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Morphological variation of *Stromatella monostromatica**

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ABSTRACT: Thirty two isolates of *Stromatella monostromatica* (Dangeard) Kornmann were studied in unialgal culture; extensive morphological variation was documented. The shape of bicellular germlings and development of young plants were similar for all isolates which had globular sporangia. These features are, therefore, the most important diagnostic characteristics of the species. The widespread distribution of *S. monostromatica* suggests that this is a cosmopolitan species.

INTRODUCTION

Stromatella monostromatica was described by Dangeard (1965) as a species of *Ulvella*, characterized particularly by its monostromatic thallus. The species was later studied by Kornmann & Sahling (1983) who concluded that the development of young plants, together with the organization of older thalli, justified a separation from *Ulvella* into a new genus, *Stromatella*, with *S. monostromatica* as the type species. Another species of *Ulvella* was simultaneously transferred to *Stromatella* as *S. papillosa* (Dangeard) Kornmann & Sahling. Kornmann & Sahling (1983) mentioned that the characteristic monostromatic morphology of *S. monostromatica* developed only when the plants grew in close contact with a firm substratum, and showed a „loose" plant with a different morphology (Kornmann & Sahling, 1983, Fig. 4 D). The present paper documents a much wider morphological variation, based on culture studies of 32 unialgal isolates.

MATERIALS AND METHODS

Unialgal isolates of *Stromatella monostromatica* were established from crude cultures initiated from scrapings off stones or shells or from fragments of host plants with the alga epiphytic. The collecting localities and dates are given in Table 1.

The isolates were maintained in test tubes or sterile plastic Petri dishes with MV 30 as culture medium (Christensen, 1982); initially 5 mg l^{-1} of GeO_2 was added to supress the growth of diatoms. Fragments of coverslips were sometimes added to the test tubes as a firm substratum for attachment of plants and easily inspected in preparations for the

* Dedicated to Dr. Dr. h. c. P. Kornmann on the occasion of his eightieth birthday.

Table 1. Isolates of *Stromatella monostromatica* with their origin, date and substratum

Isolate	Origin	Date	Substrate/Host
Group A			
011085-5-3	Tjärnö, Sweden	01-10-85	stone, littoral
011085-7-2-2	Tjärnö, Sweden	01-10-85	calcareous shell, littoral
021085-1-2	Tjärnö, Sweden	02-10-85	*Zostera marina* L., drift
050785-3	Frederikshavn, northern Kattegat, Denmark	05-07-85	calcareous shell, 8 m
050785-7-1	Frederikshavn, northern Kattegat, Denmark	05-07-85	calcareous shell, 8 m
220879	Sangstrup Klint, Kattegat middle part, Denmark	22-08-79	*Littorina mariae* L.
302379	Norden Huse, Fyn, Great Belt, Denmark	30-11-79	stone, littoral
155178	Stevns Klint, Baltic around Møn, Denmark	15-11-78	stone, littoral
266578	Vodice, Adriatic Sea, Yugoslavia	26-05-78	calcareous shell, littoral
155480	Leigh Marine Station New Zealand	15-04-80	calcareous shell
281083-12-2	Puerto Aldea, Chile	28-10-83	calcareous shell, littoral
141183-1-2	Antofagasta, Chile	14-11-83	*Colpomenia tuberculata* Saunders
141183-2-2	Antofagasta, Chile	14-11-83	calcareous shell, littoral
141183-2-5	Antofagasta, Chile	14-11-83	calcareous shell, littoral
141183-4-2	Antofagasta, Chile	14-11-83	stone, littoral
191083-4	Bahia Herradura de Guayacan, Coquimbo, Chile	19-10-83	*Lessonia* sp.
191083-11-1	Bahia Herradura de Guayacan, Coquimbo, Chile	19-10-83	calcareous shell, 8–9 m
161183-1-3	Bahia Herradura de Guayacan Coquimbo, Chile	16-11-83	stone, littoral
171183-10-2	Fray Jorge, Parque de Nacional, Chile	17-11-83	stone, littoral

Table 1 (continued)

