Large dasycladalean algae from Upper Jurassic limestone deposits of the Apuseni Mountains (Romania) – habitat and depositional environment

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ABSTRACT
Three species of dasycladalean algae are described: *Petrascula piai* Bachmayer, 1944, *P. bursiformis* (Etallon, 1859) and *Steinmanniporella kapelensis* (Sokač & Nikler, 1973). Two of them, *Petrascula piai* and *Steinmanniporella kapelensis*, are relatively seldom reported and consequently poorly known algae. They were found at two locations in the Apuseni Mountains: Sândulești quarry (Trascău Mountains) and Şerbota Hill (near Aștileu, Pădurea Craiului Mountains). The two species of *Petrascula* were essentially identified from sections of the stalk. Their study provides, especially for *P. piai*, useful supplementary data related to the morphology of the laterals and the structure of the stalk. Regarding *Steinmanniporella kapelensis*, Sândulești is only the second locality (after the type locality) where this alga is known to occur as numerous well preserved specimens. Microfacies and sedimentological data suggest that these algae were restricted to micro-environments within the external part of the carbonate platforms.

KEY WORDS
Calcareous algae, Dasycladales, paleoenvironment, Upper Jurassic, Apuseni Mountains, Romania.

RÉSUMÉ
Grandes algues dasycladales des calcaires du Jurassique supérieur des monts Apuseni (Roumanie) – habitat et milieu de dépôt.
Trois espèces d’algues dasycladales sont présentées : *Petrascula piai* Bachmayer, 1944, *P. bursiformis* (Etallon, 1859) et *Steinmanniporella kapelensis* (Sokač & Nikler, 1973). Deux d’entre elles, *Petrascula piai* et *Steinmanniporella kapelensis*, sont rarement citées dans la littérature et, par conséquent, relativement peu connues. Elles ont été trouvées dans deux localités des monts Apuseni : la carrière de Sândulești (monts de Trascău) et la colline de Şerbota (près d’Aștileu, monts de Pădurea Craiului). Les deux espèces de *Petrascula* ont été essentiellement
INTRODUCTION AND GEOLOGICAL SETTING

The dasycladean algae presented here were collected from two different regions of the Apuseni Mountains: Şerbota Hill (near Aștileu, northern part of Pădurea Craiului Mountains), and Săndulești quarry (the northern end of Trascău Mountains) (Fig. 1).

Two main facies associations have been distinguished within the Upper Jurassic succession of the Aștileu area (Fig. 2): 1) distal shelf (offshore) facies, identified in the lower part of the succession; and 2) shallow-water, external carbonate platform facies (bioclastic shoals), in the upper part.

1) The distal-shelf facies are represented by peloidal-bioclastic packstone/wackestone with stromatolites and peloidal-bioclastic packstone/grainstone (Fig. 2). Within these facies, rare ammonites, small foraminifers (including small miliolids), hemipelagic foraminifers (Lenticulina sp.), sponge spicules and echinoderm fragments are also present (Fig. 4A).

2) The distal-shelf facies gradually pass upwards into shallow-water bioclastic shoal deposits (Fig. 2). Intercalations of grainy limestones with diverse microfossils increase along this transition. The more representative shallow-water facies consist of intraclastic-bioclastic grainstone/packstone, ooid-bioclastic grainstone and ooid-pisoid-bioclastic grainstone (Fig. 4B-D). The clasts are sand-size and subangular to subrounded in shape, pointing to a relatively high-energy depositional environment. The clasts consist of reefal intraclasts and bioclasts, ooids, oncoids, and peloids. The bioclasts are represented by fragments of corals, echinoderms, molluscs, bryozoans, foraminifers, dasycladalean algae and rivulariacean-type cyanobacteria. This composition is consistent with their external platform bioclastic shoal environment.
Fig. 1. — Location of the sections studied within the Carpathian area and in relation to the tectonic outline of the Apuseni Mountains, based on Balintoni (2001). Abbreviations: PC, Pădurea Craiului; T, Trascau Mountain.
Fig. 2. — Succession of the carbonate deposits at Şerbota Hill (Aștileu, Pădurea Craiului Mountains): 1, peloids; 2, intraclasts; 3, ooids; 4, pisoids; 5, bioclasts; 6, emersion surface; 7, breccia; M, mudstone; W, wackestone; P, packstone; G, grainstone; R, rudstone.
The dasycladalean assemblage, represented by Salpingoporella pygmaea (Gümbel, 1891) Pia, 1925, Salpingoporella annulata Carozzi, 1953, Campbelliella striata (Carozzi, 1954) Bernier, 1974, Neoteutloporella socialis (Praturlon, 1963) Bassoullet et al., 1978 and species of the genus Petrascula (P. piai Bachmayer, 1944 and P. bursiformis (Etallon, 1859) Pia, 1920), is present in the upper part of the succession. The large Dasycladales (Petrascula specimens) have been found in ooid-pisoid or coarse intraclastic–bioclastic grainstones together with abundant echinoderm fragments (Fig. 4B, C).

Based on sedimentological and micropaleontological data, the large dasycladaleans from the Aştileu area developed on submarine dunes, as well as in protected inter-dune areas, in the external part of the Bihor–Pădurea Craiului Upper Jurassic carbonate platform.

Two main facies have also been distinguished in the limestones from Sănduleşti: carbonate breccia and microbreccia consisting mainly of reef fragments, and coral-microbial bioconstructions.

