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NOTES ON MARINE, BENTHIC ALGAE FROM MADEIRA IN NATURE AND IN CULTURE

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With 14 figures

ABSTRACT. Four species of marine, benthic algae are reported for the first time from the island of Madeira. These comprise **Corynophlaea crispa** (Fucophyceae), **Audouinella membranacea** (Bangiophyceae), **Epicladia flustrae** and **Acrochaete leptochaete** (Chlorophyceae). The cells of the true hairs in **Corynophlaea crispa** are often infected by a phycomycete referred to the genus **Eurychasma.** Details of the life history in culture of **Epicladia flustrae,** and **Feldmannia irregularis** are added. They both have a direct type of life history under the culture conditions applied. **Acrochaete leptochaete** remained sterile in culture. **Feldmannia irregularis** is considered an advanced member of the Ectocarpaceae due to immediate embryospore differentiation into erect and rhizoidal filaments and presence of meristems.

SUMÁRIO. No presente trabalho, quatro espécies de algas bênticas marinhas são assinaladas pela primeira vez na Ilha da Madeira. Estas compreendem **Corynophlaea crispa** (Fucophyceae), **Audouinella membranacea** (Bangiophyceae), **Epicladia flustrae** e **Acrochaete leptochaete** (Chlorophyceae). As células dos pêlos verdadeiros em **Corynophlaea crispa** estão muitas vezes infectadas por um ficomicete referido como do género **Eurychasma.** Detalhes do ciclo de vida em cultura de **Epicladia flustrae** e **Feldmannia irregularis** são mencionados. Ambas têm um ciclo de vida do tipo directo, sob as condições de cultura aplicadas. **Acrochaete leptochaete** mantem-se estéril em cultura. **Feldmannia irregularis** é considerada um membro avançado dos Ectocarpaceae devido à diferenciação imediata do embriósporo nuns filamentos rizoidais e erectos e à presença de meristemas.

MATERIAL AND METHODS

The material was collected in the littoral and upper sublittoral zones at Prainha (loc. 1) on 22 August 1978 and at Funchal (Club de Turismo, loc. 2) in the sublittoral zone on 28 August 1978. Some material

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was preserved in a 4% solution of formaldehyde. Crude cultures were established by inoculation of fertile plants into MLG 30. Subsequent unialgal cultures were made by pipetting germlings after the return to Copenhagen. The following particulars are added for the species in culture : *Feldmannia irregularis* grew epiphytically on *Cystoseira abies marina* on loc. 1. *Epicladia flustrae* and *Acrochaete leptochaete* grew on a hydroid found on *Sargassum* on loc. 2. The unialgal cultures of these species were cultured in medium ML 30 or M 30 in a 16 h light/8 h dark (LD) photoregime using warm white Philips fluorescent tubes, TL MF 29. The media used are modifications of Provasoli's ES. Recipes for the media are given by Christensen (1982). The following combinations of temperature, salinity, light quantity, and photoperiod were used: 1) 15° C, 30 °/₀₀, 2635 lx, LD; 2) 5° C, 30 °/₀₀, 1275 lx, LD. Only *F. irregularis* was exposed to conditions 2.

Bangiophyceae

Audouinella membranacea (Magnus) Papenfuss

This species has not previously been reported from Madeira (cf. Levring 1974). The plants were found in a hydroid *(Thecaphora)* on *Dictyopteris membranacea* (Stack.) Batters (loc. 2). Only endozoic filaments, loose and distant, were present. Few tetrasporangia-like cells were observed on the surface of the hydroid.

Fucophyceae

Feldmannia irregularis (Kütz.) Hamel

The life history of this species is of the direct, monophasic type under conditions 1. Only attenuated, plurilocular sporangia occur on macrothalli (Fig. 1), and microthalli are always sterile. The swarmers from plurilocular sporangia settle, round off, and germinate bipolarly. The two germination tubes are formed asynchronously (Fig. 5a). Further development is by immediate differentiation. One germination tube (Fig. 5a, arrows) develops into an initial macrothallus identified by early development of a meristem, while the other develops into a rhizoidal filament (Fig. 5a, arrows) ; this rhizoidal filament functions as holdfast as can be seen in Fig. 1, arrow. Further branching occurs from the cell corresponding to the embryospore (Fig. 5b, arrow); it forms cells from which secondary development of macrothalli occurs (the oldest erect filament is indicated by an arrowhead, Fig. 5b) and it also develops secondary rhizoidal filaments (Fig. 5b).

