Geologia Croatica	61/2–3	159–176	6 Figs.	1 Tab.	4 Pls.	Zagreb 2008

Petrascula iberica (DRAGASTAN & TRAPPE), *Tersella genotii* BARATTOLO & BIGOZZI, and the relationships of club-shaped dasycladalean algae during Late Triassic-Early Jurassic times

Filippo Barattolo[1], Bruno Granier[2], Roberta Romano[3] and Bruno Ferré[4]

[1] Dipartimento di Scienze della Terra, Università degli Studi di Napoli, Federico II, Largo San Marcellino 10, I-80138 Napoli, Italy; (lippolo@cds.unina.it)

[2] Département des Sciences de la Terre, UFR des Sciences et Techniques, Université de Bretagne Occidentale (UBO), 6, avenue Le Gorgeu, F-29238 Brest Cedex 3, France; (bgranier@univ-brest.fr)

[3] Dipartimento di Scienze Geologiche, Ambientali e Marine, Università di Trieste, via Weiss 2, Trieste, Italy; (robroman@unina.it)

[4] 2 rue Guy de Maupassant, F-76800 Saint-Étienne du Rouvray, France; (bruno.ferre@laposte.net)

Geologia Croatica

ABSTRACT

New observations on abundant material from the type locality of Petrascula iberica *(DRAGASTAN & TRAPPE) GRANIER et al. reveal the presence of a reproductive structure (ampulla) located on the inner-middle part of each primary lateral. This fact suggests a new interpretation of the alga and the establishment of a new genus:* Granieria *BARATTOLO & ROMANO, n. gen. Also, the taxonomic status of the other club-shaped specimens from both the High and Middle Atlas of Morocco and the Central Apennines of Italy is reviewed.*

Keywords: Club-shaped dasycladales, systematic, High and Middle Atlas – Morocco, North-eastern Spain, Central Apennines Italy, Early Jurassic

1. INTRODUCTION

This paper begins with a discussion of the taxonomic history of three dasycladalean taxa: *Petrascula, Tersella* and *Dissocladella*. It is a good example of the complexity of taxonomic work, in which the timing of the publication of a taxonomic revision and the quality of the material used to make it are of critical importance. We summarize the main steps in the last twenty years regarding changes in the attributions of these three genera.

DELOFFRE & LAADILA (1991) described a large club-shaped dasycladales from the lowermost Jurassic strata of the Middle Atlas (Morocco) and ascribed it to *Palaeodasycladus mediterraneus* (PIA). BARATTOLO et al. (1994) suggested that the specimens illustrated by DELOFFRE & LAADILA (1991) should be referred to the genus *Tersella*.

At the "6th International Symposium on Fossil Algae" (6th I.S.F.A.) held in Ankara (1995), GRANIER et al. (1995) reported that the Moroccan species then consequentially designated as *Palaeodasycladus mediterraneus* (PIA) was similar to the forms that DRAGASTAN & TRAPPE (1986) had set up as *Dissocladella iberica* and *Dissocladella ebroensis*.

GRANIER et al. (1995) referred the previous cited species to the genus *Petrascula* and named it *Petrascula iberica* (DRAGASTAN & TRAPPE) while discarding *Dissocladella ebroensis* as a junior synonym. Unfortunately the proceedings of the Ankara meeting were never published. However these authors were invited to submit the unpublished paper to the 7th I.S.F.A. volume (Nanjing, 1999). This volume was issued four years later (GRANIER et al., 2003) so finally the new designation was in print. However between the first proposal (GRANIER et al., 1995) and its valid publication (GRANIER et al., 2003), a new paper (BARATTOLO & BIGOZZI, 1996) was issued concerning the taxonomic status of the Iberian and Moroccan specimens. In it, the authors introduced a new taxon, *Tersella genotii*, erected to designate an Early Jurassic alga from Central Italy. Barattolo e Bigozzi (1996) suggested the close affinity of this new taxon with the Moroccan specimens previously attributed by DELOFFRE & LAADILA (1990) to *Palaedasycladus mediterraneus* PIA. Moreover, they suggested that all the Spanish specimens described by DRAGASTAN & TRAPPE (1986) may be but one species of *Tersella*. The new combination *Tersella iberica* is used in BARATTOLO & ROMANO (2005).

More recently the comparison between sets of measurements from GRANIER et al., (1995, 2003) and BARATTOLO & BIGOZZI (1996) enabled GRANIER et al., (2003) at the 8th I.S.FA. (Granada, September 2003), to confirm the taxonomic identity of the Moroccan and Iberian specimens, thus assigning them to *Petrascula iberica* (DRAGASTAN & TRAPPE).

At about the same time, shortly before the Granada Symposium, Barattolo and Romano collected samples from the lowermost Jurassic strata of Prejano (Northeastern Spain), the type locality of DRAGASTAN & TRAPPE's (1986) species. The data supplied by the new Spanish material required that for its correct allocation not only the former attribution to *Dissocladella* be discarded, but also that the subsequent assignments to both *Tersella* and *Petrascula* be abandoned.

Well then, the peculiar characteristics observed suggest that this taxon represents a new genus.

These new data were presented at the "9th International Symposium on Fossil Algae" (Zagreb, September 2007). The generic identity of the other Italian and Moroccan specimens was confirmed and both were referred to *Tersella.* In the following section we report the conclusions derived from the study of Moroccan (High and Middle Atlas) material and describe the new genus detected in the Spanish deposits.

2. SPECIMENS FROM THE HIGH ATLAS, MOROCCO

In the Toundout area (Moroccan High Atlas, see BLOMEIER & REIJMER, 1999), our colleague, A. Poisson, found dasycladacean algae in Lower Jurassic oolitic deposits. The oolitic rocks are made of bioclastic-algal floatstones with radial-ooid grainstone matrices. Sixty-four thin sections were prepared and analyzed using a Mitutoyo measuring microscope. This study revealed that, in spite of wide variability in measurements (ranging from 25 to 59% on any one parameter), these algal remains are representatives of but one species because they are all characterised by a unique branching pattern.

In this earliest Jurassic species, the calcified branches consist of a large club-shaped phloiophorous primary pore bearing a cluster of (probably six) secondary open pores with key-hole shaped longitudinal diameters, i.e. they are globular in their proximal part, show a narrowing in their median part, and widen at their distal end. This pattern is similar to the one known from the species *Tersella alpina* CROS & LEMOINE. Pore lengths (l) and diameters (p) range considerably in their degree of calcification. Therefore the variability in the dimensions of these parameters is closely related to the variability in the thickness (e) of the calcified sheet, i.e. up to about 30%. Considering outer (D) and inner (d) diameters of the thallus sections, as already mentioned, variability is even greater (up to 59 per cent). The outer diameter ranges between 1262 to 8187 μm (average: 4274 μm); the inner diameter is from 749 to 7044 μm (average: 3163 μm). A cross-plot diagram of both parameters clearly displays two linear trends (Fig. 1), suggesting that either there is a degree of segregation within a single species or there are two species, varieties or forms (e.g. fertile versus sterile forms). The first option is preferred.

3. SPECIMENS FROM THE MIDDLE ATLAS, MOROCCO, AND THEIR GENERIC ASSIGNMENT

DELOFFRE & LAADILA (1991) described a large club-shaped dasycladalean alga from the Lower Jurassic strata of Morocco. They ascribed it to *Palaeodasycladus mediterraneus* (PIA), but according to BARATTOLO et al. (1995), the illustrated specimens did not belong to this species. Additional observations on the branching pattern and many precise measurements lead to the conclusion that the well-preserved specimens here and the ones from the High Atlas represent the same species. The two linear trends observed on the cross-plot diagram (Fig. 1) of outer (D) and inner (d) diameters are the result of the varying degrees of calcification in any one specimen. The head of this club-shaped alga is relatively less calcified than its stalk (outer diameter smaller than 4500 μm). Primary and secondary branches are calcified in both the stalk and the head; there is no evidence of tertiary branches. Some sections show the characteristic apical opening of the club-shaped head (Fig. 2). This species is therefore related to the genus *Tersella* J. MORELLET in J. MORELLET & TERS 1951. In the Middle Atlas, the dimensions of the specimens are even greater than those previously observed from the High Atlas. Here, the algae were fossilised *in situ* within a boundstone facies, whereas the oolitic grainstones of the High Atlas are reworked debris that underwent some mechanical sorting.

