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THE LIFE HISTORY OF COILODESME BULLIGERA STRÖMF. (PHAEOPHYTA, DICTYOSIPHONALES)*

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Coilodesme bulligera from the Bay of Fundy was studied in culture. Swarmers from unilocular sporangia give rise to two types of thalli, microthalli with plurilocular sporangia and macrothalli with embedded, unilocular sporangia. The development of these 2 types of thalli was related to photoperiod at a temperature of around 5°C.

Introduction

Although the morphology and anatomy of *Coilodesme* has been studied in detail by Kuckuck (1929), the taxanomic position of this genus and the validity of the family Coilodesmaceae are still in dispute (Wynne 1969; 1972). In the North Atlantic, there is a single species C. *bulligera* which is considered a cold-water species, being recorded from Greenland (Rosenvinge 1893; 1898), Alaska (Wynne 1972), Labrador (Wilce 1959), and the west coast of Iceland (Kuckuck 1929). Along the northeastern coast of North America, Nova Scotia is probably the southern limit of distribution of this species (Edelstein & McLachlan 1967). In the Bay of Fundy (Digby Neck), isolated plants occur during spring and early summer in the intertidal zone epiphytic on *Ralfsia fungiformis* (Wilson et al. 1979), disappearing by midsummer. Only embedded unilocular sporangia have been found in the elongate, saccate macrothalli which erode after spore release (Kuckuck 1929).

Some species of Dictyosiphonales in culture have been shown to have a heteromorphic life history, plurilocular sporangia being formed on ephemeral microthalli (Wynne & Loiseaux 1976). In a recent study Wynne (1972) reported on the life history of 3 species of *Coilodesme* from the Pacific coast of North America; C. *bulligera* from Amchitka Island, Alaska had a 'direct' type of life history. In the present instance we are reporting on the development in culture of this species from the Bay of Fundy.

Material and Methods

Culture conditions, techniques (Chen et al. 1969), and medium (McLachlan 1973) were as previously described. Mature plants (Fig 1) were collected at Gulliver Cove and Tommy Beach, Digby Co., N.S. respectively in April 1968 and 1975. Unialgal cultures were established by procedures similar to those reported elsewhere (Edelstein et al. 1970). Incubation conditions were 5°C at 2 light periods, 16:$\overline{8}$ h and 8:$\overline{16}$ h (L:D); irradiance was 20 μE m^{-2} s^{-1} provided by 40-W, cool-white fluorescent lamps. During the initial stages when the cultures were being established, GeO_2 was added (5 mg l^{-1}) to the medium which was changed weekly.

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Results

Development of the Macrothalli

Swarmers from unilocular sporangia (Fig 2), embedded in saccate thalli, developed into filamentous germlings (Fig 3) 2 to 3 days after release. About 2 weeks later, those germlings assumed various morphologies, probably representing different developmental stages. Two noticeable types of development were distinguished: one was branched filaments (Fig 4); the second type was loosely attached discs (Fig 5) with short cells. Within 2 months the majority of the filamentous thalli had formed small, globular to irregular parenchymatous bodies (Fig 6). Microscopic examination revealed the manner of differentiation of these bodies. Cells of the primary filament cut off lateral clusters of colorless, large, reniform cells (Fig 7) which subsequently formed the medulla of the macrothallus. Rapid cell-division and growth of the primary filaments gave rise to the pigmented cortical cells (Fig 8) resulting in spherical to irregularly shaped bodies with long, branched filamentous extensions. Similar differentiation occurred in the discoid germlings. Large reniform cells formed from the lower portion of the disc, lifting it up from the substratum. Rapid growth of the surface cells (i.e. cortical cells) resulted in a cup-shaped structure which finally became spherical, this being generally devoid of long, filamentous projections. After more than 2 months, when the spherical bodies reached a size of about 1 mm in diameter, erect fronds started to proliferate from it, forming clusters of saccate macrothalli of different lengths and shapes. Only a few of these macrothalli continued growth, and after 6 months hollow, clavate fronds characteristic of *Coilodesme* (Fig 9) were obtained in cultures under a long (16:8 h) light period at 5°C. Often fronds of the macrothalli aborted, the cortical layer failing to differentiate or else developing in patches over the medullary cells. In both cases, however, normal embedded unilocular sporangia (Fig 10) were formed, and after a further 2 months swarmers were released.