1) The breccia/microbreccia levels are decimetric to metric in thickness and consist of coarse “reefal” intraclasts in a fine-grained (silt, and sand sized) carbonate matrix (Fig. 3). Microfacies include intraclastic-bioclastic rudstone/floatstone and coarse intraclastic-bioclastic grainstone/packstone (Fig. 4H). These deposits are unstructured and poorly sorted. The clasts are chaotically distributed, angular to subrounded, with dimensions ranging from gravel to boulders. They are represented mainly by coral and sponges boundstones, corallomicrobialite boundstones, microbial crusts and bioclastic grainstones/packstones. In most cases, the top of the carbonate breccia/microbreccia is intensely encrusted by microbialite. Accordingly, these facies associations are interpreted as reef slope deposits in the proximity of the reef crest.

2) The reef bioconstructions are made up mostly of corals, microbialites and sponges (Fig. 4E, F). Bryozoans, encrusting microorganisms (Trogirotella incrustans Wernli & Fookes, 1992, Thaumatoporella parvovesiculifera) (Raineri, 1922) Pia, 1927, Crescentiellamorrenensis (Crescenti, 1969) Senowbari-Daryan et al., 2008, Radiomura cautica Senowbari-Daryan & Schäfer, 1979, Koskinobullina

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**Fig. 3.** — Succession of carbonate deposits in the Sănduleşti quarry (Trascău Mountains): 1, reef breccia (rudstone); 2, reef limestone (boundstone); 3, terrigenous deposits; M, mudstone; W, wackestone; P, packstone; G/B, grainstone/boundstone; R, rudstone.
socialis Cherchi & Schroeder, 1979, Lithocodium aggregatum Elliott, 1956), and annelid worms also contributed to the reef framework development. Syndepositional (radial fibrous) cement is frequently associated with the microbialites and played an important role in framework development. The intra-reefal sediment contains fragments of echinoderms, bivalves, gastropods, fish teeth (Sphaerodus maximus Wagner, 1863), foraminifers, and dasycladalean algae (Fig. 4G). In most cases, the sediments between the bioconstructions are wackestone/packstone with sponge spicules and packstone with Crescentiella morronensis and sponges. These sediments, together with the presence of microbial crusts, suggest relatively low sedimentation rates that were favorable for the nucleation and development of the bioconstructions.

Facies associations from the Sândulești area are characteristic of reef-slope environments located near the shelf margin. They demarcate the paleo-slope of a carbonate platform that was developed in this region on an island-arc topography during the Upper Jurassic-Lower Cretaceous.

In the Sândulești area, the dasycladalean algae assemblage consists of: Steinmanniporella kapelensis, Petrascula piai and Petrascula bursiformis. Steinmanniporella kapelensis was found only in the Sândulești area, while the two species of Petrascula are present in both areas.

**Petrascula piai** Bachmayer, 1944  
(Figs 5–8)

Petrascula piai Bachmayer, 1944: 238, figs 3-6 (emend. Bernier 1979: 845, pls 3, 4). — Bernier 1984: 478, pl. 11, figs 1, 2. — Moshammer & Schlagintweit 1999: 557, pl. 1, figs 4, 5. — Bucur & Săsăran 2005: 28, pl. 3, fig. 1.

Non Petrascula cf. piai — Okla 1991: 92, pl. 2, figs 3-5.

Montenegrorella sp. — Bodeur 1992: pl. 16, figs 5, 7-9, 12.

?Suppiluliumella tuberifera (Sokač & Nikler) — Dya 1992: 81, pl. 8, figs 1, 2, 6, 7.

?Dasycladale indet. — Carras 1995: pl. 22, fig. 2.

**Remarks**

*Petrascula piai* was firstly described by Bachmayer (1944) from Jurassic limestones at Dörfless (Austria). The species was based on four fragments partly detached from the matrix, with two head fragments and two stalk fragments. No specimen was illustrated in thin section. Bachmayer's description (translated from the German) is as follows: “This form is characterized by a sharp difference between head and stalk. The head is almost spherical. Head and stalk were found separately. However, it is likely that the fragments illustrated in figs. 5 and 6 belong to the same species. The head consists of densely arranged secondary veriticillated branches, so that little space is left for the calcareous deposit. Within the skeleton, the secondary pore fillings were joined by calcite recrystalisation, and made a rigid sphere. The outer ends of the pore fillings give the exterior very regular, hemispherical papillae-like prominences, and very probably the pores were closed to the exterior. In addition, tertiary verticillar branches could not be recognized. Within the stalk the primary verticillar branches are set at a distance from each other, and in very well defined verticils. They are set obliquely to the upper part. The branch number in a verticil ranges from 16 to 20. The division of primary ver-
Fig. 4. — Main microfacies in the limestones from Aștileu and Sândulești: A, wackestone/packstone with sponge spicules and juvenile ammonites (Sa 270 As); B, intraclastic-bioclastic grainstone with dasycladean algae and echinoderm fragments (Sa 10684 As); C, pisoid-bioclast grainstone with dasycladean algae (Sa 10684 As); D, ooid grainstone with bioclastic cores to the ooids (frequently small dasycladean algae; Sa 10685 As); E, coral-microbial boundstone (Sa F11-m 18.2 Sd); F, microbialites and internal sediment from bioconstructions (Sa F8-m 81.9 Sd); G, internal sediment from bioconstructions: bioclastic packstone with dasycladean algae (Sa F10-m 9.2 Sd); H, intraclastic-bioclastic grainstone/rudstone with coral fragments and dasycladean algae (Sa F10-m 96.6 Sd). Scale bars: 1 mm.
Fig. 5. — *Petrascula piai* Bachmayer, 1944, longitudinal (A, B, D, E) and longitudinal-oblique (C, F) sections through the cylindrical stalk; the upper part in D shows a small portion of the transition from stalk to head. A, Sa F10-96.6 SaD; B, E, Sa 10684 As; C, Sa 3357 As; D, Sa 10684a As; F, Sa 10684c As. Scale bars: 0.5 mm.
Fig. 6. — *Petrascula pia* Bachmayer, 1944, longitudinal-oblique (A), oblique-tangential (B) and oblique (C-F) sections. A-E, Sa 10684 As; F, Sa 10684a As. Scale bars: 0.5 mm.
Fig. 7. — *Petrascula piai* Bachmayer, 1944: A–F, transverse sections (F, probably at the transition between stalk and head); G–I, tangential sections. A, C, F–I, Sa 10684 As; B, D, E, Sa 3357 As. Scale bars: 0.5 mm.
Fig. 8. — *Petrascula piai* Bachmayer, 1944: A, fragment in longitudinal-oblique section showing the transition from stalk to head; B, D, close-up view of laterals in transverse (B) and longitudinal-oblique (D) sections; arrows point to the third order laterals; C, E-G, fragments of the head, with calcification restricted to the distal part of second order and third order laterals. A, E, F, Sa 10684c As; B, C, Sa 3357 As; D, Sa 10684a As; G, Sa 10684b As. Scale bars: A, C, F, G, 0.5 mm; B, D, E, 0.25 mm.
ticillar branches into secondaries can be observed in some places, but the number of secondary branches within a bush could not be established due to the poor preservation of the stalk.”