In conclusion the specimens from both the Middle and the High Atlas are referable to this single species. In addition, the general size of the biometric parameter suggests that these specimens are referable to *Tersella genotii.*

4. SPECIMENS FROM THE IBERIAN RANGE, SPAIN AND THEIR SPECIFIC ASSIGNMENT

DRAGASTAN & TRAPPE (1986) described a rich algal assemblage from the lowermost Jurassic strata of Prejano (Northeastern Spain) (Fig. 3). These algal remains were ascribed to "*Dissocladella lucasi* (CROS & LEMOINE)" (originally quoted as *Linoporella*), "*Gyroporella retica* (ZANIN BURI)" (originally quoted as *Macroporella*), *Sestrosphaera liasina* PIA, and to three new species: *Dissocladella ebroensis* DRAGASTAN & TRAPPE, *Dissocladella iberica* DRAGASTAN &

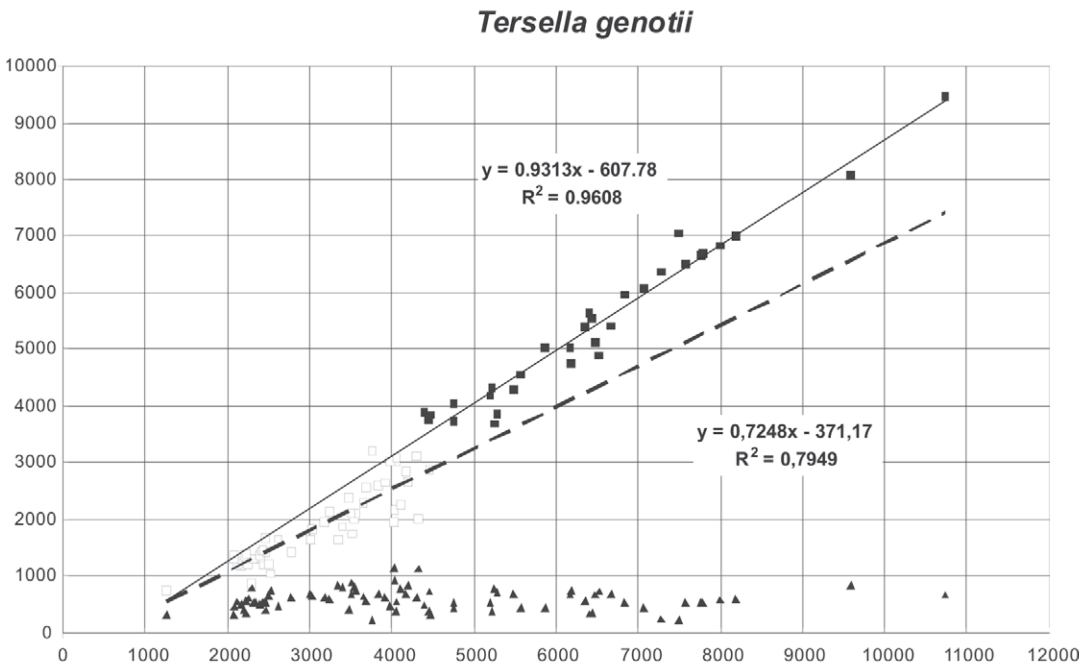


Figure 1: *Tersella genotii* (Lower Jurassic strata, Toundout, High Atlas, Morocco). Cross-plot diagrams of the calcification thickness (triangles) and of the inner diameter (Y axis) versus the outer diameter (X axis). There are two discrete trend-lines: the smallest diameters (empty squares) correspond to the stalk, the largest ones (black squares) to the head. All dimensional values are provided in μm.

TRAPPE, and "*Macroporella* nov. sp.". As in the Moroccan High Atlas, this assemblage was found in grainstones of radial ooids and bioclasts often enveloped in micritized and microbialitic films. New material from Spain includes a considerable number of well-preserved specimens that, using the new biometric information collected, allows a complete characterization of the shape, size and general anatomy of the entire plant body. A statistical analysis of 72 specimens showed that the ratio between the outer (D) and inner (d) diameters of the specimens clearly displays a linear trend. According to GRANIER et al. (1995, 2003), this linearity suggests that the dimensional differences between specimens can be ascribed to normal intraspecific variation. The specimens previously described as *Dissocladella iberica* and *Dissocladella ebroensis* are consequently only one species. New data from the re-sampled type locality, moreover, demonstrate that this species must be referred to a new genus for which we propose the taxonomic combination *Granieria iberica.*

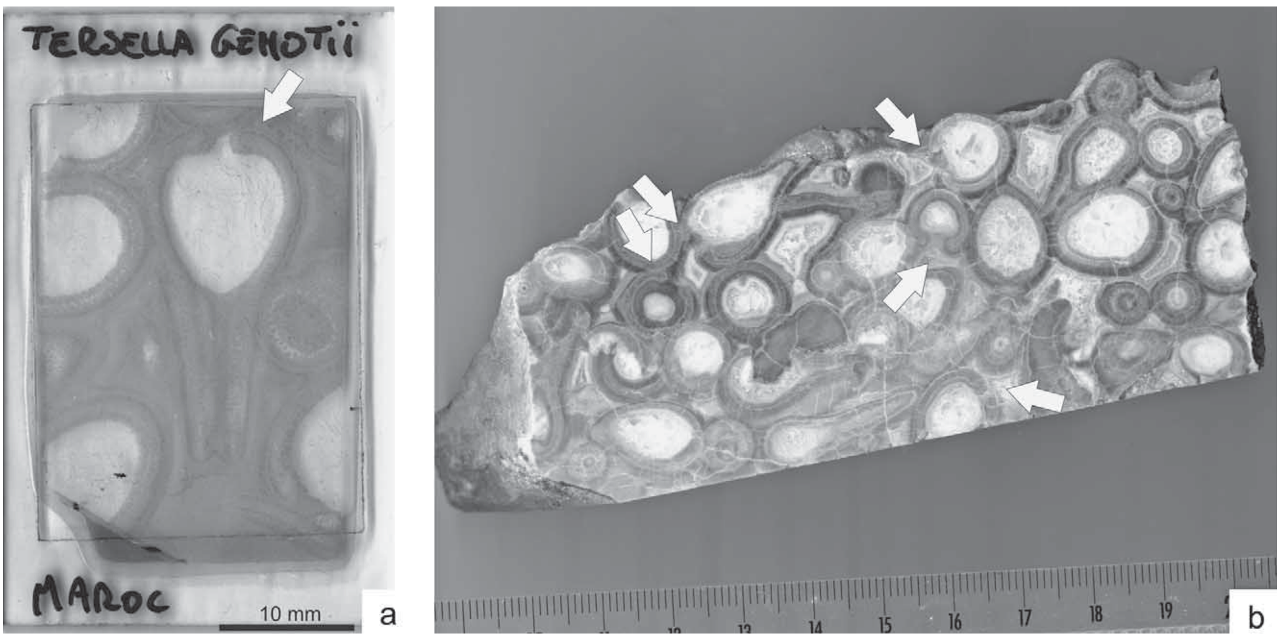


Figure 2: a – Thin section of the High Atlas material with *Tersella genotii* (Lotharingian strata, N Ribat el Khaďr, Middle Atlas, Morocco), showing some unfragmented specimens of *Tersella genotii*. **b** – Polished section (counterpart of the rock sample illustrated by DELOFFRE & LAADILA, 1990, pl. I, fig. 3, and from which the thin section was cut) showing several specimens of *Tersella genotii.* Arrows point to some well preserved apical apertures.