Under a short light period (8:16 h), development of erect macrothalli was poor or failed to occur, and the basal, spherical bodies became dark and necrotic. The structure of these spherical dark bodies was identical to that of the macrothallus, and they too developed normal unilocular sporangia, releasing swarmers and germinating in the same manner as ones from field-collected plants. Although we have not quantified the number of erect macrothalli under different photoregimes, our observations indicate that cultures kept under a long light period (16:8 h) developed many more erect macrothalli than those maintained at 8:16 h. In general agitation of the medium stimulated growth of macrothalli which usually attained a length of up to 2 cm when growth ceased and unilocular sporangia developed.

Development of the Microthalli

Under both long and short light periods, some filamentous germlings did not differentiate into spherical bodies. Instead, these filamentous clusters became darker and assumed a fuzzy appearance caused by densely-packed uniseriate, plurilocular sporangia (Fig 11). Unlike the spherical bodies of macrothalli, these clusters were composed of numerous branched filaments; we refer to these as microthalli (Christensen 1962). It, therefore, became important to study separately the progenies of both unilocular and plurilocular sporangia. Cultures were established using as inoculum complete microthalli clusters with plurilocular sporangia, and fragments of microthalli with unilocular sporangia. After 2 to 3 months of incubation, it became clear that progenies of spores from the 2 types of sporangia developed similarly, each giving rise to a mixture of new macro- and microthalli. In addition