Isolate	Origin	Date	Substrate/Host
Group B			
171186-3-2	Friday Harbour Laboratory, San Juan Island, Washington, USA	17-11-86	calcareous shell, littoral
181083-7-3	Bahia Herradura de Guayacan, Coquimbo, Chile	18-10-83	calcareous shell, rockpool
031183-1-2	Maullin, Chile	03-11-83	stone, littoral
Group C			
280186-1-2	Arrieta, Lanzarote	28-01-86	calcareous shell, littoral
280186-8-4	Arrieta, Lanzarote	28-01-86	calcareous shell, littoral
310186-2-2	Arrieta, Lanzarote	31-01-86	*Laurencia* sp.
310186-5-5-1	Arrieta, Lanzarote	31-01-86	*Anadyomene stellata* (Wulfen) C.Ag.
310186-10-1	Arrieta, Lanzarote	31-01-86	calcareous shell
310186-10-7	Arrieta, Lanzarote	31-01-86	calcareous stone
010286-5-2	Harbour, Puerto del Carmen, Lanzarote	01-02-86	*Sargassum* sp.
010286-7-1-1	Castillo de los Colorados, Lanzarote	01-02-86	calcareous shell
130387-1-3	Phuket, Thailand	13-03-87	calcareous shell, littoral
130387-1-4	Phuket, Thailand	13-03-87	calcareous shell, littoral

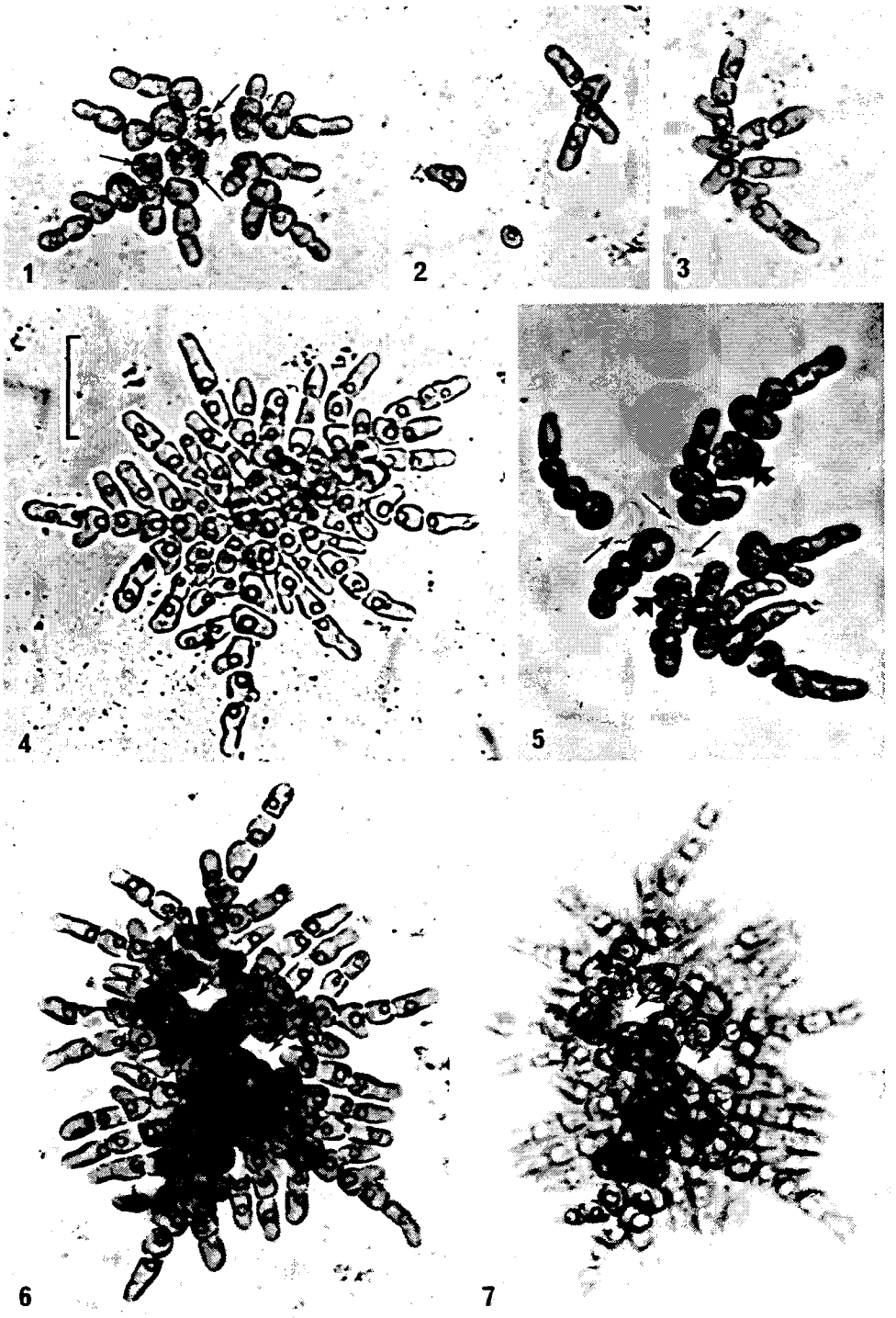
microscope; observation of plants growing in plastic Petri dishes was carried out using a × 25 seawater-immersion objective. The cultures were maintained at 15 °C with an irradiance of about 16 $\mu M\ m^{-2}\ s^{-1}$ on a 16 : 8 h light: dark cycle; group C isolates (Table 1) were also grown at 20 °C and an irradiance of about 25 $\mu M\ m^{-2}\ s^{-1}$ on a 12 : 12 h light:dark cycle.