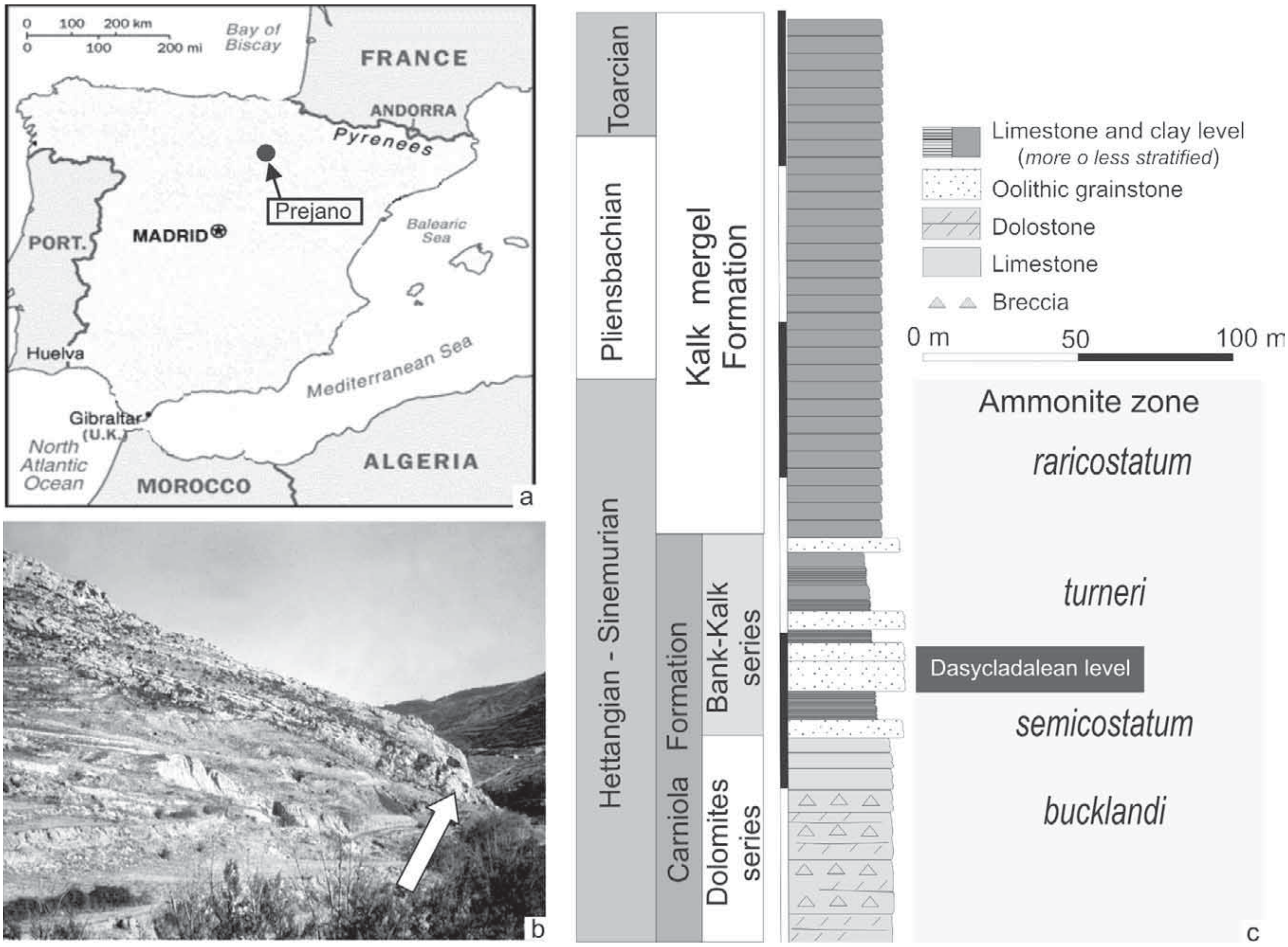


Figure 3: a – Location of the type-locality of *Granieria iberica* nov. comb. **b** – Field photography of the Prejano outcrop. The studied sample was collected from the oolithic massive level (*arrow*), Field of view is approximately 0.5 km wide. **c** – Schematic diagram of Lower Jurassic deposits of the Prejano area, with the position of the dasycladales bearing level (modified from DRAGASTAN & TRAPPE, 1986).

5. SYSTEMATICS (FILIPPO BARATTOLO AND ROBERTA ROMANO)

Division: Chlorophyta
Order: Dasycladales PASCHER, 1931
Family: *Dasycladaceae* BERGER & KAEVER, 1992
Tribe: *Bornetellae* (MORELLET, 1913) BASSOULLET et al., 1979
Genus: *Granieria* BARATTOLO & ROMANO, n. gen.

Origin of the name: The genus is dedicated to our colleague and friend Bruno Granier in observance of his great contributions to the fund of knowledge on fossil dasycladales.

Type species: *Granieria iberica* (DRAGASTAN & TRAPPE) BARATTOLO & ROMANO, n. comb.

Diagnosis: Club-shaped simple thallus, phloiophorous primary laterals arranged in more or less close whorls (euspondyl arrangement). Short phloiophorous secondary laterals making a cortex. One ampulla is attached on the side of each primary lateral in its inner- middle part (reproduction of choristosporous type).

Comparisons: At first sight the new genus closely resembles other club-shaped Early Jurassic genera like *Tersella* and *Petrascula*, and less so *Palaeodasycladus* and *Sestrosphaera*. Nevertheless *Granieria* differs from all these genera mainly in the apparatus of reproduction (choristosporous) rather than cladosporous or endosporous and in part in the number and shape of the laterals. With regard to verticils, *Granieria* differs from *Palaeodasycladus* and *Petrascula* in the orders of ramification, (three in *Petrascula* and *Palaeodasycladus* rather than the two of *Granieria*). Moreover in *Petrascula* the tertiary laterals do not make a cortex.

Choristosporous rather than cladosporous reproduction is obviously the main criterion distinguishing *Granieria* from *Tersella*. The more or less differentiated club-shaped thallus, the presence of the terminal opening related to the same type of apical zone, the two order ramification and the general setting of the calcareous skeleton, are all characteristics shared by *Granieria* and *Tersella*. Consequently the occurrence of the lateral ampulla on the primary lateral represents the sole diagnostic character that distinguishes the new genus from *Tersella*. Taking into account the importance of reproductive structures in taxonomy (e.g. BERGER & KAEVER, 1992), this fact suggests a separation of the two genera at the family level.

In any case, the main problem in the taxonomy of fossil dasycladaleans is their degree of calcification. The amount of calcification is extremely variable (extensive, scattered or absent). Consequently, the structure of the alga must be interpreted only from the pores defined in the calcified portions. The species of *Tersella* show incomplete calcification of the inner portion of the primary laterals, in particular in the upper portion of the thallus. This incomplete calcification can obscure the presence of reproductive structures on the lower portion of the primary laterals. However, the great number of specimens of *Tersella* studied, although they differ in size, degree of calcification and stage of development, confirms the absence of a reproductive structure (ampulla) in the genus *Tersella.*

Apart from its type of reproduction, the genus *Sestrophaera* differs from *Granieria* in: 1) the presence of only one order of laterals, 2) a more differentiated club-shaped thallus, 3) a closed, well-calcified apical zone rather than an open one.

Granieria's choristosporous reproduction distinguishes this new genus from that of several other genera that appeared after the Jurassic (e. g. *Goniolina* and *Eodasycladus*).

In addition, *Granieria* differs from *Eodasycladus* in ramification order, (two lateral orders rather than three) and in the general shape of the thallus (club-shaped in *Granieria*, cylindrical in *Eodasycladus)*. Another important difference between these genera concerns the location of the ampulla. In *Eodasycladus* the ampulla is at the outer end of the primary laterals, in *Granieria* it is positioned on one side of them.

According to BERGER & KAEVER (1992), the position of the reproductive organs with respect to the laterals is a distinctive feature, very important in the discrimination of the tribes of any one dasycladalean family.

So, position of the ampulla structure on the side of the primary laterals distinguishes *Granieria* n. gen. from *Eodasycladus.* The placement of the ampulla on the side of the primary laterals also distinguishes *Granieria* from the Cretaceous-Tertiary genera *Neomeris* and *Afghanopolia*, for they too are characterized by a terminal position of the ampulla on the primary laterals.

Granieria (one ampulla per lateral) is distinguishable from other choristosporous genera including *Bornetella*, *Jodotella*, *Goniolina* and *Microsporangiella* that have more than one ampulla per lateral.

The comparison of *Granieria* with *Cylindroporella*, *Chinianella*, and *Otternstella* is complicated by the taxonomic status of these taxa that in some cases demand a careful restudy of the type species. In any event, at the present state of knowledge, *Otternstella* and *Chinianella* are characterized by whorls of fertile ampulla directly connected with the central stem that alternate with whorls of sterile laterals, while *Granieria* does not have this organization into alternating verticils. *Cylindroporella* is characterized by an alternation in the same whorl of sterile laterals and ampulla, directly connected to the central stem. In this respect too, *Granieria* shows no alternation between sterile and fertile laterals, nor are some ampulla set directly on the main axis.

Otherwise, *Bakalovaella* established by BUCUR (1993) shows an ampulla aside the primary laterals, but differs from *Granieria* in the general shape of the thallus, (cylindrical versus club-shaped), and the order of ramification (only one versus two). *Granieria* shows some morphological affinity with *Pseudoactinoporella* CONRAD, emend. CONRAD & PEYBERNES. According to BUCUR (2000) this latter genus is characterized by a club shaped thallus, but calcified only in its basal part. The structure of laterals is interpreted as a short primary lateral prolonging into a single secondary lateral and giving rise to a terminal ampulla set aside. Therefore the genus *Granieria* differs from *Pseudoactinoporella* at least for the structure of the laterals and position of the reproductive organs. Actually the ampulla of *Granieria* is attached to the inner part of a long primary lateral instead of terminally on a short one, and the secondary laterals are in tufts versus a single lateral.

Attribution of *Granieria* to family and tribe: According to the BERGER & KAEVER (1992) classification of the modern dasycladalean algae, an euspondyl arrangement of laterals with choristosporous gametangia attached to the middle part of the laterals by a short stalk restricts the attribution of *Granieria* n. gen. to the family *Dasycladaceae.* The presence of an individual reproductive organ (ampulla) set on the side of the primary laterals, the presence of an external cortex, and the club-shaped thallus assign *Granieria* n. gen. to the tribe *Bornetellae*.

Granieria iberica (DRAGASTAN & TRAPPE) BARATTOLO & ROMANO, n. comb. (Pls. I–IV)

Synonymy lists – only illustrated specimens:

1986 *Dissocladella iberica* nov.sp. – DRAGASTAN & TRAPPE, p. 174, figs. 3/5, 4/1–4, 5/2
1986 *Dissocladella ebroensis* nov.sp. – DRAGASTAN & TRAPPE, p. 176, fig. 4/6–7
1986 *Dissocladella lucasi* (CROS & LEMOINE) – DRAGASTAN & TRAPPE, p. 172, fig. 3/1–4
1986 *Gyroporella retica* (ZANIN BURI) – DRAGASTAN & TRAPPE, p. 178, fig. 5/1
1986 *Sestrosphaera liasina* PIA – DRAGASTAN & TRAPPE, p. 176, fig. 4/5
1986 *Macroporella* nov. sp. aff. *sturi* BYSTRICKY – DRAGASTAN & TRAPPE, p. 178, fig. 5/6

Emended diagnosis: Club-shaped simple thallus, slightly differentiated into a sub-cylindrical lower part (stalk) and an enlarged ellipsoidal upper one (head). Primary laterals arranged in close alternating whorls. They are set almost perpendicularly to the main axis near the base of the thallus; as they approach the top of the thallus, the primary laterals incline upward more and more so they are set vertically near the apex. Primary laterals in the stalk region have a circular cross-section, are moderately long and widen outwards, in the upper part of the thallus, only the distal end of the primary laterals is preserved. Secondary laterals, 3–4 per tuft, are shorter and also widen outwards. They show the same changes in inclination as the primary laterals and form a distal cortex probably with a hexagonal mesh. Choristosporous reproductive organs are sited on the primary laterals. Each consists of a sub-spherical ampulla connected by an inclined short peduncle to the upper side of the inner-middle portion of the primary lateral. The calcareous skeleton is thicker along the stalk where it almost entirely encases the primary laterals, the reproductive

PLATE I

Granieria iberica nov. comb.

