. Anterior pairs diverge at an angle of 132°. Angle inscribed posteriorly by the two posterior ambulacra is 55°. Ambulacra are open at base and taper slightly adapically; in each column ambulacral pores become gradually smaller and more widely spaced towards ambitus.

Interambulacra. Interambulacra composed of relatively large, broad plates; at ambitus interambulacral zones more twice breadth of ambulacral zones. On oral surface plastron is mesamphisternous with long funnel-shaped labral plate with length ca. 20 % of test length; posterior border of this plate straight while the anterior does not project over peristome. Both sternal plates in contact with labral plate, suture between plates 2a and 2b runs vertically. Sternal plates slightly more than twice length of labrum, broader towards posterior. Two pairs of small and hexagonal episternal plates follow them.

Periproct. Periproct small, oval in outline, slightly broader than tall, situated high on posterior face; height of periproct opening 35-42 % of height of test, 80-84 % of its width.

Peristome. Peristome roughly D-shaped in outline with convex anterior margin, posterior face very slightly concave.

Tuberculation. All specimens are abraded with tubercles and miliary granules preserved only in small area near peristome of holotype and adjacent to ambitus of

paratype MGPD 29013. Tubercles randomly arranged, small with circular areoles. Miliary tubercles abundant, densely packed between primary tubercles. Subanal fasciole not preserved. Although these specimens do not preserve this important morphological feature, they nevertheless are considered to retain sufficient details to permit description as a new species

Discussion. The apical system and swollen centrally ambulacral and interambulacral plates of *O. protodecimae* are most like those of *O. reticulatus* Smith & Gallemi from which it differs in having a less globular and more triangular test, taller periproct. Moreover, it differs in having a shorter labrum and more elongated sternal plates.

Because of the absence of good illustrations of *O. zignoanus* in the available literature (see above), our material has been also compared with specimens corresponding to the original description of *O. zignoanus* stored in the extensive collection of the Euganei Hills Museum (Padova province). One of the best-preserved specimens is figured in Pl. 2 (Figs. 1-5). *O. protodecimae* differs from Late Cretaceous *O. gauthieri* Cotteau and *O. zignoanus* d'Orbigny, in having a stouter, less angular test and in lacking a frontal groove leading to the peristome on the oral surface. Moreover, *O. protodecimae* shows a more globular and triangular test and the apical system is located in a subcentral position. Compared to *O. zignoanus* the posterior end of the new species is vertically truncated without indication of an anal rostrum (see Mortensen 1950). For this reason the periproct is seen only from the posterior (i.e. not in dorsal view). Further, the plastron of the new taxon is not inflated and all the dorsal plates are swollen centrally.

Stratigraphy and Age. Danian (calcareous nannofossils Zone NP1 in the Forada and South Ardo sections, calcareous nannofossil Zone NP4, above the FO of *Sphenolithus primus*, in the Facen section). Venetian Prealps (NE of Italy).

Association and palaeodepth of the type horizon. *Ovulaster protodecimae* n. sp. is associated with scattered macrofossils such as small irregular echinoids, crinoid columnals and abundant ichnotaxa such as *Zoophycos*. Microfossils include planktonic and benthic foraminifera, scattered ostracods and rare ichthyoliths.

The benthic foraminifera assemblage is highly diverse, dominated by *Aragonia velascoensis*, *Gavelinella beccariiiformis*, *Cibicidoides velascoensis*, *Cibicidoides dayi*, *Clavulinoides trilatera*, *Clavulinoides amorpha*, *Marssonella oxycona*, *Nuttallides truempyi*, *Bolivinoidea delicatulus* and *Osangularia velascoensis*. Most of these belong to the typical bathyal to abyssal Velasco fauna (Berggren & Aubert 1975). Species with an upper depth

limit of ca. 500 m are dominant with many taxa common in middle-lower bathyal environment (e.g. van Morkhoven et al. 1986; Alegret et al. 2003). Specifically, the occurrence of *Clavulinoides trilatera*, *Aragonia velascoensis* and *Cibicidoides velascoensis* might be indicative of a lower bathyal depositional environment (e.g. Kaminski et al. 1988; van Morkhoven et al. 1986). Similar palaeodepth estimation has been inferred on the basis of benthic foraminifera assemblages for the Facen and South Ardo localities.