Bachmayer (1944) gives neither details related to the morphology of the primary and secondary laterals, nor remarks on the paleoenvironment.

In his detailed study of the species of the genus Petrascula, Bernier (1979) emended the diagnosis (i.e. description) given by Bachmayer (1944) based on many specimens observed in thin section. Bernier (1979) made the following remarks:

– the primary laterals are spherical to subspherical or ovoid; sometimes, the incomplete calcification around the primary laterals make them communicate in some places;
– the 4 to 5 secondary laterals seem to be vesiculiform, with a proximal filiform portion, and a distal enlarged portion.

Bernier (1979: 846) mentioned that he had the opportunity to examine Bachmayer’s type material, and noted that the “original figurations are of very bad quality”. Bernier (1979) also made some remarks on the paleoenvironment and noted that “Le biotope de P. piai était certainement un milieu calme de plate-forme peu profonde, dans une eau relativement chaude”. However, he noted that he had not found any complete skeleton, only separated head and stalk fragments.

In the section from Şerbota Hill (near Astileu, Pădurea Craiului Mountains; Fig. 2) we identified numerous specimens referable to this species. Most of them are stalk fragments (Figs 5-7; 8A, B, D), but some rare fragments could belong to the head (Fig. 8C, E-G).

**Morphology of the stalk**

The stalk fragments are cylindrical (Figs 5-7), with a slight enlargement in the upper part where the passage from stalk to the head begins (Figs 5D; 8A). The longitudinal and longitudinal-oblique sections (Fig. 5) allow the morphology of the laterals to be well observed. The first-order laterals are spheroidal to ovoidal in shape (Fig. 5A, B, D-F). In some longitudinal sections (Fig. 5C) the first-order subspherical laterals become subquadrangular, being higher than wide (see also the oblique sections in Fig. 6A, B and the tangential section in Fig. 7H). This is due, most probably, to reciprocal pressure between laterals of the same verticil (e.g., Fig. 8B). This reciprocal pressure does not operate in the vertical plane because of the spaced out arrangement of the verticils along the stalk. In transverse sections (Fig. 7A-E) the shape of the first-order laterals range from sub-cylindrical to sub-quadrangular.

The relationship between the first-order and second-order laterals is visible in oblique sections (Fig. 6): each first-order lateral gives rise to a bush of secondaries. The second-order laterals have a proximal narrow tubular part and enlarge distally to the exterior (phloiophorous type). The link between the first-order and second-order laterals is made by a short narrow peduncle (Figs 7A [left side]; 8D). The number of second-order laterals in a bush originating from a first-order lateral varies from 4 to 6. This is clearly visible in tangential sections (Fig. 7G, I).

Both Bachayer (1944) and Bernier (1979) emphasized that *P. piai* has only two orders of laterals. Bachmayer (1944) considered that *P. piai* differs from *P. bursiformis* by (translated from the German): “sharp passage from the stalk to the head, and the ending of pores with papillae, and additionally by the lack of calcified tertiary verticillar branches”. The same character (the lack of third-order laterals) was utilised by Bernier (1979) to differentiate *P. piai* from *P. bursiformis* and *P. guembeli*: “Elle se distingue aussi aisément de *P. bursiformis* et *P. guembeli* qui presentent trois ordres de ramifications dans la tige et au collet”. However, some rare specimens found in the Şerbota Hill section (Pădurea Craiului Mountains) (Fig. 2) show that *P. piai* can also have three orders of laterals (Fig. 8B, D [arrows]). The second-order laterals give rise, sometimes, to a bush of third-order phloiophorous short laterals. Very probably, the third-order of laterals was present only in some portions of the stalk. The thin calcification of the external part of the thallus, as well as the abrasion of the skeletons due to sedimentary transport, have made preservation of the third-order laterals very rare. On the other hand, it is very unlikely that the second-order laterals were closed to the exterior (as put forward by Bachmayer 1944); more probably the second-order or tertiary laterals formed an external cortex.
Fig. 9. — A-H, I-J. *Petrascula bursiformis* (Etallon, 1859) Pia, 1920, transverse (A-C) and oblique (D, E, G, H) sections through the stalk and stalk-head transition; F, close-up view of the specimen in C showing the third order laterals; I, J, probably fragments of the head. A, E, H, Sa 10684b As; B, Sa F3-m 59.2 Sa; C, D, Sa 10684a As; I, Sa 3357 As; J, Sa 10709 As; G, Sa 10.684 As. Scale bars: A-E, G-I, 0.5 mm; F, J, 0.25 mm.
Table 1. — General dimensions (in mm) of *Petrascula piai* Bachmayer, 1944. Abbreviations: D, external diameter of the thallus; d, internal diameter of the thallus; d/D, ratio between internal and external diameters; h, distance between two consecutive verticils; l1, length of the primary laterals; l2, length of the secondary laterals; p1, diameter of the primary laterals; p2, diameter of the secondary laterals; p2-distal, diameter of the secondary laterals in their distal part.