Prejano (type-locality) Lower Jurassic (Hettangian–Sinemurian)

1–9 Transverse-oblique sections of the lower part of the calcareous skeleton Fig. 1, BA.3139.31; Fig. 2, BA.3139.40; Fig. 3, BA.3139.38; Fig. 4, BA.3139.24; Fig. 5, BA.3139.37; Fig. 6, BA. 3139.29; Fig. 7, BA.3139.16; Fig. 8, BA.3139.39; Fig. 9, BA.3139.1.

10–12 Oblique sections of the lower part of the calcareous skeleton. Fig. 10, BA.3139.25; Fig. 11, BA.3139.28; Fig. 12, BA. 3139.26.

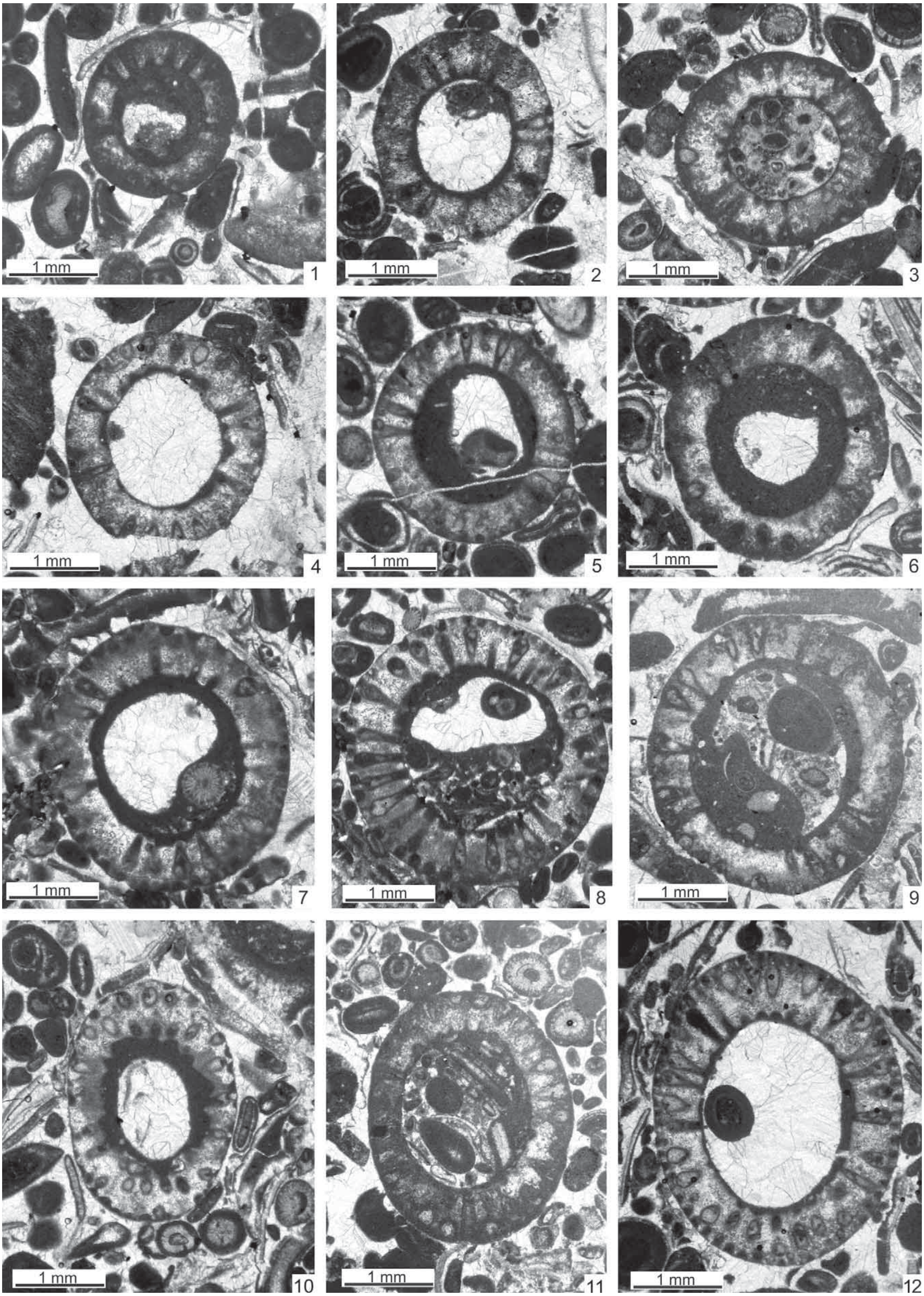

1 mm
1
1 mm
2
1 mm
3
1 mm
4
1 mm
5
1 mm
6
1 mm
7
1 mm
8
1 mm
9
1 mm
10
1 mm
11
1 mm
12

PLATE II

Granieria iberica nov. comb.

Prejano (type-locality) Lower Jurassic (Hettangian – Sinemurian)

1–4 Oblique sections of the lower part of the calcareous skeleton. Fig. 1, BA.3139.40; Fig. 2, BA.3139.14; Fig. 3, BA.3139.34; Fig. 4, BA. 3139.22.

5–6 Longitudinal sections. Fig. 5, BA. 3139.22; Fig. 6, BA. 3139.29.

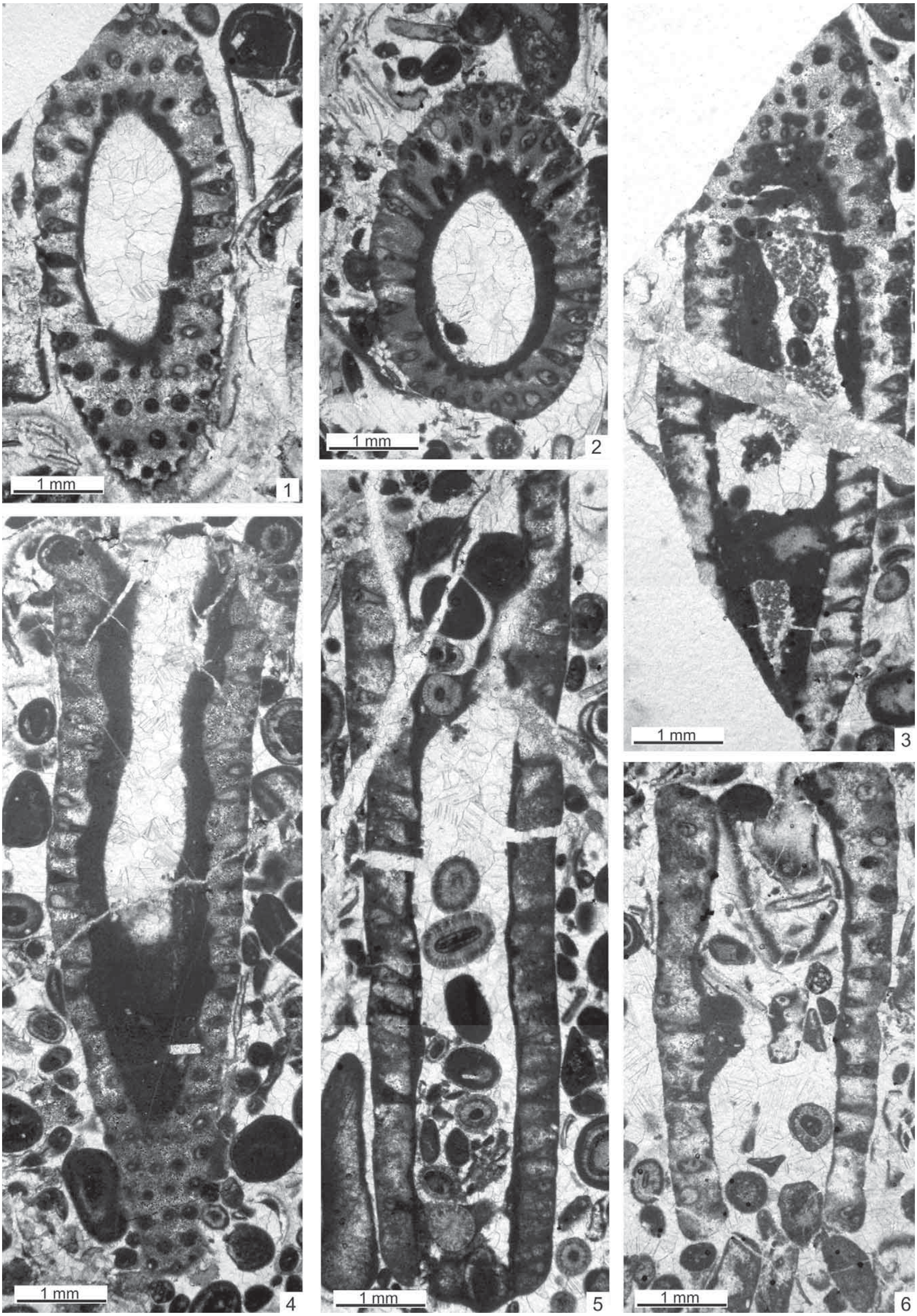

1 mm
1
1 mm
2
1 mm
3
1 mm
4
1 mm
5
1 mm
6

PLATE III

Granieria iberica nov. comb.