Remarks

Evolution of K/T boundary echinoids is very topical, and has resulted in a number of recent publications (e.g. Jeffery 1997a,b; Jeffery 1998; Smith & Jeffery 1998; Smith et al. 1999; Smith & Jeffery 2000; Jeffery 2001). In particular, attention has been paid to heart urchins (Irregularia, Atelostomata, including *Ovulaster*) and to their response to the biotic collapse at the end of the Cretaceous (Jeffery 2001). This paper could be considered a little contribution to this fascinating problem. The survival of the genus *Ovulaster* at the K/T boundary had previously only been inferred, through the identification of its post-Palaeocene sister taxon *Habanaster* (see Jeffery 2001). Its presence in the Danian, as reported in Smith et al. (2003) is unconfirmed. This record of *Ovulaster*, from the Veneto region definitively demonstrates that the genus not only survived the K/T boundary event, but persisted at least until the late Danian (upper NP4 calcareous nannofossils zone above the FO of *Sphenolithus primus*), i.e. about 4.4 million years after the event according to the time scale of Berggren et al. (1995).

Acorn barnacles attached on the test of the specimen MGPD 28877

Paratype MGPD 28877 differs from others in the type series by the presence of twelve barnacles (Pl.1, Figs 6-10; Pl. 2, Figs 8, 9). These barnacles are of the sessile family Verrucidae, and although the diagnostic opercular valves are not preserved, the specimens show sufficient similarity to *Verruca prisca* Bosquet, 1854, to tentatively include them within that species.

- Sub Class **Cirripedia** Burmeister, 1834
- Suborder **Verrucomorpha** Pilsbry, 1916
- Family **Verrucidae** Darwin, 1854
- Genus **Verruca** Schumacher, 1817
- Type species: *Lepas stroemia* Müller, 1776.

Diagnosis. Shell box-like, operculum flat, parallel to base; radioalar area between fixed scutum and fixed tergum small or linear,

rostral and carinal apices marginal, internally with well developed myophore on fixed scutum.

Verruca sp. cf. **V. prisca** Bosquet, 1854.

Description. (Based on the best-preserved and largest specimen: Pl. 2, fig. 8: specimen at lower left). Carino-rostral diameter: 6.7 mm. Shell with compartments smooth; operculum D-shaped; rostrum with two broad flat, weakly striated articulating ribs; fixed scutum slightly wider than fixed tergum, upper margin of large, triangular alae-form expansion in line with apex, single rib articulating with rostrum; fixed tergum with triangular alae-form expansions on both sides, single articulating rib on carinal side.