| Sample  | Specimen | D   | d   | d/D | l1  | l2  | p1  | p2  | p2-distal | h   |
|---------|----------|-----|-----|-----|-----|-----|-----|-----|-----------|-----|
| F3-59.2A(4) | 1 | 2.49 | 1.04 | 0.42 | 0.42 | 0.27 | 0.27 | 0.16 |
| F10-96.6B | 2 | 2.62 | 0.3 | 0.06 | 0.16 | 0.5 |
| 3357(1) | 3 | 2.76 | 1.37 | 0.5 | 0.29 | 0.37 | 0.23 |
| 3357(2) | 4 | 2.4 | 0.62 | 0.34 | 0.12 |
| 3357(3) | 5 | 2.18 | 0.84 | 0.39 | 0.25 | 0.43 | 0.34 | 0.17 | 0.21 | 0.56 |
| 3357(3) | 6 | 2.54 | 1.26 | 0.5 | 0.26 | 0.33 | 0.32 | 0.12 |
| 3357(7) | 7 | 2.52 | 1.23 | 0.5 | 0.27 | 0.33 | 0.33 | 0.12 |
| 3357(4) | 8 | 3.04 | 1.78 | 0.59 | 0.29 | 0.38 | 0.22 | 0.08 |
| 3357(4) | 9 | 2.63 | 1.24 | 0.47 | 0.23 | 0.36 | 0.25 | 0.14 | 0.52 |
| 3357(5) | 10 | 2.87 | 1.62 | 0.5 | 0.29 | 0.37 | 0.35 | 0.16 | 0.55 |
| 3357(7) | 11 | 2.6 | 1.46 | 0.56 | 0.21 | 0.28 | 0.15 | 0.06 |
| 3357(7) | 12 | 2.34 | 1.31 | 0.56 | 0.23 | 0.37 | 0.17 | 0.06 | 0.16 |
| 3357(8) | 13 | 2.7 | 1.24 | 0.46 | 0.27 | 0.38 | 0.2 | 0.11 |
| 3357(11) | 14 | 2.32 | 1.15 | 0.5 | 0.33 | 0.2 | 0.17 | 0.07 |
| 3357(12) | 15 | 2.98 | 1.67 | 0.56 | 0.26 | 0.37 | 0.6 |
| 3357(13) | 16 | 2.27 | 1.04 | 0.46 | 0.34 | 0.37 | 0.2 | 0.07 |
| 3357(15) | 17 | 2.79 | 1.44 | 0.52 | 0.36 | 0.35 | 0.2 | 0.09 |
| 3357(15) | 18 | 2.85 | 1.37 | 0.48 | 0.38 | 0.34 | 0.18 | 0.08 |
| 3357(17) | 19 | 2.69 | 1.51 | 0.56 | 0.27 | 0.31 | 0.26 | 0.07 |
| 3357(17) | 20 | 2.45 | 1.31 | 0.53 | 0.27 | 0.28 | 0.23 | 0.09 |
| 3357(18) | 21 | 2 | 1.07 | 0.54 | 0.3 | 0.1 | 0.1 | 0.06 | 0.09 |
| 3357(18) | 22 | 2.66 | 1.27 | 0.48 | 0.34 | 0.37 | 0.2 | 0.07 |
| 3357(18) | 23 | 2.7 | 1.47 | 0.54 | 0.36 | 0.42 | 0.19 | 0.07 | 0.18 |
| 3357(18) | 24 | 2.05 | 1.08 | 0.53 | 0.3 | 0.27 | 0.1 | 0.05 |
| 3357(20) | 25 | 2.15 | 1.43 | 0.67 | 0.27 | 0.31 | 0.26 | 0.07 |
| 3357(24) | 26 | 2.63 | 1.23 | 0.47 | 0.28 | 0.32 | 0.23 | 0.07 |
| 3357(24) | 27 | 2.8 | 1.4 | 0.5 | 0.37 | 0.34 | 0.17 | 0.07 | 0.15 |
| 3357(29) | 28 | 2.49 | 1.26 | 0.51 | 0.36 | 0.42 | 0.19 | 0.07 | 0.18 |
| 3357(32) | 29 | 3.03 | 1.56 | 0.51 | 0.36 | 0.42 | 0.19 | 0.07 | 0.18 |
| 10684* | 30 | 2.25 | 0.35 | 0.25 | 0.08 | 0.57 |
| 10684B | 31 | 2.59 | 1.16 | 0.45 | 0.33 | 0.27 | 0.1 | 0.05 |
| 10718 | 32 | 2.32 | 0.26 | 0.16 | 0.08 |
| 10684(1) | 33 | 2.71 | 1.21 | 0.45 | 0.38 | 0.37 | 0.28 | 0.09 | 0.16 |
| 10684(2) | 34 | 2.11 | 0.97 | 0.46 | 0.37 | 0.28 | 0.17 | 0.07 |
| 10684(3) | 35 | 2.37 | 1.86 | 0.78 | 0.29 | 0.3 | 0.18 | 0.1 |
| 10684(3) | 36 | 2.48 | 1.3 | 0.52 | 0.28 | 0.32 | 0.17 | 0.07 | 0.12 |
| 10684(4) | 37 | 2.24 | 0.86 | 0.38 | 0.32 | 0.35 | 0.19 | 0.08 |
| 10684(7) | 38 | 2.35 | 1.25 | 0.53 | 0.25 | 0.31 | 0.26 | 0.08 | 0.63 |
| 10684(8) | 39 | 2.68 | 1.34 | 0.57 | 0.31 | 0.32 | 0.14 | 0.07 |
| 10684(11) | 40 | 2.32 | 0.95 | 0.41 | 0.39 | 0.32 | 0.24 | 0.09 | 0.39 |
| 10684(13) | 41 | 2.14 | 1.01 | 0.47 | 0.32 | 0.32 | 0.2 | 0.08 | 0.18 |
| 10684(14) | 42 | 2.44 | 1.09 | 0.45 | 0.3 | 0.3 | 0.2 | 0.08 | 0.19 |
| 10684(14) | 43 | 2.35 | 1.26 | 0.54 | 0.31 | 0.18 | 0.2 | 0.09 |
| 10684(16) | 44 | 2.54 | 1.43 | 0.56 | 0.26 | 0.32 | 0.15 | 0.05 |
| 10684(17) | 45 | 2.22 | 1.14 | 0.51 | 0.29 | 0.29 | 0.2 | 0.05 |
| 10684(18) | 46 | 2.22 | 0.84 | 0.38 | 0.09 | 0.16 |
| 10684(19) | 47 | 2.38 | 1.28 | 0.54 | 0.36 | 0.37 | 0.28 | 0.17 | 0.07 |
| 10684(19) | 48 | 2.8 | 1.38 | 0.49 | 0.36 | 0.27 | 0.13 | 0.07 |
A distinctive character observed in the specimens from Apuseni Mountains is the presence, in some cases, of a fissuration at the interverticillar level, visible in tangential sections (Figs 6B; 7H).

