DASYCLADES ALGAE FROM THE NORIAN-RHAETIAN REEF CARBONATES OF ARGOLIS PENINSULA, GREECE

Baba Senowbari-Daryan

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Abstract Three new dasycladales algae, including Probolocuspis sarmeikensis nov. sp. Probolocuspis? tenuipora nov. sp. and Diplopora obliguspora nov. sp. are described from Mavrovouni Mountains (Argolis Peninsula, Greece). The specimens were found embedded in micritic sediments between the reef builders in the Norian-Rhaetian reef carbonates near the town of Sarmeika. The genus Probolocuspis was known from the Ladinian-Carnian of Iran and the Alps. Argolis Peninsula is the third locality, where this genus was found. The stratigraphic range of the genus should be extended from Ladinian to Norian (perhaps to Rhaetian?).

Keywords: Dasycladales, Probolocuspis, Diplopora, Norian, Rhaetian reef, Argolis, Greece.

INTRODUCTION

Norian-Rhaetian reef structures, so called „Dachsteinkalk-Reefs“ in the Alps, are known from several localities in tethyan realm (Alps, Sicily, Turkey, Iran, Pamir Mountains) and outside of the Tethys (USA, Canada). Such “Dachsteinkalk-Reefs” also occur in Mavrovouni Mountains (Argolis Peninsula, Greece). Available information about the occurrence of Norian-Rhaetian reefs within the so called „Pantokrator-limestones“ in Greece are limited to few publications of e. g. Renz (1908), Bachmann & Risch (1979) and Flügel (1983). Detailed investigations about the facies and palaeontological content of these reefs are not carried out. An example for Norian-Rhaetian reef carbonates within the „Pantokrator-limestones“ are the reef structures and shallow-water carbonates in the Mavrovouni Mountains. These structures reach a size of about two Kilometers and are exposed near the town of Sarmeika, southeast of the town of Adami (Argolis Peninsula, compare Fig. 1). Matarangas et al. (1995) were the first authors, who reported the occurrence of a relatively large reef near Sarmeika. The age of organisms in this reef, especially of the corals was dated into Carnian by these authors. Senowbari-Daryan et al. (1996) and Senowbari-Daryan et al. (2002) described some typically Norian-Rhaetian reef organisms from the same reef complex near Sarmeika. Further investigations on reef communities confirmed the Norian-Rhaetian age of these reef limestones. Hypercalcified sponges, including chambered sphenozoans, non-chambered inozoans, disjectoporids and chaetetids are the most abundant reef builders, followed by scleractinian corals and other reef organisms. The Upper Triassic to Lower Jurassic shallow-water carbonates of “Pantokrator-limestones” (Partsch, 1887; Renz, 1955; Flügel, 1983) are widely distributed in the Adriatic-Ionic region and in the Argolis Peninsula, northeastern Peloponnes in Greece (Fig. 1). The main facies of the „Pantokrator- limestones“ is represented by bedded limestones and dolomites indicating their depositional environment in lagoon and in tidal flats with algal mats, known as “Loferitic facies”. This facies type is known from several localities in northern and southern parts of the Tethys (Alps: e. g. Fischer 1964; Enos & Samankassou 1998; Satterley 1996; Haas 1982; Sicily:...
Catalano et al. 1974), and own observations from Oman. Upper Triassic “Loferitic facies” from the Argolis Peninsula were described by Vartis-Matarangas & Matarangas (1991), Pomoni-Papaioannou (2008), and Photiades et al. (2010).

**Depository:** The holo- and paratypes of described algae are deposited in the Geozentrum Nordbayern, FG Palaeoumwelt (Material: Senowbari-Daryan, Trias, Argolis).

**SYSTEMATIC PALAEONTOLOGY**

Devision Chlorophycophyta Papenfuss, 1955  
Class Chlorophyceae Kützing, 1843  
Order Dasycladales Pascher, 1931  
Family Triploporellaceae (Pia, 1920)  
Genus Probolocupsis Brönnimann, Zaninetti, Moshtaghian & Huber, 1974  
Type species: Probolocupsis espahkensis Brönnimann, Zaninetti, Moshtaghian & Huber, 1974  
Further species: P. aculeata Nittel, 2006; P. sarmeikensis nov. sp.

Remarks: Brönnimann et al. (1974) described individual and disintegrated laterals of the thallus as “tooth-like”, “bifide” or “trifide” elements, if two or three laterals are still preserved together. The elements were compared with conodonts, but because of the calcareous skeleton they were interpreted as “tooth-like microfossil” (“incertae sedis”) by these authors. Senowbari-Daryan & Majidifard (2003) revealed the nature of these elements documenting them as disintegrated parts of the dasycladean thallus of Probolocupsis. They gave following diagnosis to the thallus of Probolocupsis: “Cylindrical thallus with trichophorous laterals of first order only, with euspondyl(?) arrangement” (Senowbari-Daryan & Majidifard 2003: p. 108).