Prejano (type-locality) Lower Jurassic (Hettangian – Sinemurian)

1–2 Oblique sections of the stalk and its junction with the head. Fig. 1, BA.3139.29; Fig. 2, BA.3139.42.

3 Oblique section of the upper part of the calcareous skeleton, BA.3139.40.

4 Detail of the Fig. 2. Note the double pores vertically paired. These represent the primary laterals and the ampulla cut in their proximal part; BA. 3139.242.

5–7 Detail of the ampulla setting in the upper inner portion of the primary laterals. Fig. 5, BA. 3139.8; Fig. 6, BA. 3139.43; Fig. 7, BA.3139.8.

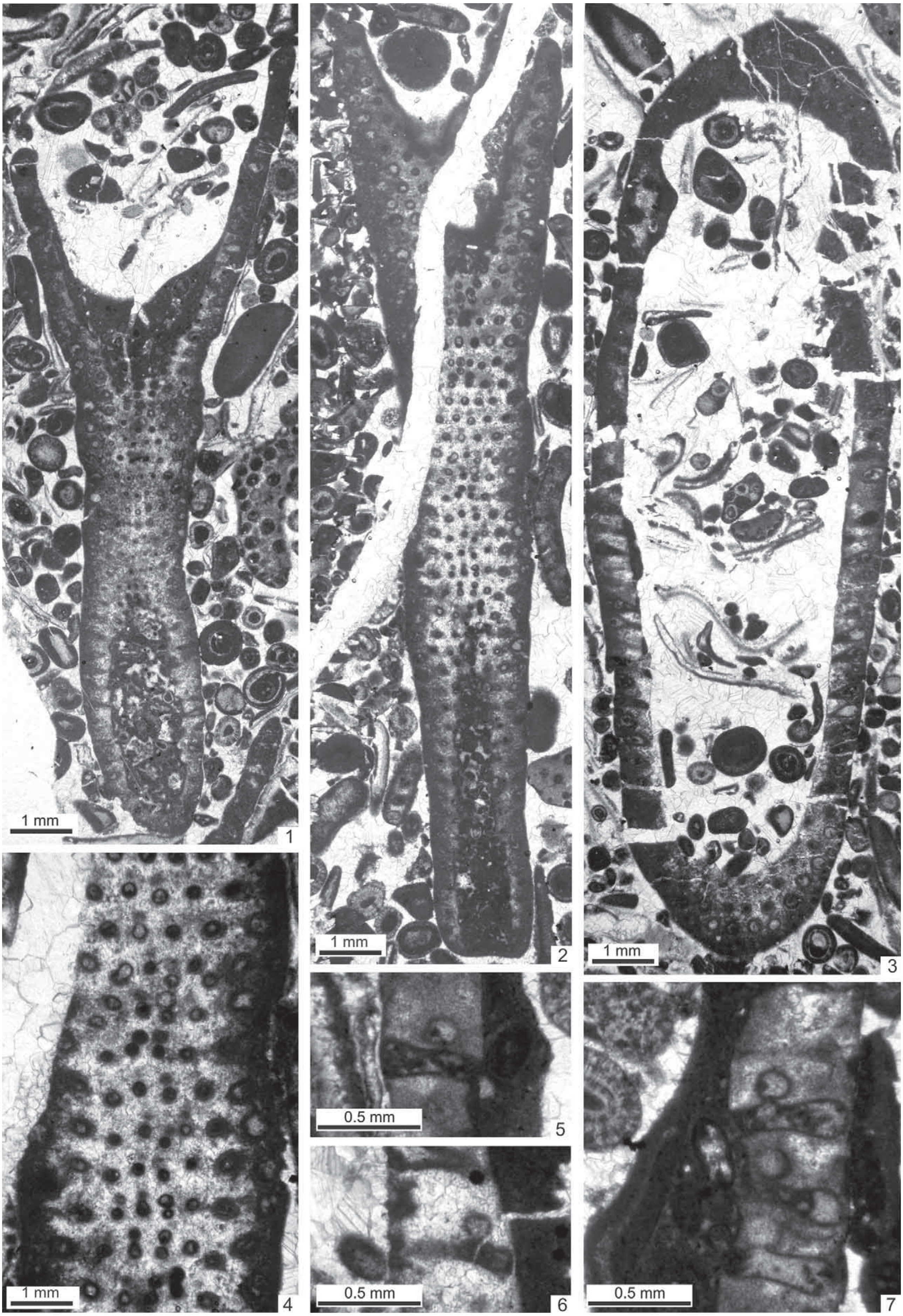

1 mm
1
1 mm
2
1 mm
3
1 mm
4
0.5 mm
5
0.5 mm
6
0.5 mm
7

PLATE IV

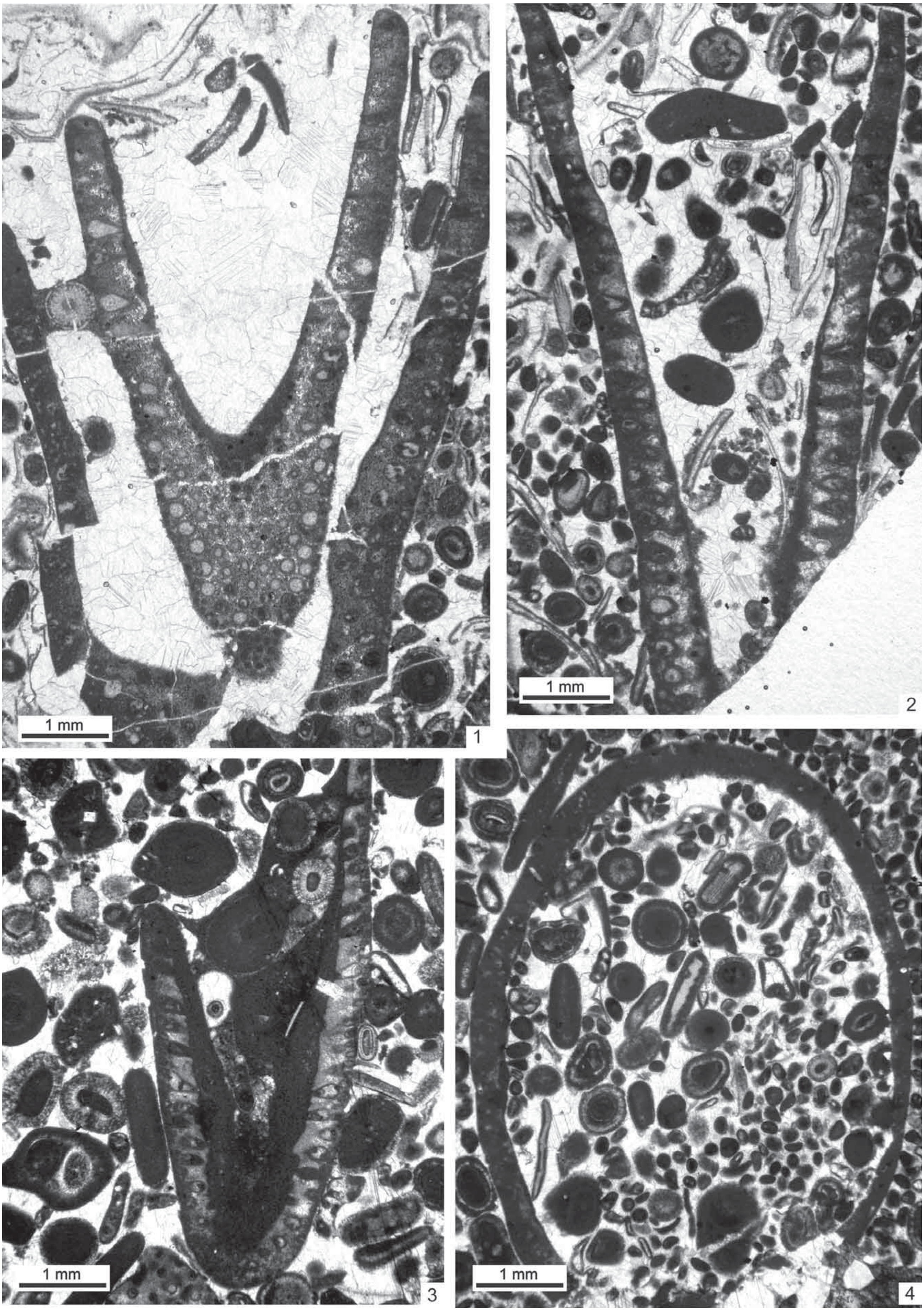
Granieria iberica nov. comb.