**HEAD FRAGMENTS**

Figure 8C, E-H illustrates fragments considered to represent calcified parts of the head of *P. piai*. The calcified parts include here, most probably, the terminal part of the second-order laterals and the third-order laterals. Lack of continuity between the head and stalk makes the attribution of these fragments to the head of *P. piai* problematic. The only specimen in which head and stalk are preserved together is a tangential-longitudinal section illustrated by Moshammer & Schlagintweit (1999: pl. 1, fig. 4).

**DIMENSIONS**

Table 1 gives the dimensions of *Petrascula piai* measured on 79 specimens.

### Table 1.

| Sample | Specimen | D   | d   | d/D | l1  | l2  | p1  | p2  | p2-distal | h   |
|--------|----------|-----|-----|-----|-----|-----|-----|-----|-----------|-----|
| 10684(30) | 55       | 2.11| 1.54| 0.73| 0.3 | 0.31| 0.32| 0.12| 0.18      | 0.45|
| 10684(30) | 56       | 2.39| 1.31| 0.55| 0.3 | 0.31| 0.32| 0.12| 0.18      | 0.45|
| 10684(34) | 57       | 2.54| 0.68| 0.27| 0.33| 0.4 | 0.29| 0.08| 0.15      | 0.06|
| 10684(37) | 58       | 1.84| 0.88| 0.48| 0.23| 0.25| 0.15| 0.06|          |     |
| 10684(40) | 59       | 1.94| 0.87| 0.45| 0.33|     |     |     | 0.18      |     |
| 10684(40) | 60       | 2.19|     |     |     |     |     | 0.56|           |     |
| 10684(40) | 61       | 2.58| 1.06| 0.41| 0.34| 0.4 | 0.29| 0.1  |           |     |
| 10684(41) | 62       | 2.38| 1.19| 0.5  | 0.33| 0.28| 0.23| 0.07|           |     |
| 10684(42) | 63       | 2.55| 1.2  | 0.47| 0.35| 0.38| 0.19| 0.07|           |     |
| 10684(43) | 64       | 2.55| 1.36| 0.53| 0.33| 0.29| 0.2  | 0.06|           |     |
| 10684(45) | 65       | 2.42| 0.8  | 0.33| 0.33| 0.32| 0.19| 0.07|           |     |
| 10684(42) | 66       | 2.43| 1.03| 0.44|     |     |     |     | 0.53      |     |
| 10684(44) | 67       | 2.54| 1.33| 0.52| 0.4  | 0.22| 0.09| 0.06|           |     |
| 10684(45) | 68       | 2.38| 1.26| 0.53| 0.31| 0.27| 0.16| 0.06|           |     |
| 10684(46) | 69       | 2.57| 1.2  | 0.47| 0.44| 0.3  | 0.24| 0.09|           |     |
| 10684(49) | 70       | 2.88| 1.34| 0.46| 0.39| 0.41| 0.33| 0.08|           |     |
| 10684(51) | 71       | 2.55| 1.3  | 0.51| 0.25| 0.29| 0.14| 0.07|           |     |
| 10684(52) | 72       | 2.89| 1.31| 0.45| 0.37| 0.23| 0.09| 0.06|           |     |
| 10684(53) | 73       | 2.62| 1.45| 0.55| 0.37| 0.22| 0.29| 0.08|           |     |
| 10684(54) | 74       | 2.3  | 1.42| 0.62|     |     |     |     |           |     |
| 10684(55) | 75       | 2.43| 1.29| 0.53|     |     |     |     |           |     |
| 10684(56) | 76       | 2.07| 0.84| 0.41| 0.32| 0.26| 0.15| 0.07|           |     |
| 10684(57) | 77       | 2.35| 0.8  | 0.34| 0.43| 0.32| 0.29| 0.09|           |     |
| 10684(58) | 78       | 2.37| 1.14| 0.48|     |     |     |     |           |     |
| 10684(60) | 79       | 2.53| 1.37| 0.48| 0.36| 0.31| 0.24| 0.11| 0.45      |     |
| **Total** |          | 74  | 71  | 72  | 63  | 62  | 63  | 58  | 13        | 19  |