Acinetospora-like stages have not been observed under the two culture conditions applied. Although the original material is adapted to relatively high temperatures, the cultured plants are able to survive constant low temperatures under conditions 2, but they remain sterile.

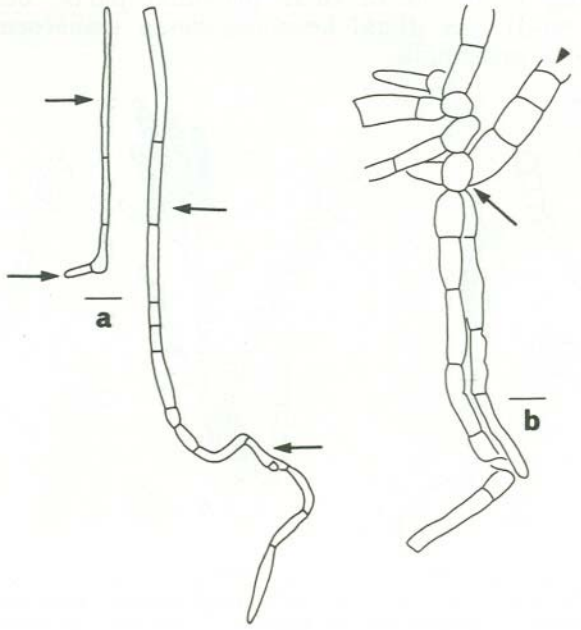


Fig. 5a, b. — **Feldmannia irregularis;** immediate differentiation of the embryospore. Fig. a. Asynchronous, bipolar germination of the embryospore (arrows), one germination tube develops into a holdfast filament (compare Fig. 1, arrow), the other develops into an initial macrothallus. Fig. b. Further development of the germling; the cell corresponding to the embryospore indicated by an arrow, the oldest macrothallus by an arrowhead. Scale 30 μm.

Corynophlaea crispa (Harv.) Kuck.

This species has not previously been reported from Madeira (cf. Levring 1974). It grew abundantly on *Cystoseira abies marina* collected in the upper sublittoral zone at loc. 1. The spherical thalli, approximately 2 mm in diameter, were easily recognized under water because the true hairs formed a «corona» around the small bodies with which *Cystoseira* was densely covered.

The assimilating filaments of the plants are straight or slightly curved, up to 10 cells long when fully developed, ending in 2-4 spherical cells, while the proximal part of the filaments is narrow, composed of

rectangular cells (Fig. 6a, d). The plants carry plurilocular sporangia abundantly, sometimes also a few unilocular sporangia. The unilocular sporangia develop from the supporting cells of assimilating filaments (Fig. 6a) while the plurilocular sporangia develop terminally on special filaments. The latter filaments are morphologically in agreement with the assimilating filaments in their proximal parts, but they branch distally (Fig. 6a-d), the distal branches being transformed into uniseriate plurilocular sporangia.