In the meantime a second species of the genus with a clearly euspondyl arrangement of the laterals is described as Probolocupsis aculeata by Nittel (2006) from the Ladinian Wetterstein limestones of the Northern Calcareous Alps, Austria.

**Probolocupsis sarmeikensis** nov. sp.  
( Fig. 2; Fig. 4a-n)

Derivatio nominis: Named from the town Sarmeika near the locality.

Holotype: Fig. 4l (magnification in Fig. 2).

Paratypes: Fig. 4a-k, m-n.

Locus typicus: Norian-Rhaetian reef carbonates, north of the town of Sarmeika in the Mavrovouni Mountains (Fig. 1).

Stratum typicum: Norian-Rhaetian reef carbonates.

Diagnosis: Cylindrical thallus with a narrow axial cavity. Trichophorous laterals of the first order are usually amalgamated at the base appearing as a thick wall around the axial cavity. Euspondyl arrangement of the laterals.

**Fig. 2 Probolocupsis sarmeikensis** nov. sp. (Holotype). The magnification from Fig. 4l shows the spine-like extended individual laterals (some of the internal pores: see arrows). Laterals are perpendicular to the thallus axis.
Dasycladales algae from the Norian-Rhaetian reef carbonates of Argolis Peninsula, Greece

Differential diagnosis: See comparison after the description of the species.

Material: Numerous specimens in several thin sections.

Description: Almost all specimens of this cylindrical alga are cut in cross sections. Two specimens illustrated in Fig. 4c and the holotype Fig. 4l (H) exhibit the most characteristics of the alga in longitudinal section. The thallus of the holotype reaches a length of almost 10 mm with a diameter of 2.2 mm. The axial cavity of the holotype has a diameter of about 0.4 mm. Both longitudinal sections show that the laterals are arranged perpendicular to the axial cavity. The alga is characterized by a narrow axial cavity of 0.25-0.5 mm and a thick thallus wall. Ratio of axial cavity/thallus diameter varies between 11 % and 25% (see Tab. 1). Individual laterals appear spine-like on the thallus outside.

Marginal sections of the laterals may appear as points or small white circles (Fig. 4e, g, k). Because of the recrystallization of the majority of specimens the base of laterals is not well recognizable. The well preserved specimen illustrated in Fig. 4j exhibits that the laterals are arisen as single from the axial cavity, but others show two or three laterals arisen from the common base (Fig. 4h). Each spine-like lateral contains a very narrow tube (Fig. 2; Fig. 4m: arrows). Length of laterals is usually 1 mm, their diameter about 0.08-0.15 mm, their number in each is 22-40. In the holotype as well as in the majority of specimens the recrystallization amalgamated the base of laterals, appearing as a thick wall around the axial cavity. Some biometrical data of *Probolocupsis sarmeikensis* nov. sp. are listed in Table 1.

### Table 1

<table>
<thead>
<tr>
<th>Specimen</th>
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<th>d</th>
<th>d/D</th>
<th>Thin section</th>
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<tr>
<td>Pl. 1, Fig. 3</td>
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<td>0.4</td>
<td>20%</td>
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<td>G05C</td>
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<td>G05C</td>
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<td>0.4</td>
<td>18%</td>
<td>G05b</td>
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<td>Pl. 1, Fig. 12</td>
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<td>0.4</td>
<td>17%</td>
<td>G05b</td>
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<td>Pl. 1, Fig. 5</td>
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<td>0.32</td>
<td>12%</td>
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<td>0.34</td>
<td>11%</td>
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<tr>
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<td>0.45</td>
<td>19%</td>
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<td>0.5</td>
<td>25%</td>
<td>G05b</td>
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<tr>
<td>Pl. 2, Fig. 4</td>
<td>1.0</td>
<td>0.25</td>
<td>25%</td>
<td>G12</td>
</tr>
</tbody>
</table>