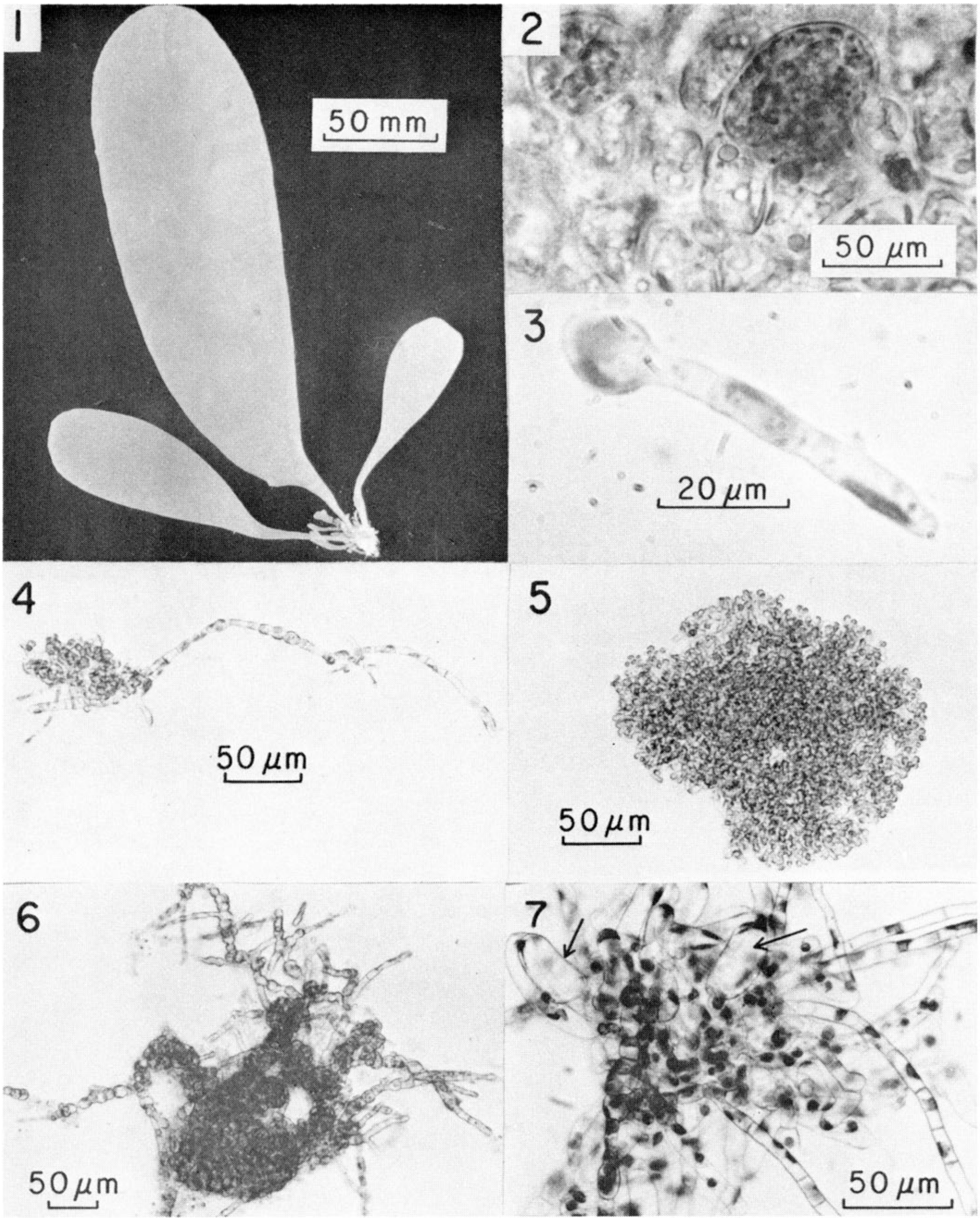
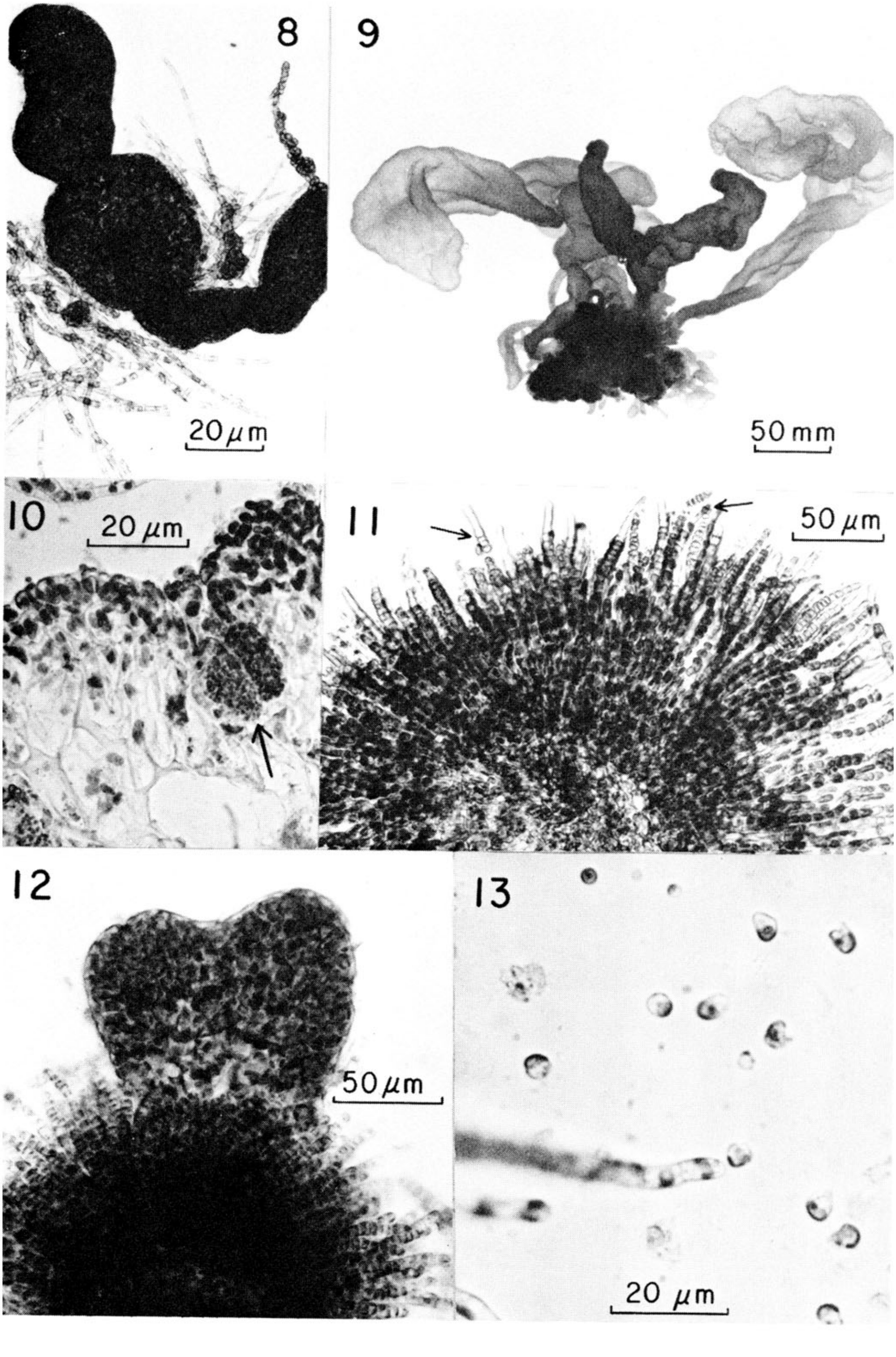