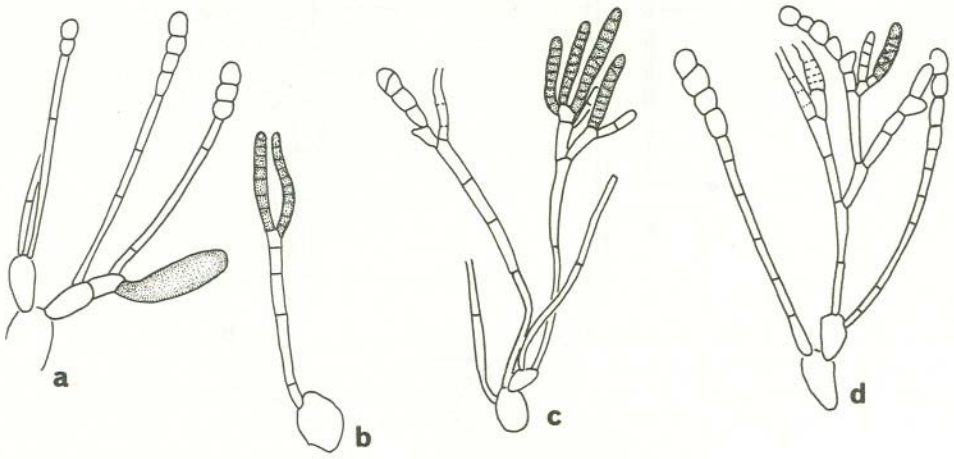


Fig. 6a-d. — Details of reproductive structures in **Corynophlaea crispa.** Fig. a. Part of plant showing assimilating filaments and an immature unilocular sporangium developed from the supporting cell of an assimilating filament. Figs. b-d. Formation of plurilocular sporangia. These are formed by transformation of the ultimate parts of special branches. Scale 20 μm.

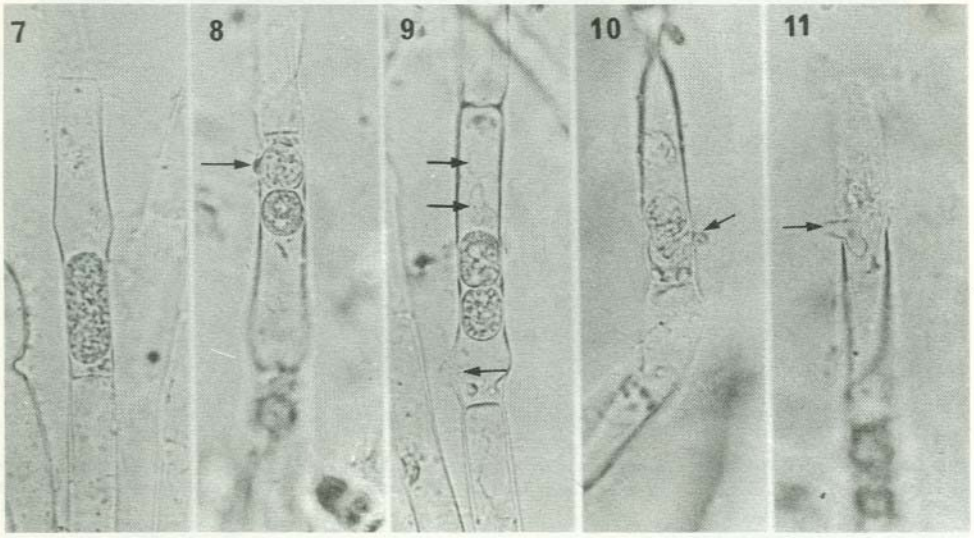
The true hairs of *Corynophlaea crispa* are often infected by a phycomycete which seems to belong in the genus *Eurychasma*. One or two round to oval cells of varying length are clearly visible within each infected hair cell (Figs 7-9). These inclusions obviously represent elements of a developmental series as empty, collapsed cells (Fig. 9, arrows) may be found in the same host cell. Each *Eurychasma* cell forms an exit tube (Fig. 8, arrow, initial stage, Figs 10, 11, later stages). The host cells are not or only slightly hypertrophied.

Chlorophyceae

Acrochaete leptochaete (Huber) Nielsen

This small plant has not previously been reported from Madeira (cf. Levring 1974).

The plants develop into small hemispherical cushions formed of branched, uniseriate filaments under conditions 1. Each cell contains a parietal, reticulate chloroplast with 1-5 pyrenoids (mean 2.02 ± s.e. 0.09, 100 counts). Hairs develop abundantly if medium M 30 is used instead of ML 30. The hairs have basally a small, hyaline bulbous en-