RESULTS

The culture studies confirmed the life history as documented by Dangeard (1965) and Kornmann & Sahling (1983). All of the isolates propagated by zoospores produced in globular sporangia (Fig. 1), with a diameter of 8–12 µm, and usually containing 8 zoospores per sporangium at maturity; sometimes only 4 zoospores were present and in a few cases sporangia may have contained 12 or 16 zoospores. Release took place through a round hole in the sporangium wall. The zoospores were pyriform, slightly elongated, measuring 2.5–3.5 × 6–7 µm. They had four flagella at the anterior papilla and a posterior chloroplast with a red eyespot. The settled zoospores germinated by enlargement. After the first cell division, the germlings often had one rounded, nearly globular cell with a diameter slightly larger than the other cell which was cylindrical and 1.5– 2 times longer than broad. During subsequent development, both cells continued growth and the young plants often were bilaterally symmetrical (Figs 2–3). The vegetative cell contained a single bilenticular pyrenoid, in the parietal lobed chloroplast, which sometimes tilted toward the upper end of the rounded cell, appearing like a cap.

In the isolates referred to group A (Table 1), attached plants were morphologically similar to the plants described by Dangeard (1965) and those dealt with by Kornmann & Sahling (1983). Unattached plants, similar to the one depicted by Kornmann & Sahling (1983), were also observed. Most of the attached plants were more or less circular in outline, pseudoparenchymatous in the central part and had mutually free filaments at the margin; alternate and opposite branching was noted (Fig. 4). In some cases, openly branched plants (Fig. 5), becoming mature without pseudoparenchymatous development, were simultanously observed. The apical cells measured 5–6.5 µm in diameter and were of the same length or up to twice as long as broad. Only in rapidly growing plants did longer cells occur, being up to four times longer than broad. Sporangia were formed by a gradual transformation of vegetative cells; the simultaneous enlargement of the cells sometimes pushed them upward resulting in the central portion of the plants becoming lumpy (Figs 6–7). An apparently different morphology developed when zoospores settled in branch angles of older plants leading to the formation of clusters that appeared as individuals without mutually free filaments at the margin. The loose plants (Figs 8–12) had rounded cells; the branching was relatively dense in some of them so that they developed an irregularly lumpy shape (Figs 9–10), while other plants were openly branched (Fig. 11). Usually, loose plants became fertile in a few-celled condition. A delay