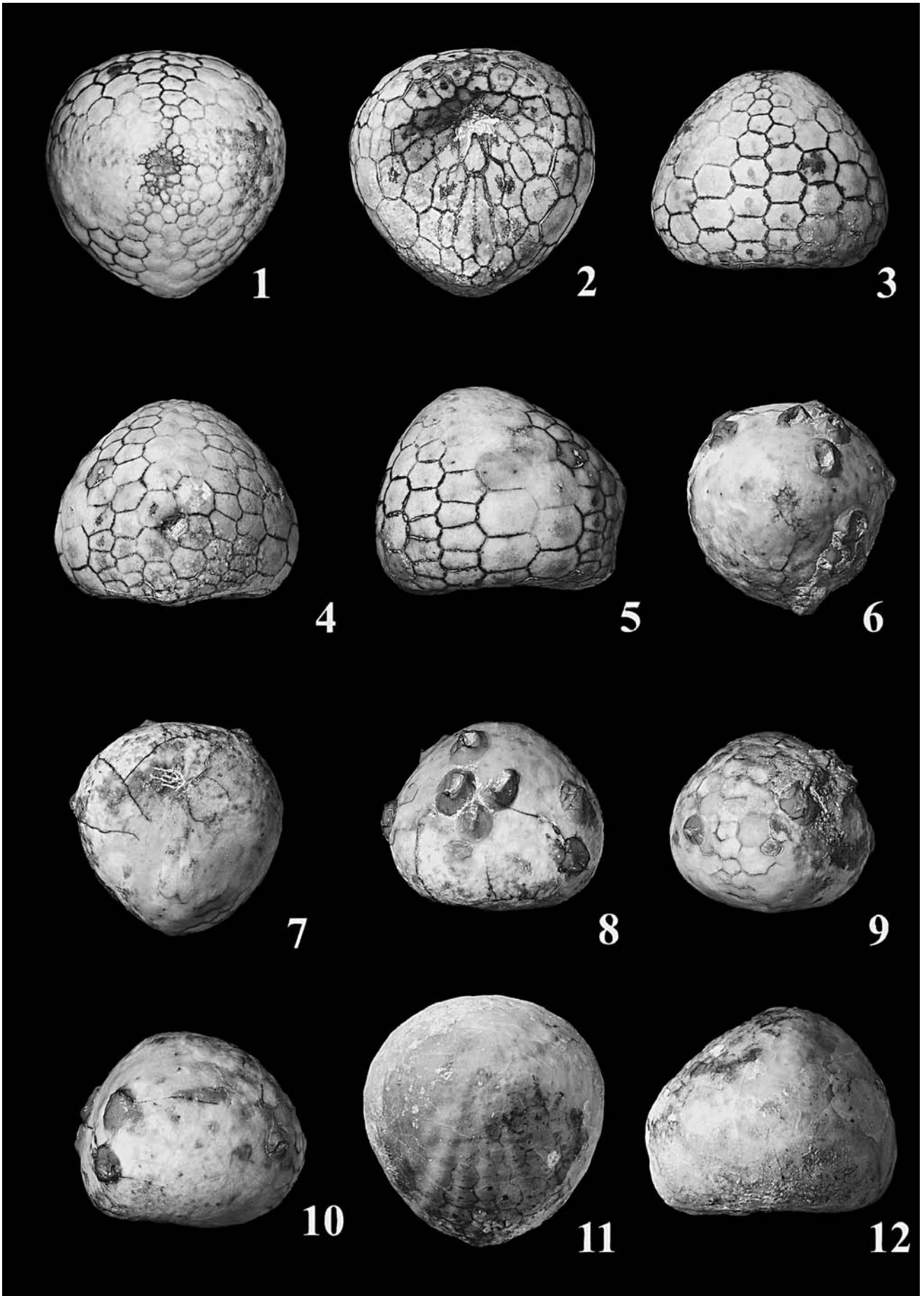
Biostratigraphic significance. *V. prisca* is known from the Upper Senonian of northwestern Europe (England, the Netherlands, Belgium and Insel Rügen, Germany), (Withers 1935). The occurrence of this material, if confirmed as *V. prisca*, from the northeast of Italy, will significantly expand the known stratigraphic and geographic ranges of the species.

Comments on preservation and palaeoecology. Key diagnostic features for verrucid classification: opercula (two movable valves) and the presence (or absence) of a myophore, are unavailable in this material. Unlike in the living situation, the wall plates in these specimens have been fused, with much of the minor detail obliterated, e.g. sutures between plates are almost completely recrystallised, and the fine detail of articulating ribs is completely lost, except on one or two specimens. Surprisingly, there are no clear indications of how the opercula may have appeared, although the size, and orientation of these, can be determined by the disposition of the D-shaped orifice. In all these aspects, the specimens conform to *V. prisca*.

PLATE 1

Ovulaster protodecimae n. sp.