Fig. 1. Field-collected mature plant
Fig 2. Portion of macrothallus with unilocular sporangia
Fig 3. 2 to 3-day germling from unilocular sporangium
Fig 4. Filamentous germling
Fig 5. Discoid germling
Fig 6. 2-month germling with irregular parenchymatous bodies
Fig 7. Initiation of medullary cells (arrows) from filamentous cells


8
20 µm
9
50 mm
10
20 µm
11
50 µm
12
50 µm
13
20 µm

microthalli with plurilocular sporangia also issued erect macrothalli (Fig 12). Unlike microthalli of many phaeophyceaen species (Wanders et al. 1972), the microthalli of *Coilodesme* did not produce successive generations without recycling the macrothallus. No fusion was noted between swarmers of either uni- or plurilocular sporangia despite repeated observations. However, resting swarmers of plurilocular sporangia (Fig 13) often increased greatly in size and acquired a thick wall, indicating possible zygote formation.

Discussion

In our culture the life history of *C. bulligera,* unlike that of *C. californica,* involved both macro- and microthalli phases. This contrasts with *C. bulligera* from the northeastern Pacific in which macrothalli directly produced macrothalli (Wynne 1972). A similar ambiguity in the life histories of a species of brown algae is well documented elsewhere (Clayton 1979). Possibly different populations of a species may exhibit distinct life histories under genetic control rather than being controlled by abiotic factors (Nygren 1975).

Alternatively it can be suggested that apomeiosis occurs in unilocular sporangia based on observations 1) that unilocular and plurilocular sporangia were produced on both macro- and microthalli; 2) that macrothalli can originate directly from microthalli; and 3) that there was no fusion observed between swarmers. However, it is then difficult to account for 2 morphologically distinctive phases, each with a specific reproductive structure. Cytological observations would be useful in attempting to resolve this problem. Nevertheless, amongst species of brown algae, such as *Ralfsia* (Edelstein et al. 1970) and *Isthmoplea* (Edelstein et al. 1971), plurilocular and unilocular sporangia are formed only on microthalli and erect macrothalli respectively. Possibly, formation of plurilocular and unilocular sporangia in different morphological stages of the same species may be determined by temperature and/or photoperiod (Clayton 1979) reflecting similar changes in nature.

The macrothallus of *C. bulligera* from the Bay of Fundy is a spring annual, and in culture it was formed at low temperature and a long light period parallelling conditions in the field. A short light period, also at a low temperature, appeared to favor development of the microthallus; thus we should expect to find this morphological phase in the field during winter.

Acknowledgement

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Fig 8. Mass of pigmented cortical cells with filamentous extensions of the thallus
Fig 9. Mature saccate macrothallus from culture
Fig 10. Portion of saccate macrothallus with embedded unilocular sporangia (arrow)
Fig 11. Densely filamentous microthalli with plurilocular sporangia (arrows)
Fig 12. Erect macrothallus formed from microthalloid cluster
Fig 13. Resting swarmers from plurilocular sporangia

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