Comparison: The distinctly narrow axial cavity of *Probolocupsis sarmeikensis* nov. sp. differs (without regard to the stratigraphic age) this species from the type species – *Probolocupsis esphahkensis* Brönnimann et al. – and from *P. aculeata* Nittel clearly. Differences of the
skeletal elements are additional criteria for distinguishing this species from the known species. Schlagintweit et al. (2013) illustrated in Fig. 3a some dasycladalean specimens (maybe recrystallized) from the “Lower Gosau Subgroup of Austria” as Milanovicella hammudai (Radoičić 1975), which are very similar to recrystallized specimens of P. sarmeikensis nov. sp. According to the diagnosis of Milanovicella, given by Granier & Berthou (1994) and compared with illustrations of the type material of Radoičić (1975), described as Likanella hammudai and revised by Schlagintweit (1990) the species of Sarmeika can not be attributed to this genus. There are some morphological similarities between the species Neogyroporella? gaviliki described from the Upper Jurassic-Lower Cretaceous of the Northern Calcareous Alps by Schlagintweit (2005, compare also Schlagintweit 2011) and P. sarmeikensis. The general appearance of P. sarmeikensis is similar to Teutoporella echinata, described by Ott (1975) from the Ladinian of the Lombardian Alps, northern Italy. The individual laterals in P. sarmeikensis are arranged perpendicular to the axial cavity, but they are orientated oblique in T. echinata. Laterals are rised as single from the axial cavity (later they can be branched: Fig. 4d, h) in P. sarmeikensis, but they may be doubled? in T. echinata. In addition the shape of laterals in P. sarmeikensis is always spine-like and their cross sections are always circular or oval, but the shapes of laterals (see Ott 1975: fig. 3) and their cross sections in T. echinata are different. Advanced interpretations of these features deserve a comparing study of the material from Alps and Argolis.

Probolascus? tenuiparia nov. sp.

(Fig. 5e-1)

Derivatio nominis: Tenuis (Latin) = thin, and paries (Latin) = wall. Named from the thin thallus wall of the species. Holotype: Fig. 5h.

Locus typicus: Norian-Rhaetian reef carbonates north of the nearby town Sarmeika (Fig. 1).

Stratum typicum: Norian-Rhaetian reef carbonates.

Diagnosis: Cylindrical thallus with thin wall and wide axial cavity. Laterals, corresponding to the thin thallus wall, are short. Individual laterals are visible only as small spines on the outer surface of the thallus.

Material: Numerous species in several thin sections.

Description: Similar to the preceding described species most specimens of this alga are cut in cross sections. The thallus walls of all specimens are recrystallized, the nature of laterals is visible only as small spines on the outer surface of the thallus. The arrangement of the laterals is not clear and therefore the attribution to the genus Probolascus is uncertain.

The specimen designated as holotype (Fig. 5h) is an oblique to longitudinal section exhibiting clearly the tip of the needle- or spine-like individual laterals on one side. Some specimens (Fig. 5e-f, j-k), cut in cross sections clearly show this character of the thallus. For the biometrical data and dimensions of the thallus see Table 2.

<table>
<thead>
<tr>
<th>Specimen</th>
<th>D</th>
<th>D/D</th>
<th>Thin section</th>
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<tr>
<td>Pl. 2. Fig. 7</td>
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<td>25 % G08a</td>
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<td>0.075</td>
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<td>30 % G08a</td>
</tr>
<tr>
<td>Pl. 2. Fig. 9</td>
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<td>0.10</td>
<td>13 % G08a</td>
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<td>Pl. 2. Fig. 8</td>
<td>0.3</td>
<td>0.05</td>
<td>17 % G08a</td>
</tr>
<tr>
<td>Pl. 2. Fig. 5</td>
<td>0.4</td>
<td>0.05</td>
<td>13 % G08b</td>
</tr>
<tr>
<td>Pl. 2. Fig. 5</td>
<td>0.5</td>
<td>0.07</td>
<td>14 % G08b</td>
</tr>
<tr>
<td>Pl. 2. Fig. 5</td>
<td>0.45</td>
<td>0.07</td>
<td>16 % G08b</td>
</tr>
<tr>
<td>Pl. 1. Fig. 5</td>
<td>0.36</td>
<td>0.08</td>
<td>22 % G08b</td>
</tr>
</tbody>
</table>

Family Diploporellaceae (Pia, 1920), Deloffre 1988

Genus Diplopora Schafhautl, 1863

Type species: Diplopora annulata (Schafhautl, 1853) 1863

Diplopora obliquuspora nov. sp.

(Fig. 3; Fig. 5a-d)

1979 Clypeina sp.- Flügel, pl. 2, fig. 9.
1980 Clypeina sp.- Senowbari-Daryan, p. 67, pl. 14, fig. 5-6.

Derivatio nominis: Obliquus (Latin) = oblique, porus (Latin) = pore. Named for the oblique running laterals.

Holotype: Specimen illustrated in Fig. 5c (magnification in Fig. 3, thin section G75).

Locus typicus: Norian-Rhaetian reef carbonates near the town Sarmeika (Fig. 1).

Stratum typicum: Norian-Rhaetian reef carbonates.

Diagnosis: Cylindrical thallus with a relatively wide axial cavity. Tufts of trichophorous laterals are originated from the common base. Oblique orientation of the laterals. A thin wall at the base of the thallus wall surrounds the axial cavity. Metaspondyl arrangement of the laterals.

Material: Four specimens.