Prejano (type-locality) Lower Jurassic (Hettangian – Sinemurian)

1–2 Oblique sections showing the gentle transition between the lower and upper portion of the calcareous skeleton. Fig. 1, BA.3139.18; Fig. 2, BA.3139.27.

3 Oblique section, BA.3139.22.

4 Oblique section of the upper enlarged portion of the calcareous skeleton, BA. 3139.20.


1 mm
1
1 mm
2
1 mm
3
1 mm
4

organs and the initial portion of the secondary laterals; elsewhere the calcification is thinner; in the upper part of the skeleton it envelops only the distal end of the primary laterals and the inner-middle portion of the secondaries. Close to the apex the calcareous skeleton is a little thicker, but probably does not affect the apex leaving an opening. The most significant biometric values are listed in Table 1.

General features of the calcareous skeleton: The calcareous skeleton is simple, continuous, without annulation or intusannulation. It exhibits moderate differentiation into a sub-cylindrical lower part (stalk) and a gradually enlarged upper part (head). The term "stalk" and "head" is used in the description although the transition between these two elements is generally not sharp or well defined (Pl. III, Fig. 1; Pl. IV, Fig. 2).

Table 1: The most significant biometric values of *Granieria iberica* nov. comb from sample BA.3020 are supplied. All dimensional values are in millimetres. *D* = outer diameter of the stalk, *d* = inner diameter of the stalk, *e* = calcification thickness, *pi* = width inner of the primary, *pd* = outer width of the primary lateral, *l* = length of the primary lateral, *p'* = width of the secondary lateral, *l'* = length of the secondary lateral, *h* = height between whorls, *w* = number of primaries in a whorl.

						Granieria iberica nov. comb.						
Sample	Specimen	section	D	d	e	pi	pd	l	p″	l′	h	w
BA 3139	1	3139..41	2,70	1,35	0,68	0,04	0,18	0,55			0,36	
BA 3139	2	3139..41	5,00	4,30	0,35		0,20		0,10	0,15		
BA 3139	3	3139..41	2,75	1,82	0,47	0,07	0,15	0,40			0,33	
BA 3139	4	3139..41	2,85	2,15	0,35	0,06	0,13					
BA 3139	5	3139..38	1,70	1,10	0,30	0,07	0,10		0,10	0,10		
BA 3139	6	3139..38	2,20	1,25	0,48	0,07	0,15	0,30	0,08	0,09	0,32	
BA 3139	7	3139..38	2,20	1,15	0,53	0,06	0,15	0,55				24
BA 3139	8	3139..38	1,90	1,10	0,40							
BA 3139	9	3139..26	2,40	1,50	0,45	0,06	0,16	0,45	0,10	0,10	0,22	31
BA 3139	10	3139..26	2,35	1,50	0,43							
BA 3139	11	3139..26	2,10	1,50	0,30	0,08	0,16	0,30				
BA 3139	12	3139..26	2,60	1,65	0,48		0,18	0,25		0,12		28
BA 3139	13	3139..15	2,90	2,30	0,30	0,06	0,15		0,10			36
BA 3139	14	3139..42	1,50	0,80	0,35						0,28	
BA 3139	15	3139..42	2,54	1,90	0,32							
BA 3139	16	3139..37	2,22	1,35	0,44	0,05	0,11	0,35	0,10	0,10		24
BA 3139	17	3139..37	2,00	1,40	0,30							
BA 3139	18	3139..39	2,80	1,70	0,55	0,08	0,11	0,50		0,10		30
BA 3139	19	3139..39	2,10	1,05	0,53	0,07	0,15	0,40		0,12	0,27	
BA 3139	20	3139..40	2,10	1,15	0,48	0,08	0,16	0,40	0,10	0,07		22
BA 3139	21	3139..40	3,00	1,80	0,60							
BA 3139	22	3139..40	2,30	1,20	0,55	0,10	0,19	0,45	0,08	0,01	0,35	
BA 3139	23	3139..40	4,80	3,80	0,50	0,01	0,21	0,60			0,35	
BA 3139	24	3139..40	1,70	1,00	0,35	0,08	0,11	0,25	0,10	0,10		20
BA 3139	25	3139..40	2,10	1,15	0,48	0,08	0,13	0,47			0,25	
BA 3139	26	3139..40	1,80	1,20	0,30	0,08	0,18				0,28	20
BA 3139	27	3139..28	2,60	1,80	0,40	0,08	0,15	0,30	0,10	0,10	0,23	
BA 3139	28	3139..28	1,80	1,00	0,40	0,10	0,12	0,50				22
BA 3139	29	3139..34	2,00	1,00	0,50	0,08	0,20	0,35			0,25	
BA 3139	30	3139..34	1,70	1,00	0,35	0,10	0,12					20
BA 3139	31	3139..34	2,00	1,20	0,40			0,60				
BA 3139	32	3139..35	2,90	1,55	0,68	0,10	0,15	0,40	0,10	0,10		24
BA 3139	33	3139..31	2,10	1,30	0,40	0,08	0,15	0,40			0,30	
BA 3139	34	3139..31	2,05	0,90	0,58	0,07	0,13	0,40	0,10	0,10		
BA 3139	35	3139..31	1,90	1,10	0,40	0,10	0,15				0,30	
BA 3139	36	3139..31	2,00	1,30	0,35							
BA 3139	37	3139..36	2,40	1,50	0,45	0,08	0,15	0,45				30
BA 3139	38	3139..43	1,60	0,90	0,35							
BA 3139	39	3139..43	1,90	1,10	0,40							
BA 3139	40	3139..43	2,40	1,60	0,40	0,07	0,15	0,40			0,30	

Table 1: continued

Granieria iberica nov. comb.												
Sample	Specimen	section	D	d	e	pi	pd	l	p"	l'	h	w
BA 3139	41	3139..43	2,50	1,50	0,50	0,07	0,20	0,45			0,30	
BA 3139	42	3139..7	4,00	3,00	0,50	0,10	0,20	0,48			0,35	
BA 3139	43	3139..7	3,35	2,00	0,68	0,08	0,20	0,40	0,10	0,10	0,35	
BA 3139	44	3139..7	4,20	3,25	0,48							
BA 3139	45	3139..7	1,90	0,90	0,50							
BA 3139	46	3139..24	2,20	1,30	0,45	0,08	0,17	0,40	0,10	0,06		26
BA 3139	47	3139..24	3,70	3,00	0,35							
BA 3139	48	3139..24	1,85	0,78	0,54	0,06	0,15	0,40	0,10	0,10		
BA 3139	49	3139..24	2,20	1,60	0,30			0,30			0,25	
BA 3139	50	3139..24	2,20	1,40	0,40							
BA 3139	51	3139..29	2,50	1,50	0,50	0,07	0,18	0,48				
BA 3139	52	3139..29	1,90	1,05	0,43	0,05	0,13	0,45				
BA 3139	53	3139..29	4,50	3,70	0,40						0,22	
BA 3139	54	3139..29	2,20	1,60	0,30							
BA 3139	55	3139..29	3,45	2,20	0,63	0,08	0,20	0,45	0,13	0,15		
BA 3139	56	3139..32	3,50	2,60	0,45							
BA 3139	57	3139..30	2,45	1,50	0,48	0,10	0,15	0,45			0,30	
BA 3139	58	3139..30	2,15	1,20	0,48	0,07	0,14	0,40			0,27	
BA 3139	59	3139..30	3,40	2,80	0,30							
BA 3139	60	3139..25	2,40	1,55	0,43	0,08	0,12	0,30			0,25	
BA 3139	61	3139..25	3,50	2,95	0,28							
BA 3139	62	3139..25	3,10	2,00	0,55	0,06	0,20	0,50			0,30	
BA 3139	63	3139..22	2,40	1,35	0,53	0,07	0,15	0,40			0,28	
BA 3139	64	3139..22	2,10	1,10	0,50	0,01	0,20	0,45	0,10	0,06	0,35	
BA 3139	65	3139..11	2,10	1,20	0,45	0,07	0,15	0,40			0,35	
BA 3139	66	3139..11	2,20	1,25	0,48	0,07	0,20	0,47			0,32	
BA 3139	67	3139..11	1,40	0,70	0,35							
BA 3139	68	3139..14	2,90	1,80	0,55	0,08	0,17	0,45	0,08	0,12	0,27	
BA 3139	69	3139..14	2,30	1,60	0,35	0,07	0,20	0,35				
BA 3139	70	3139..14	2,50	1,50	0,50	0,07	0,18	0,48			0,30	
BA 3139	71	3139..14	2,60	1,60	0,50	0,08	0,20	0,45				28
BA 3139	72	3139..12	2,00	1,10	0,45	0,05	0,15	0,50			0,30	
BA 3139	73	3139..12	2,25	1,70	0,28							
	74											
	Number		73	73	73	49	51	46	18	20	31	15
	Min		1,40	0,70	0,28	0,01	0,10	0,25	0,08	0,01	0,22	20,00
	Max		5,00	4,30	0,68	0,10	0,21	0,60	0,13	0,15	0,36	36,00
	Average		2,491	1,612	0,439	0,072	0,160	0,422	0,098	0,098	0,295	25,667
	St. Devation		0,743	0,732	0,098	0,019	0,030	0,081		0,031		4,746

The stalk is cylindrical, flaring slightly upward. It is rather strongly calcified, for generally the entire length of the primary laterals is encased, or at least most of it, and occasionally the sheath extend outward to include the inner portion of the secondary laterals (Pl. I, Figs.1–6; Pl. II, Fig. 2). Calcification does not usually attain the central stem because the inner surface of the calcareous skeleton is often irregular and the tapering proximal part of the primary laterals close to their junctions to the main axis is rarely observable.