**Minim**

| D   | 1.84 | 0.68 | 0.27 | 0.21 | 0.1 | 0.09 | 0.05 | 0.09 | 0.39 |
|-----|------|------|------|------|-----|------|------|------|------|

**Maxim**

| D   | 3.04 | 1.86 | 0.78 | 0.44 | 0.43 | 0.34 | 0.17 | 0.21 | 0.65 |
|-----|------|------|------|------|------|------|------|------|------|

**Average**

| D   | 2.456 | 1.219 | 0.496 | 0.315 | 0.309 | 0.207 | 0.08 | 0.16 | 0.541 |
|-----|-------|-------|-------|-------|-------|-------|------|------|-------|

**Standard deviation**

| D   | 0.271 | 0.236 | 0.079 | 0.054 | 0.062 | 0.060 | 0.023 | 0.031 | 0.071 |
|-----|-------|-------|-------|-------|-------|-------|-------|-------|-------|

**Conodyctium bursiforme** Etallon, 1859: 530.

*Petrascula bursiformis* (Etallon) Pia (emend. Bernier 1979: 843, pl. 2). — Bernier 1984: 477, pl. 10, figs 1-5. — Schlagintweit & Ebli 1999: 394, pl. 9, figs 1, 2. — Rasser & Fenninger 2002: 176, pl. 2, fig. 3 (reproducing the specimen illustrated by Fenninger & Holzer [1972: pl. 17, fig. 4]; following Bernier [1979: 844], this specimen does not belong to *Petrascula bursiformis*). — Schlagintweit & Gawlick 2009: fig. 2/5.

For more, see synonymy list in Bernier (1979).
Some *Petrascula* specimens (Fig. 9) identified both in the Şerbota Hill (Aştileu) and Sânduleştii areas belong to *Petrascula bursiformis*. Even in transverse sections through the stalk (Fig. 9A-C) and oblique sections at the stalk-head passage level (Fig. 9D, E, G, H), the differences with respect to *Petrascula piai* are shown by the shape of the first-order laterals: longer in *P. bursiformis* and with a general club-like shape. They have a narrow proximal part, followed by a sudden and then a gradual enlargement to the distal part (Fig. 9B, C). The presence of three orders of laterals within the stalk and the stalk-head passage is also illustrated in the specimens we identified (Fig. 9B, F). Rare fragments, somewhat similar in shape to the fragments of "*Pseudoepimastopora jurassica*" Endo, 1961 (Fig. 9I, J), could represent fragments of the head of *Petrascula bursiformis*. Bernier (1979: 848) stressed both in the text and in table 2, the pearl-string shape of the third order laterals of *P. bursiformis*. Unfortunately, in the absence of close-up views, this character is not visible in the illustration provided (Bernier 1979: pl. 2).

### REMARKS

Table 2 gives the dimensions measured on 25 specimens of *P. bursiformis* identified in the Apuseni Mountains.

### TABLE 2. — General dimensions (in mm) of *Petrascula bursiformis* (Etallon, 1859) Pia, 1920. Abbreviations: see Table 1.