- Figs 1-5 - Holotype MGPD 28877 from the lowermost Danian of Forada Creek (Belluno province, NE Italy); 1: apical, 2: oral, 3: posterior, 4: anterior, 5: lateral view.
 - Figs 6-10 - Paratype MGPD 28878 from the lowermost Danian of Forada Creek (Belluno province, NE Italy); 6: apical, 7: oral, 8: posterior, 9: anterior, 10: lateral view.
 - Figs 11, 12 - Paratype MGPD 29013 from the upper Danian of Facen (Belluno province, NE Italy); 11: apical, 12: lateral view.
- All the figures are x 1.4.



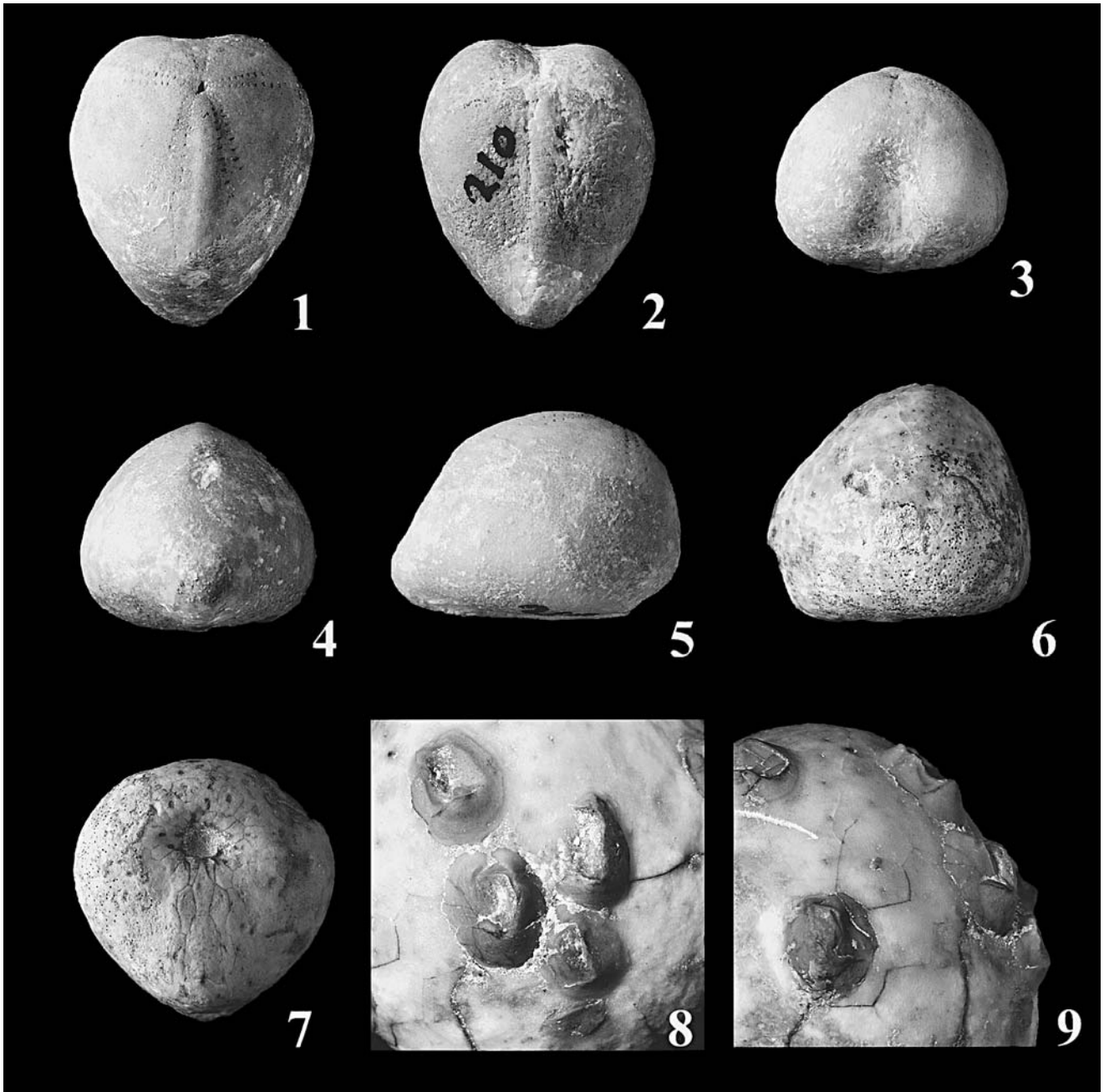


PLATE 2

Ovulaster zignoanus (d'Orbigny, 1854)