Description: The thallus of this cylindrical and tiny alga is composed of a relatively thick thallus wall. The length of the holotype (Fig. 3) is about 8 mm with thallus diameter (D) of 1.4 mm. Diameter of axial cavity (d) is 0.6 mm (about 43%). Characteristic of the alga is the metaspondyl arrangement of the laterals as indicated by the relict appearance of the tufts through the thallus wall (Fig. 3: large arrows). Each tuft is composed of about five laterals (in longitudinal section three are recognizable, Fig. 3: small arrows).

Laterals are oriented oblique to the axial cavity with about 30-75° off-axis angle).

Around the axial cavity a thin wall of only 0.06 mm thickness is pierced by the base of laterals. Diameter of individual laterals is about 0.05 mm. Individual laterals are extended spine-like over the thallus surface appearing as circles in cross section (see at the base of the thallus).

Discussion: The attribution of this species to the genus Diplopora is based on the metaspondyle arrangement of
Dasycladales algae from the Norian-Rhaetian reef carbonates of Argolis Peninsula, Greece

Fig. 4 a to n Probolocupsis sarmeikensis nov. sp. from the reef carbonates near the town of Sarmeika, Peloponnes, Greece. a Cross section exhibiting the narrow axial cavity and the thick thallus wall. Laterals appear as white points in section through them. G058, x10. b Cross section through two poorly preserved specimens. G058, x8. c Oblique longitudinal section through an incomplete? specimen exhibits the laterals, which are oriented perpendicular to the axial cavity. G05C, x16. d Cross section of a specimen exhibiting the partly recrystallized laterals of the thallus. G05A, x16. e Cross section through an apparently poorly preserved specimen. Laterals appear as white points in section through them. G058, x16. f Cross section through an incomplete specimen. G050, x8. g Sections through a complete and an incomplete specimen. Laterals appear as white points around the incomplete specimen. G05B, x16. h Cross sections through two specimens. G05C, x12. i Cross section through a relatively well preserved specimen. G05C, x16. j Oblique section similar to Fig. i. G05C, x10. k Cross section exhibiting the pores (arrows) in the laterals. G05B, x16. l Longitudinal section through the holotype (for magnification see Fig. 2) and cross sections through two paratypes. G05C, x6. m Cross section through a recrystallized specimen. Arrows indicate the pores within the laterals. G05B, x16. n Cross section through a strongly recrystallized specimen causing the disappearance of the axial cavity. G025, x16.
Fig. 5  *Diplopora obliguspora* nov. sp. (a to d) and *Probolocuspis tenuiparia* nov. sp. (e to l) from the Norian-Rhaetian reef carbonates of Sarmeika, Peloponnes, Greece. a Specimen exhibits the thin wall around the axial cavity and the spine-like extended laterals. Thin section G1, x32. b Similar section as Fig. a showing the common base of oblique orientation of individual laterals. Thin section G89, x12. c (Holotype). Longitudinal section exhibiting the metaspondyle arrangement of the laterals, tuft of laterals and the thin wall around the axial cavity (for more information see Fig. 3). Thin section G75, x8. d Two cross sections exhibiting the spine-like extended individual laterals. G12, x20. e Cross sections through several specimens with thin thallus wall. Thin section G012, x20. f Sections through three specimens with relatively thick thallus wall but the individual laterals are recognizable. Thin section G08a, x25. g Oblique to longitudinal section. Thin section G08a, x20. h Holotype. The oblique section shows the individual laterals at the base. Thin section G08a, x20. i Sections through four specimens showing the laterals in part. Thin section G08a, x20. j Sections similar to Fig. i. Thin section G08a, x20. k Cross sections clearly showing the spine-like extended laterals. Thin section G08a, x40. l Similar to k. Thin section G40/1, x12.
Dasycladales algae from the Norian-Rhaetian reef carbonates of Argolis Peninsula, Greece

the laterals and the tufts arising from the common base. Cysts within the axial cavity were not found in the Sarimeika species. Such spine-like extended individual laterals of the new species – like in Probolocopsis sarmiensis described above – are not known from the other species of the genus Diplopora.

Diplopora obliquispora – similar sections were described from the Norian-Rhaetian reef carbonates of the Northern Calcareous Alps as Cleyena sp. by Flügel (1979) and Senowbari-Daryan (1980). Both specimens from the Alps, including their dimensions of the thallus are similar to the Sarimeika species illustrated in Fig. 5a. The classification of these specimens as Diplopora obliquispor is uncertain. Diplopora obliquispora differs from the known species of the genus by the inclination of the laterals, very thin laterals and the outer surface of the thallus. Dimensions are given in table 3.

Table 3. Some biometrical data of the thallus of Diplopora obliquispora nov. sp. (H= holotype). All measurements are in mm. For abbreviations see Table 1.

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<th>d/D</th>
<th>Thin section</th>
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