The head is ellipsoidal to ovoid, somewhat elongate; calcification is rather thin there, but it envelops the distal end of the primary laterals and a part of the secondaries (see forward, Fig. 4). Near the top, the amount of calcification increases so thinner primary and secondary laterals are encased, but it does not seem to be present at the apex, leaving an opening as in some species of the genus *Tersella* (Fig. 4b–c). In any case, the rare sections of the entire head never show this opening probably because they do not precisely cut the axis of the apical zone.

The inner diameter starts at 0.70 mm in the stalk and reaches 4.3 mm in the head portion. In the same way the outer diameter ranges from 1.40 mm in the stalk to 5.0 mm in the head.

Primary laterals: The primary laterals are set perpendicularly to the main axis along the greater extent of the thallus (Pl. II, Figs. 4–6; Pl. III, Fig. 3), but moving up to the apical zone the inclination of the laterals increases until they probably stand roughly vertically at the apex.

The primary laterals in the lower part of the stalk are phloiophorous, club-shaped, their diameter gradually increasing in size outwards (Pl. II, Figs. 4–5). Moving from the stalk to the head, the primary laterals tend to assume a slight differentiation into a inner sub-cylindrical portion and a more globular distal portion (Pl. IV, Figs. 1–2). The laterals are circular if cross sectioned and their diameter ranges from 0.01–0.10 (*pi*) to 0.10–0.15(*pd*) mm, in the inner and the distal parts respectively. The junction between primary laterals and the central stem is never observed because the calcification does not reach the main axis.

The primary laterals of the head are apparently short, bigger than those of the stalk (0.15–0.21 mm), and globular in shape (Pl. IV, Fig. 1). Their reduced length is combined with a large central cavity; this fact seemingly is the result of calcification restricted to the distal part of the primary laterals. This assumption is strengthened by the trend of calcification which tapers upward in the stalk/head transition and because the primary pores open to the inner cavity through large pores.

The primary laterals are arranged in simple euspondyl whorls. The number of primary laterals for each whorl is 20–24 mm in the stalk and reaches 40–46 mm in the head. Subsequent whorls exhibit laterals arranged in alternate position (Pl. II, Figs. 1, 4). The height between whorls (h) is 0.22–0.36 mm.

Secondary laterals: The secondary laterals originate from the distal part of the primary laterals. The secondary laterals are mainly observable in the middle and upper parts of the thallus, while in the lower stalked part they are rarely visible, because they are only rarely encrusted by calcification. Anyway their size and number per tuft (3–4) remain constant throughout the whole thallus.

Secondary laterals are rather short and quickly flare outwards (Pl. I, Figs. 7–8, 12). They display a close packed arrangement at the outer surface of the calcareous skeleton (Pl. IV, Fig. 3). This fact allows for the argument that the uncalcified distal parts were adequately widened out in order to touch laterally in order to form a cortex.

Reproductive organs: A single sub-spherical ampulla per primary lateral (0.10–0.18 mm,) is attached, through an inclined short peduncle, on the upper side, in the inner-middle portion of the lateral. Only a few well preserved longitudinal sections of the stalk (Pl. III, Figs. 5–7) clearly show this characteristic. However the presence of such structures can be detected more frequently in tangential and oblique sections cut very close to the central cavity. The whorl appears to be constituted by a row of vertically paired pores (Pl. III, Figs.1–2, 4). The pores of a couple are set very close to each other and are of comparable size. On moving laterally the paired pores disappear and only a row of single pores, increasing in size, continues. Each couple of pores represents the section of the inner portion of the primary lateral and the ampulla or its oblique peduncle.

Reproductive organs are only preserved in the stalk because the calcification almost completely encrusts the primary laterals. The fact that calcification in the head is restricted to the distal part of the primary laterals means that all the inner structures are not preserved.

Reconstruction: Most elements of the thallus that are calcified have been described above. Only the shape of primary laterals in the upper part of the thallus, the presence of the reproductive structure in the head and the outer end of the secondary laterals are not preserved and are therefore treated here in a prospective reconstruction of the thallus (Figs. 5–6).

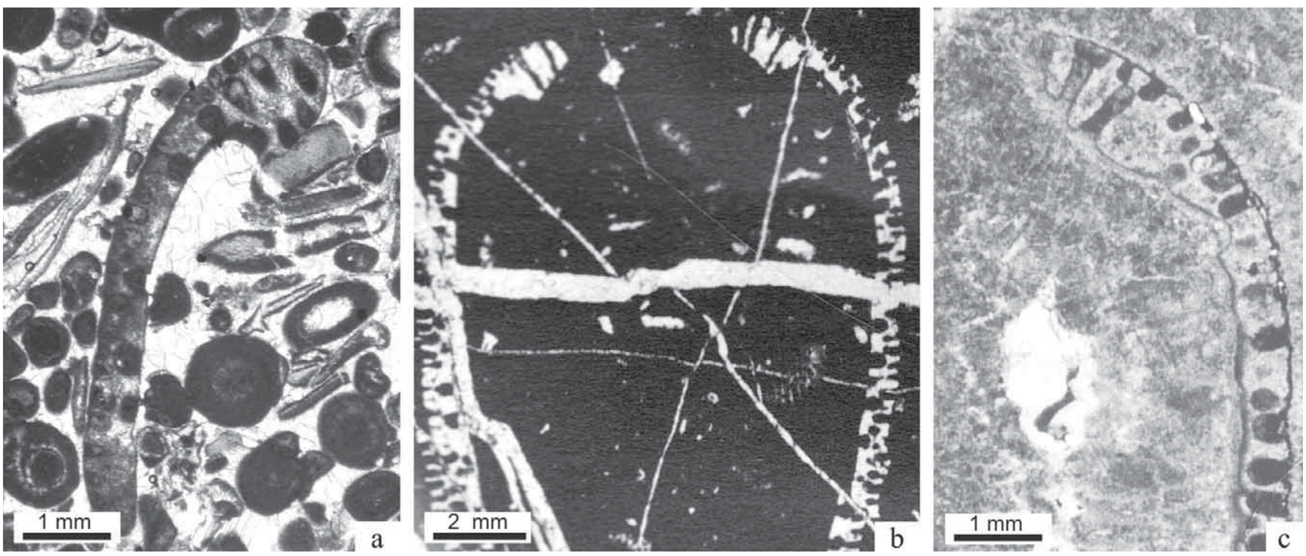


Figure 4: Close up of the three different apical zones showing that the calcification thickness increases enveloping thinner primary and secondary laterals, but seemingly, it disappears at the apex, leaving a cavity. **a** – *Granieria iberica* nov. comb. **b** – *Tersella alpina* (close-up from CROS & LEMOINE, 1967). **c** – *Tersella genotii* (close-up from BARATTOLO & BIGOZZI, 1996).

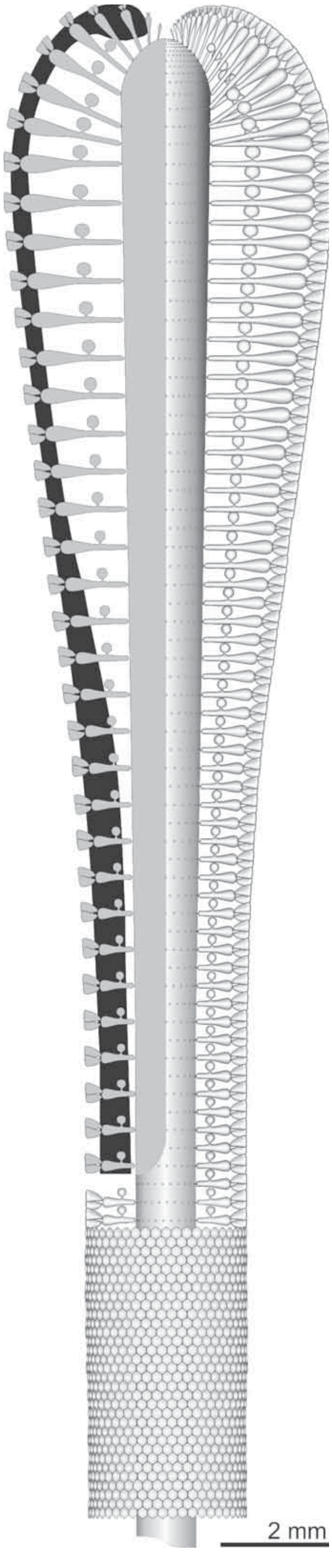


Figure 5: *Granieria iberica* nov. comb. Reconstruction of the thallus in longitudinal view. *Left side*: stem, primary laterals and calcification (black) in axial section. *Right side*: longitudinal view of the thallus without calcification; in the lower part a perspective view of the primary and secondary laterals, and cortex is drawn.