| Sample | Specimen | D    | d    | d/D  | l1   | l2   | p1   | p2   |
|--------|----------|------|------|------|------|------|------|------|
| F3-59.2(2) | 1 | 2.7  | 0.77 | 0.29 | 0.73 | 0.23 | 0.25 | 0.11 |
| F10-10.0(1) | 2 | 2.35 | 0.93 | 0.4  | 0.5  | 0.45 | 0.24 | 0.08 |
| F10-10.0(3) | 3 | 2.27 | 0.81 | 0.36 | 0.5  | 0.25 | 0.21 | 0.06 |
| 10.684B | 4 | 2.35 | 1    | 0.43 | 0.29 | 0.26 | 0.11 | 0.05 |
| 10684(20) | 5 | 3.57 |      |      | 0.68 | 0.4  | 0.12 | 0.08 |
| 10684(A4)| 6 | 2.43 | 0.78 | 0.2  | 0.62 | 0.35 | 0.17 | 0.06 |
| 10684(A4)| 7 | 2.34 | 0.6  | 0.26 | 0.62 | 0.44 | 0.15 | 0.07 |
| 10684(A4)| 8 | 3.44 |      |      | 0.65 | 0.4  |      |      |
| 10684(A6)| 9 | 2.62 |      |      | 0.5  | 0.29 | 0.15 | 0.07 |
| 10684(A7)| 10| 2.54 | 0.96 | 0.38 | 0.56 | 0.32 | 0.14 | 0.08 |
| 10684(A7)| 11| 2.1  | 0.62 | 0.3  | 0.41 | 0.24 | 0.13 | 0.06 |
| 10684(A10)| 12| 2.86 | 1.02 | 0.36 | 0.47 | 0.32 | 0.13 | 0.08 |
| 10684(A14)| 13| 2.79 | 0.75 | 0.27 | 0.77 | 0.23 | 0.36 | 0.08 |
| 10684(A16)| 14| 2.25 | 0.8  | 0.36 | 0.51 | 0.21 | 0.18 | 0.08 |
| 10684(B3)| 15| 3.06 | 1.06 | 0.35 | 0.72 | 0.32 | 0.17 | 0.1  |
| 10684(B3)| 16| 2.08 | 0.65 | 0.31 | 0.64 | 0.25 | 0.17 |      |
| 10684(B4)| 17| 2.83 | 0.81 | 0.29 | 0.55 | 0.39 | 0.19 | 0.09 |
| 10684(B12)| 18| 4.36 |      |      | 0.95 | 0.32 | 0.22 | 0.1  |
| 10684(B13)| 19| 3.09 |      |      | 0.62 |      | 0.17 |      |
| 10684(B14)| 20| 3    | 1.1  | 0.37 | 0.59 | 0.34 | 0.21 | 0.07 |
| 10684(B15)| 21| 3.69 |      |      | 0.76 | 0.37 | 0.23 | 0.1  |
| 10684(B16)| 22| 2.27 | 0.71 | 0.31 |      |      |      |      |
| 10684(B16)| 23| 1.08 | 0.57 | 0.32 | 0.36 | 0.16 | 0.1  | 0.06 |
| 10684(C4)| 24| 2.84 | 1.05 | 0.37 | 0.62 | 0.39 | 0.17 | 0.09 |
| 10684(C5)| 25| 2.71 | 0.69 | 0.25 | 0.74 | 0.35 | 0.17 | 0.08 |
| **Total** | 25 | 19   | 19   | 24   | 23   | 23   | 21   |
| **Minim** |   | 1.08 | 0.57 | 0.2  | 0.29 | 0.16 | 0.1  | 0.05 |
| **Maxim** |   | 4.36 | 1.1  | 0.43 | 0.95 | 0.45 | 0.36 | 0.11 |
| **Average** | | 2.705 | 0.825 | 0.325 | 0.598 | 0.317 | 0.18 | 0.079 |
| **Standard deviation** | | 0.642 | 0.168 | 0.058 | 0.146 | 0.078 | 0.057 | 0.016 |
Fig. 10. — *Steinmanniporella kapelensis* (Sokač & Nikler, 1973) Bucur, Granier & Schlagintweit, 2010, longitudinal (A), longitudinal-oblique (B-D, G), transverse (E) and oblique (F) sections. A, D, Sa F10-m 9.3 Sd; B, Sa F2-m 10 Sd; C, E, F, Sa F10-m 9.2 Sd; G, Sa F11-m 37.4 Sd. Scale bars: 0.5 mm.
**Steimanniporella kapelensis**  
(Sokač & Nikler, 1973)  
Bucur, Granier & Schlagintweit, 2010  
(Figs 10, 11)

*Linoporella kapelensis* Sokač & Nikler, 1973: 65, pls 1-3. — Bassoullet *et al.* 1978: 152, pl. 17, figs 6, 7 (reproducing original illustrations by Sokač & Nikler 1973). — Bucur *et al.* 2005: 110, pl. 3, figs 4, 5.

*Linoporella cf. kapelensis* — Schlagintweit & Ebli 1999: 393, pl. 8, fig. 4.

*Steimanniporella kapelensis* — Bucur *et al.* 2010: fig. 1a (reproducing the original illustration in Sokač & Nikler 1973: pl. 1, fig. 1 – the holotype).

**Remarks**

So far, this nice dasycladalean alga, described in 1973 by Sokač & Nikler, has seldom been identified in other similar deposits. In some cores from drillings in the Săndulești quarry (Fig. 3), we identified numerous quite well preserved specimens. “*Linoporella* kapelensis” represents the type species of the recently introduced genus *Steimanniporella* (Bucur *et al.* 2010) as a consequence of the emendation of the genus *Linoporella* by Barattolo & Romano (2005). The genus was further emended by Radoičić *et al.* (2009).

All the characteristics given by Sokač & Nikler (1973) can be recognized in the specimens from Săndulești. The first-order laterals, tubular in shape, are inclined with respect to the axial cavity; a characteristic well seen in longitudinal and oblique sections (Fig. 10A-D, F, G). They give rise to a bush of four second-order laterals, tubular in the proximal part and enlarged distally. The oblique and transverse-oblique sections (Fig. 11A-F, H, K) show the junction between first-order and second-order laterals, and the number of the secondaries (e.g., Fig. 11D, lower part). Transverse sections (Figs 10E; 11G) show the number of first order laterals in a whorl, as well as their shape (e.g., Fig. 10E).

**Dimensions**

The dimensions of the specimens of *S. kapelensis* from the Apuseni Mountains are given in Table 3.

**Environmental Significance**

Following Bernier (1984), Moshammer & Schlagintweit (1999) noted that “different representatives of the genus *Petrascula* show distinct variations in their paleoenvironmental distribution. While, for example, *P. bursiformis* is typically found in very shallow and well agitated external facies, *P. piai* occurs in very shallow and quiet water settings of the inner platform”. However, Bernier (1984: 477) made the following remark on *P. bursiformis*: “Cette espèce vivait certainement dans un milieu peu profond, relativement calme (mudstones) même si on a pu la retrouver fragmentée jusque dans des grainstones, après transport”. Our specimens from the Apuseni Mountains show that both *P. bursiformis* and *P. piai* could occur in protected micro-environments in external platform settings.

The sedimentological and micropaleontological data indicate that the large dasycladaleans from the Aștileu area lived onto submarine dunes and protected inter-dune areas in the external part of the Bihor-Pădurea Craiului Upper Jurassic carbonate platform.