Figs 1–7. *Stromatella monostromatica* in culture. Fig. 1. Fertile plant with three sporangia (arrows). Figs 2–3. Germlings and attached young plants. Fig. 4. Vegetative pseudoparenchymatous plant. Fig. 5. Fertile plant without pseudoparenchymatous development; empty (thin arrows) and mature sporangia (broad arrows). Figs 6–7. Pseudoparenchymatous fertile plant, lumpy in the central area with empty (thin arrows) and mature sporangium (broad arrow). Fig. 1: Isolate 310186-10-1. Figs 2–4, 6–7: Isolate 266578. Fig. 5: Isolate 220879. Figs 1–7 same magnification: scale bar = 25 µm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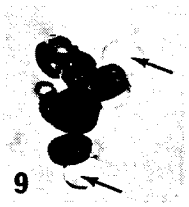
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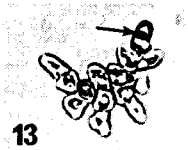
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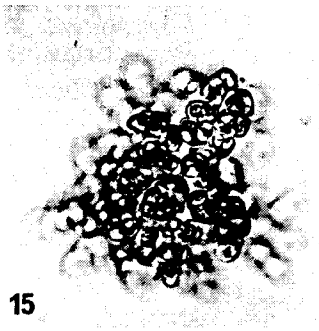
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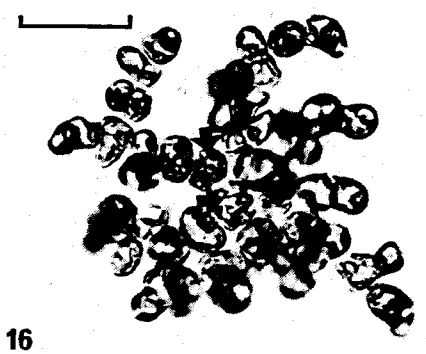
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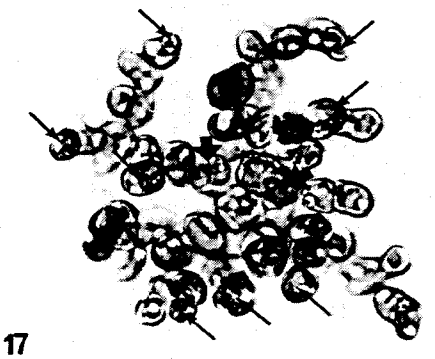
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in the production of sporangia occurred occasionally resulting in lumpy plants developing into relatively large irregular clumps and the openly branched plants forming large bushes of freely branched filaments (Fig. 12).

The tendency to form bushes was pronounced in isolates placed in groups B and C (Table 1). The plants of group B formed a pseudoparenchymatous basal layer, documented by the young plant in Figure 13 with only a single ascending branch. The plants of group C usually had a prostrate system of openly branched filaments consisting of nearly globular cells from which erect branches appeared at several points (Figs 16–17). Change of culture conditions from 15 °C to 20 °C made no difference to the morphology of group C plants. The morphology varied considerably in all isolates. Within each of the groups, A, B and C, plants referable to another group were occasionally noted.

DISCUSSION

The similarity of morphology sometimes observed in plants from different groups (Table 1) indicates that this grouping expresses morphological variation within a single species rather than the existence of three different species. The monostromatic thallus is less important in delimiting species of *Stromatella* than is indicated from the literature. The shape of bicellular germlings and the development of young plants together with the globular sporangia are features of all plants examined by Dangeard (1965) and Kornmann & Sahling (1983) and in my own investigation. These features, therefore, characterize the genus and the species better than the gross morphology. The sporangia of *S. papillosa*, according to Dangeard (1965), are formed from central cells that "tendent à se dresser vers l'extérieur, à devenir saillantes et finalement à se développer en papilles marquées"; this shape is so different from the globular sporangia of *S. monostromatica* that the two species may not be congeneric. Further studies of *S. papillosa* are needed to determine its generic status.

Stromatella monostromatica has hitherto been reported from the Atlantic Ocean (Kornmann & Sahling, 1983), the Baltic (Nielsen, 1988), and the Mediterranean Sea (Dangeard, 1965). The occurrence of *S. monostromatica* on the northern and southern hemispheres and in temperate and tropical waters suggest that this species is cosmopolitan in its distribution.

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Figs. 8–17. *Stromatella monostromatica* in culture. Figs 8–12. Loose plants. Fig. 8. Germlings and young plants. Figs 9–10. Few-celled lumpy plants with empty (thin arrows) and mature sporangium (broad arrow). Figs 11–12. Vegetative, openly branched plants; large bush-like in Figure 12. Fig. 13. A young plant, group B, with one erect branch (arrow). Figs 14–15. Different focus of a large bush-forming vegetative plant, group B. Figs 16–17. Different focus level of a fertile plant, group C; nearly mature sporangia (broad arrows), and erect branches at several points (thin arrows). Figs 8–11: Isolate 050785-3. Fig. 12: Isolate 191083-11-1. Figs 13–15: Isolate 171186-3-2. Figs 16–17: Isolate 280183-8-4. Figs 8–15 same magnification. Figs 16–17 same magnification. Scale bars = 25 μm

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