The uncalcified primary laterals in the upper part of the thallus are assumed to be similar to those in the lower part, but are comparatively longer. The reproductive structures are thought to be present in the head too because in other dasycladales it is specifically the upper part of the thallus that is deputed to reproduction. The position of the ampulla has been postulated as similar to that of those visible in the lower part of the thallus, but larger in comparison to the size of the lateral.

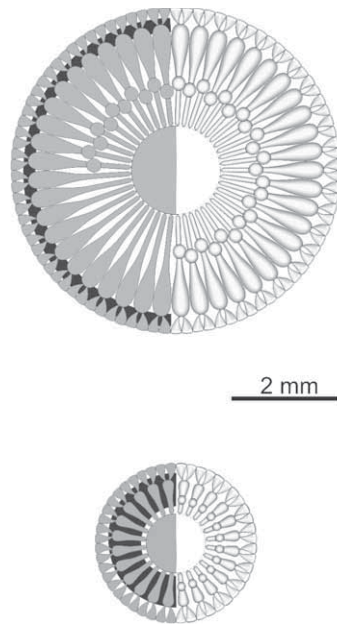


Figure 6: *Granieria iberica* nov. comb. Reconstructions in transverse view. *Left-side* transverse section at whorl level showing primary and secondary laterals and calcification (black); *right-side*: primary, secondary laterals and ampulla without calcification. Lower – stalk region, upper – head region

Finally the top of the thallus is believed to resemble those of other morphologically similar fossil genera such as *Tersella* (*e.g*. *Tersella alpina*, *Tersella genotii*).

Comparisons: As discussed above, *Granieria* displays close analogies with other club-shaped Early Jurassic genera. In particular the type species *Granieria iberica* (DRAGASTAN & TRAPPE) nov. comb. shows a marked resemblance to the genus *Tersella*.

Granted that the presence of a choristosporous type of reproductive apparatus (ampulla) is sufficiently decisive to distinguish *Granieria iberica* n. comb from all not-choristosporous species of *Tersella*, there are other morphological differences.

Tersella genotii BARATTOLO & BIGOZZI and *Tersella incompleta* MORELLET are very close to *Granieria iberica* in that they share a slightly differentiated club shaped calcareous skeleton and a general similarity in the pattern of calcification from the stalk to the head. *T. genotii* is larger than *Granieria iberica* and its secondary laterals are cylindrical to slightly widened outwards rather than short and cone shaped as in *Granieria iberica. T. alpina* CROS & LEMOINE shows a narrowing in the middle portion of the secondary laterals, and *T. incompleta* also narrows, but in the sub-terminal portion, while *Granieria iberica* has regularly widening short, cone-shaped, secondary laterals.

Finally, *Tersella quercensis* differs from *Granieria iberica* in that a distinction between head and thallus is well-marked in the club-shaped skeleton.

Granieria iberica shares its choristosporous type of reproduction with *Cylindroporella?liasica* but the thallus in this species is cylindrical, not a moderately differentiated club-shape. The fertile ampulla is larger and forms an elongated ellipsoid rather than sub-spherical globe (*Granieria iberica*).

6. CONCLUSIONS

The taxonomic relationships of several forms of dasycladales from Morocco, Italy and Spain are more complicated than previously supposed.

The validity of *Tersella genotii* from Central Italy (Gran Sasso, BARATTOLO & BIGOZZI, 1996) is confirmed.

The Moroccan specimens initially described as *Palaeodasycladus mediterraneus* by DELOFFRE & LAADILA (1991) are now referred to *Tersella genotii*. This attribution is based on the restudy of two discrete Moroccan dasycladalean assemblages, one from the High Atlas and the other from the Middle Atlas.

The Spanish specimens formerly described as *Dissocladella ebroensis* and *D. iberica, Dissocladella lucasi* (CROS & LEMOINE), *Gyroporella retica* (ZANIN BURI), *Sestrosphaera liasina* PIA and "*Macroporella* nov. sp." by DRAGASTAN & TRAPPE (1986), are referred to a single species in agreement with the work of GRANIER et al. (1995, 2003) and BARATTOLO & BIGOZZI (1996), but here this species is referred to the new genus *Granieria*.

The establishment of the new genus *Granieria* brings to light that in the Early Jurassic the genera developed, although apparently similar in aspect, are fundamentally different in reproductive strategy. The position of *Cylindroporella*? *liasica* (BARATTOLO & PARENTE 2000) should be analyzed in the light of the coincident occurrence of a structurally similar taxon, *Granieria*, which differs mainly in the shape of the thallus.

ACKNOWLEDGMENT

The present research has been funded by a grant from MURST (PRIN 2004 Barattolo). Many thanks are due to Nestor J. Sander for improving the manuscript by means of constructive and appropriate remarks. Sincere thanks to I. Bucur and F. Schagintweit for their suggestions and comments.

REFERENCES

BARATTOLO, F., DE CASTRO, P. &. PARENTE, M. (1995): Some remarks on the genera *Palaeodasycladus* (Pia, 1920) Pia, 1927 and *Eodasycladus* Cros & Lemoine, 1966 *ex* Granier, B. & Deloffre, R. (1993) (Green Algae, Dasycladales). – In: PILLER, W.E. (ed.): Proceedings of the International Symposium and Field-Meeting "Alpine Algae '93". Beiträge zur Paläontologie, 19 (1994), 1–11.

BARATTOLO, F. & BIGOZZI, A. (1996): Dasycladaleans and depositional environments of the Upper Triassic–Liassic carbonate platform of the Gran Sasso (Cental Appennines, Italy). – Facies, 35, 39–54.

BARATTOLO, F. & PARENTE, M. (2000): New observation on *Uragiella liasica* (LEBOUCHÉ & LEMOINE) (Green Algae, Dasycladales) from the type-locality (Canders, Languedoc-Southern France). – Boll. Soc. Paleont. Ital., 39/2, 123–137.

BARATTOLO, F. & ROMANO, R. (2005): Some bioevents at the Triassic–Liassic boundary in the shallow water environment. – Boll. Soc. Geol. Ital., 124, 123–142.

BASSOULLET, J.-P., BERNIER, P., DELOFFRE, R., GENOT, P., JAFFREZO, M., & VACHARD, D. (1979): Essai de classification des Dasycladales en tribus. – In: 2eme Symposium international sur les Algues fossiles (Paris, 23–26 avril 1979). Bull. Centr. Rech. Explor. – Prod. Elf-Aquitaine, 3–2, 429–442.

BERGER, S. & KAEVER, M.J. (1992): Dasycladales. An illustrated monograph of a fascinating algal order. – Georg Thieme Verlag, Stuttgart, 247 p.

BLOMEIER, D.P.G. & REIJMER, J.J.G. (1999): Drowning of a Lower Jurassic carbonate platform: Jbel Bou Dahar, High Atlas, Morroco. – Facies, 41, 81–110.

BUCUR, I.I. (1993): Some new or poorly known calcareous algae (Dasycladales, Gymnocodiacea) in the Lower Cretaceous deposits from the Resita – Moldova Noua zone (Southern Carpathians, Romania). – Rev. Espan. Micropal., 25/1, 93–126.

BUCUR, I.I. (2000): Lower Cretaceous dasyclad algae from the from Padurea Craiului Massif (Northern Apuseni Mountains, Romania). – Acta Palaeont. Roman., 2, 53–72.

CROS, P. & LEMOINE, M. (1967): Dasycladacées nouvelles ou peu connues du Lias inférieur des Dolomites et de quelques autres régions méditerranéennes (2e partie). – Rev. Micropal., 9/4, 246–257.

DELOFFRE, R. & LAADILA, M. (1990): Un niveau exceptionnel à *Palaeodasycladus mediterraneus* dans le Lotharingien du Moyen-Atlas (Maroc) – Emendation du genre et de l'espèce-type. – Rev. Paléobiol., 9/2, 309–320.

DRAGASTAN, O. & TRAPPE, J. (1986): Some Dasyclad Algae of the Sinemurian from the north-western Iberian Chains (Spain). – Paläont. Zeitschr., 60/3–4, 169–179.

GRANIER, B., POISSON, A., FERRÉ, B. & DELOFFRE, R. (1995): New data on a Liassic club-shaped Dasycladacean. – In: GÜVENÇ, T. (ed.): 6th International Symposium on Fossil Algae and Carbonate Platforms, Ankara (September 18th–22nd), Abstracts, 1 p.

GRANIER B., POISSON, A., FERRÉ, B. & DELOFFRE, R. (2003): New data on *Petrascula iberica* Dragastan et Trappe 1986, n. comb., a Liassic club-shaped Dasycladacean. Preliminary note. – Acta Micropal. Sinica, 20/1, 67–74.

MORELLET, J. & TERS, M. (1951): Deux Dasycladacées du Lias de Vendée.- Boll. Soc. géol. France, (6), I, 643–648.

PASCHER, A. (1931): Systematische Übersicht über die mit Flagellaten in Zusammenhang stehenden Algenreihen und Versuch einer Einreihung dieser Algenstämme in die Stämme des Pflanzenreiches.- Botanisches Centralblatt, 48, 317–332.

Manuscript received May 19, 2008
Revised manuscript accepted June 16, 2008