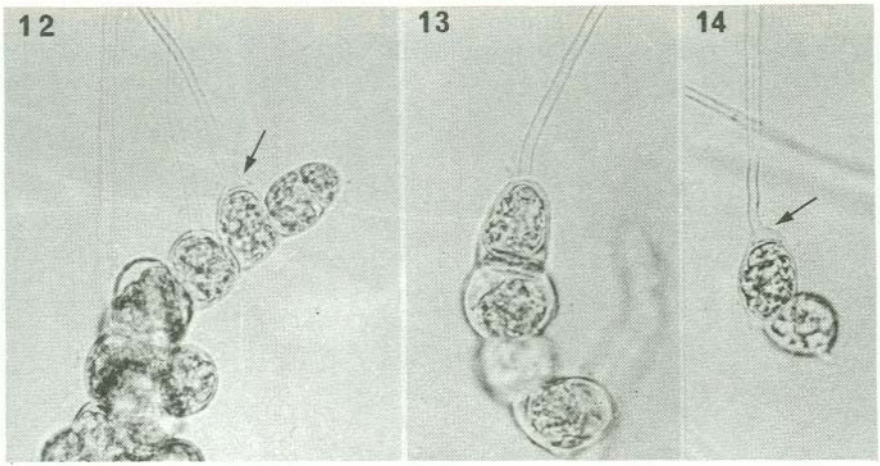
Figs 7-11. — **Eurychasma** infection of hair cells in **Corynophlaea crispa.** Fig. 7. Large, oval phycomycete cell in a hair cell. The hair cell is slightly hypertrophied above the phycomycete. Fig. 8. Hair cell with two round phycomycete cells; one cell shows initial formation of an exit tube (arrow). Fig. 9. Hair cell infected by two oval **Eurychasma** cells. Two to three empty, collapsed cells are also visible (arrows). Fig. 10. Formation of exit tube (arrow). Fig. 11. Empty cell with clearly visible exit tube (arrow). All x 600.

largement (Figs 12, 14 arrows) which is only visible if the cell is seen in proper lateral view — otherwise the hair seems to develop immediately from the vegetative cell (Fig. 13). The plants remained sterile under the culture conditions tested.

Epicladia flustrae Reinke

The plants in culture agree morphologically with the description by Reinke (1889). They develop into small pseudoparenchymatous discs formed by dense branching. Hairs are always absent also in a medium with low content of nutrients. The discs are composed of rounded cells in the central part and free marginal filaments of cylindrical cells (Fig. 2). More lumpy thalli have been observed; their morphology probably depends on the degree of contact with a suitable substratum. Each cell

contains a parietal chloroplast with one pyrenoid. At fertility several cells close to each other are transformed into sporangia. Empty sporangia always have an irregular outline (Fig. 3) which indicates that the sporangial walls are thin and soft.



Figs 12-14. — **Acrochaete leptochaete**; hair-bearing plants. Note that the appearance of the small, basal bulbous enlargement depends on the orientation of the cell in relation to the viewer. All x 600.

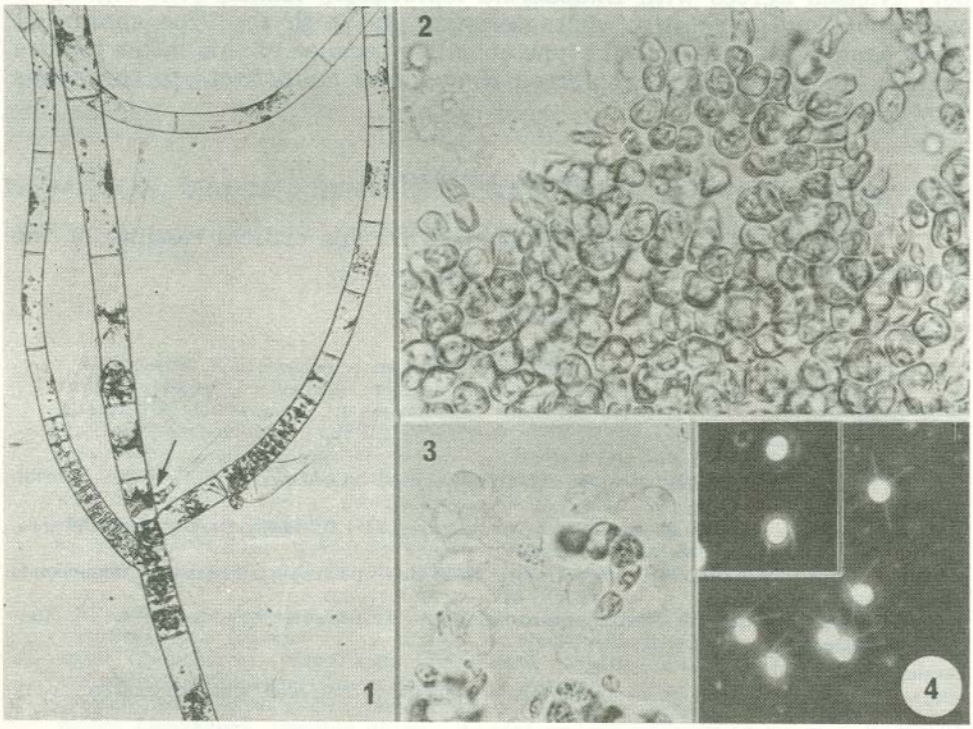
The swarmers liberated from the sporangia are quadriflagellate (Fig. 4) and function as zoospores. When the zoospores search for a suitable substratum to settle on the flagella are anteriorly directed (Fig. 4, inset). The zoospores develop into plants similar to the mother plant.