In ooid-pisoid and coarse intraclastic grainstone, the dasycladaleans (mainly *Petrascula piai*) are typically surrounded by a microbial cortex and/or encrusted by foraminifers and calcified cyanobacteria. These encrustations point to a comparatively low energy paleoenvironment (protected inter-dune areas) from where the algae were reworked into higher energy environments in the dunes. Other large specimens, but devoid of a microbial cortex, show abrasion due to erosion (Fig. 4B). They indicate increased wave action in the submarine dunes. Large intraclasts containing fragments of *Neoteutloporella socialis* indicate the proximity of small reefs. Smaller dasycladaleans (e.g., *Salpingoporella* sp.) frequently constitute the cores of ooids, or occur as fragments (Fig. 4C, D).

In the Săndulești area, dasycladaleans (mostly *Steimanniporella kapelensis*) occur in intra-reefal sediments, and also in relatively low-energy deposits, being frequently reworked into the high-energy, rudstone environment where rare specimens of *Petrascula* are also found.
Fig. 11. — *Steinmanniporella kapelensis* (Sokač & Nikler, 1973) Bucur, Granier & Schlagintweit, 2010, oblique (A-D, F), transverse-oblique (E, H, K), and transverse (G, I, J) sections. A, F, Sa F11-m 15.8 Sd; B, Sa F11-m 37.4 Sd; C-F, Sa F10-m 9.3 Sd; G, F4-m 126.7 Sd; H, F8-m 6.6 Sd; I, F10-m 10 Sd; J, F3-m 59.2 Sd; K, F10-m 9.2 Sd. Scale bars: 0.5 mm.
These two case studies provide support for previous assumptions that large dasycladeans mainly lived onto the external parts of carbonate platform margins, such as reefal and bioclastic shoals (Bucur & Săsăran 2005 and references herein).

CONCLUSION

Specimens of the large dasycladeans Petrascula piai, P. bursiformis and Steinmanniporella kapelensis occur in Upper Jurassic limestones of the Apuseni Mountains, north-west Romania. Two of these algae (P. piai and S. kapelensis) have previously only seldom been identified and consequently were poorly known. This new material allows improved descriptions and illustrations of these algae, as well as some remarks on their habitat and depositional environment.

Acknowledgements

The paper is a contribution to the research project supported by CNCSIS grant ID 561. We thank Robert Riding for improvement of the English, and the reviewers Marc Conrad, Filippo Barattolo and Valéry Malécot for their help to improve the manuscript. I also thank my colleague C. Balica for his substantial help with drawing the Figures.

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| Sample     | Specimen | D  | d   | D/D | l1  | l2  | p1  | p2  | h |
|------------|----------|----|-----|-----|-----|-----|-----|-----|---|
| F3-59.2(4) | 1        | 1.89| 0.95| 0.5 | 0.31| 0.22| 0.11| 0.06|  |
| F4-162.7(4)| 2        | 2.92| 1.26| 0.43| 0.51| 0.27| 0.1 |  |
| F8-6.6(4)  | 3        | 2.03| 0.81| 0.4 | 0.34| 0.25| 0.09| 0.07|  |
| F10-9.2    | 4        | 2.32| 0.97| 0.42| 0.45| 0.35| 0.11| 0.08|  |
| F10-9.2    | 5        | 1.89| 0.8 | 0.42| 0.45 | 0.9 | 0.06| 0.31|  |
| F10-9.2    | 6        | 1.91| 0.97| 0.51| 0.45 | 0.9 | 0.06| 0.31|  |
| F10-9.2    | 7        | 1.9 | 0.98| 0.52| 0.45 | 0.9 | 0.06| 0.31|  |
| F10-9.3(1) | 8        | 2.03| 0.71| 0.35| 0.43 | 0.33| 0.11| 0.09| 0.42|
| F10-9.3(1) | 9        | 2.09| 0.98| 0.47| 0.43 | 0.33| 0.11| 0.09| 0.42|
| F10-9.3(1) | 10       | 2.27| 1.11| 0.49| 0.43 | 0.33| 0.11| 0.09| 0.42|
| F10-9.3(2) | 11       | 0.71| 0.84| 0.49| 0.38 | 0.23|  |
| F10-9.3(2) | 12       | 1.93| 0.83| 0.43| 0.41 | 0.24| 0.12| 0.07|  |
| F10-9.3(2) | 13       |     |     |     | 0.4  | 0.26| 0.11| 0.07| 0.4 |
| F10-9.3(4) | 14       | 2.12| 0.79| 0.37| 0.41 | 0.31| 0.1 | 0.06| 0.4 |
| F10-9.3(4) | 15       | 2.05|     |     | 0.43 | 0.26| 0.11| 0.07| 0.48|
| F10-10.0(3)| 16       | 1.83| 0.88| 0.48|     |     |     |     |     |
| F10-10.0(4)| 17       | 1.96| 0.79| 0.4 | 0.5  | 0.32| 0.47 |  |
| F10-10.0(4)| 18       | 1.65| 0.74| 0.45| 0.44 | 0.27| 0.1 | 0.07| 0.43|
| F11-15.6(4)| 19       | 2.01| 0.82| 0.41|     |     |     |     |     |
| F11-15.8(5)| 20       | 2.31| 0.89| 0.39| 0.48 | 0.31| 0.11| 0.07| 0.52|
| F11-37.4(1)| 21       | 1.61| 0.51| 0.32| 0.39 | 0.26|     |     |     |
| F11-37.4(4)| 22       | 2   | 0.79| 0.4 |     |     |     |     |     |

Total 21 20 19 15 14 12 11 10
Minim 0.71 0.51 0.32 0.31 0.22 0.09 0.06 0.31
Maxim 2.92 1.26 0.52 0.51 0.35 0.12 0.09 0.52
Average 1.973 0.871 0.433 0.422 0.277 0.105 0.07 0.437
Standard deviation 0.397 0.157 0.057 0.055 0.040 0.009 0.009 0.061
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Submitted on 8 March 2011; accepted on 29 September 2011.

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