Figs 1-5 - Specimen 210, Museum of Euganei Hills, Padova (Italy). Coniacian-Santonian of Monte Santo di Lovertino (Euganei Hills). 1: apical, 2: oral, 3: posterior, 4: anterior view, 5: lateral view. All figures are x 1.5.
Ovulaster protodecimae n. sp.

Figs 6, 7 - Paratype MGPD 29014 from the upper Danian of Facen (Belluno province, NE Italy); 6: lateral view, 7: oral view. All figures are x 1.4.

Figs 8, 9 - Paratype MGPD 28878 from the lowermost Danian of Forada Creek (Belluno province, NE Italy). Details of the posterior (Fig. 8) and lateral (Fig. 9) views showing verrucid barnacles attached to the test (x 3.0).

Most barnacles are opportunistic when selecting substrates, and this species has encrusted an organism that if alive, would normally not be available for colonisation. *O. protodecimae* is a solid, heavily calcified species, and upon death, has been exposed on the sea-floor for sufficient time to provide substrate for en-

crusting organisms. The fact that the barnacles are all approximately the same size (i.e. they probably result from one spawning event), that they were probably adults (they are of similar size to most adults of *Verruca* spp.), and that they are found on all sides of the test except the oral surface (Pl.1, Figs 6-10), suggests that the

spatangoid was not rolling about on the seafloor. As the spatangoid test is "subspherical" and could be expected to be moved by modest currents, we conclude that the palaeoenvironment, at least where this specimen once existed, was of low energy. Interestingly, tests of the Late Cretaceous holasteroid *Echinocorys scutata*, in chalk horizons at Norfolk, England, were colonised by *V. prisca* (Withers 1935).

Relationship with other Verrucidae. *V. prisca* falls within a group of predominantly shallow water *Verruca*, i.e. the living *V. cookei* Pilsbry, 1927, *V. jago* Buckeridge, 1997, *V. laevigata* (Sowerby, 1827), *V. spengleri* Darwin, 1854 and *V. stroemia* (Müller, 1776), which range from the intertidal to depths of approximately 200 metres (Buckeridge 1997); and the fossil species *V. digitali* Buckeridge in Buckeridge & Finger, 2001 (Miocene, California), *V. nuciformis* Buckeridge, 1983 (Miocene, New Zealand), *V. tasmanica* Buckeridge, 1983 (upper Cretaceous – lower Miocene, New

Zealand, Australia), *V. pusilla* Bosquet, 1857 (upper Cretaceous, NW Europe) and *V. rocana* Steinmann in Wilckens, 1921 (Danian, Argentine). Except for *V. pusilla* (of which little is known), all of these fossil forms are associated with shallow water bivalves and gastropods (Withers 1935; Buckeridge 1983).

Acknowledgements. We thank Andrew Smith and David N. Lewis for their excellent reviews of the manuscript. Domenico Rio is thanked for his incisive comments on an earlier draft. Eliana Fornaciari and Claudia Agnini are acknowledged for providing unpublished data on calcareous nannofossils biostratigraphy of the considered sections. We are deeply grateful to Franco Colombara for access to the collection of echinoids of Euganei Hills Museum. Stefano Castelli and Lorenzo Franceschin are also acknowledged for technical assistance. This study was conducted under a project on Early Palaeogene pelagic successions of Veneto area. The work has been supported by the financial support from COFIN Murst 2001 "Cretaceous to Palaeogene extreme climates and "transient" climatic events as documented in Ocean Drilling Program (ODP) sediments and on land pelagic successions" (national coordinator Isabella Premoli Silva; co-ordinator of the unit of Padova, Domenico Rio).

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