DISCUSSION

The genus *Feldmannia* must be considered an advanced member of the Ectocarpaceae due to the following traits which are considered apomorphous: the embryospores show immediate differentiation by asynchronous, bipolar germination, one germination tube developing into an erect thallus, the other into a rhizoidal filament. The growth is meristematic and the meristem is formed at an early stage of development. The formation of sporangia is localized, restricted to transformation of hypomeristematic, short laterals. This is in contrast to *Ectocarpus,* which shows mediate differentiation, absence of meristems, and sporangial formation not restricted to certain laterals.

Some species of *Feldmannia* have *Acinetospora*-stages in their life histories, for example, *Feldmannia kjellmanii* Kylin (Knoepffler-Péguy 1977). The *Feldmannia-Acinetospora* connexion depends on en-

vironmental conditions (Knoepffler-Péguy 1977). The type species of *Feldmannia,* according to Farr *et al.* (1979), is *F. lebelii* (Crouan frat.) Hamel, now placed as a variety under *F. caespitula* (J. Ag.) Knoepffler-Péguy (1970). *Feldmannia caespitula* has an *Acinetospora*-stage in its life history (Knoepffler-Péguy 1972-73), so, according to the rules of priority the type species of the genus must be referred to *Acinetospora.*



Figs 1-4. — **Feldmannia irregularis** (Fig. 1) and **Epicladia flustrae** (Figs 2-4) in culture. Fig. 1. Detail of macrothallus of **F. irregularis** showing distinct meristems and an empty plurilocular sporangium. A germling uses the mother plant as substratum (arrow). x 150. Fig. 2. Disc-shaped **E. flustrae** with rounded central cells and free marginal filaments. x 600. Fig. 3. Empty sporangia; note their irregular outline. x 600. Fig. 4. Quadriflagellate zoospores I_2KI treated; inset: zoospores with anteriorly directed flagelia. x 600.

Feldmannia, irregularis, however, has not formed an *Acinetospora*-stage although tested under suboptimal (winter) conditions. The possibility exists, therefore, that the genus *Feldmannia* as presently circumscribed should be divided into two genera, in which case the generic name *Feldmannia* may be maintained by conservation for the species without an *Acinetospora*-stage.

The phycomycete infecting the hair cells of *Corynophlaea crispa* is referred to the genus *Eurychasma*. Sparrow (1969, cf. Fig. 45) illustrates a parasite very similar to the one found in *Corynophlacea*, but due to uncertainty with regard to delimitation from nearby fungi, he does not give it a specific name. All fungi mentioned by Sparrow under *Eurychasma* spp. are found in ectocarpoid algae.

The plant from Madeira referred to *Acrochaete leptochaete* (Huber) Nielsen agrees with *Endoderma leptochaete* Huber with regard to cytological and vegetative characteristics and with the type species of *Acrochaete* with regard to its type of hairs: because of this latter feature Nielsen (in press) has transferred *Endoderma leptochaete* to the genus *Acrochaete*.

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