THE ALGAL MICROVEGETATION IN AND ON BARNACLE-SHELLS, COLLECTED ALONG THE DUTCH AND FRENCH COASTS

by

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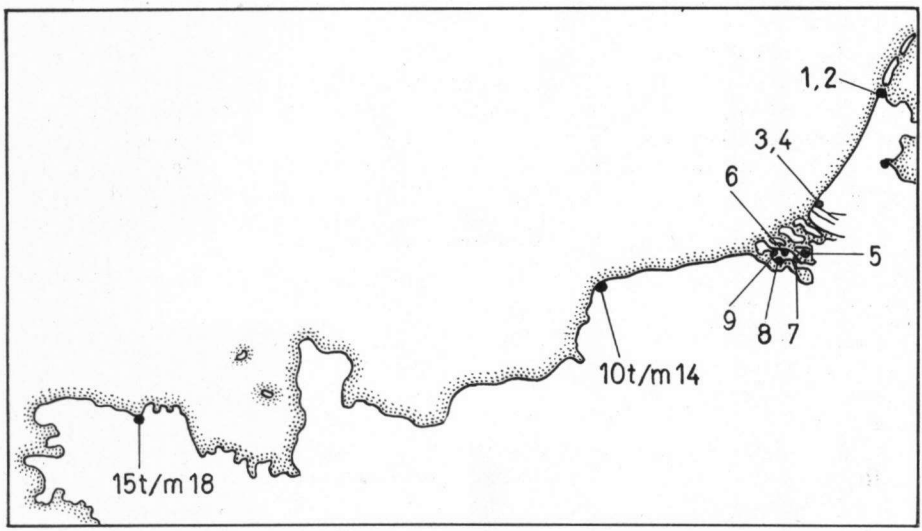
During some trips to several points on the Dutch and French coasts barnacles were collected in order to get an impression of the algal microvegetation perforating into the shells and growing on them.

The barnacles were dried or conserved in formaldehyd-solution; they were decalcified in diaphanol. By treating slides with chloriodide of zinc the chlorophyceae could be distinguished from the remaining algae by their cell-walls and starch-grains stained violet and blue.

Description of the localities, where barnacles were collected

(see map)



1. DEN HELDER, 6-9-1956. On the sea-dike in the *Porphyra-Enteromorpha* girdle, high in the littoral belt.
2. DEN HELDER, 6-9-1956. On the sea-dike in the *Fucus serratus* girdle, low in the littoral belt.
3. HOEK VAN HOLLAND, 24-11-1956. On the north-side of the north-pier of the Nieuwe Waterweg, in the *Enteromorpha compressa*-girdle, mid-littoral.

4. HOEK VAN HOLLAND, 24-11-1956. On the south-side of the north-pier of the Nieuwe Waterweg, in the *Fucus spiralis-Enteromorpha compressa*-girdle.
5. SEA-DIKE NEAR STRIJENHAM (THOLEN, south coast), 27-10-1956. In the *Ascophyllum nodosum-Fucus vesiculosus*-girdle.
6. KATTENDIJKE (ZUID-BEVELAND), 15-5-1956. On the sea-dike, in the *Fucus vesiculosus*-girdle.
7. KANAAL-DOOR-ZUID-BEVELAND, NEAR POSTBRUG, 14-5-1956. On the east-side. Inner side of a *Mytilus*-shell.
8. DIKE OF THE WESTERSCHELDE BETWEEN BORSSELE AND ELLEWOUTSDIJK (ZUID-BEVELAND, south coast), 14-5-1956. In the *Ascophyllum nodosum*-girdle.
9. DIKE OF THE WESTERSCHELDE, NOORDNOL, (ZUID-BEVELAND, south coast), 14-5-1956. In *Ascophyllum nodosum*-girdle.
10. AUDRESSELLES, August 1955. High in the littoral belt, in the *Fucus spiralis*-girdle. On the shadowy, steep north-side of a rock, in a vegetation of *Gelidium pusillum*.
11. AUDRESSELLES, August 1955. High in the littoral belt, in the *Fucus spiralis*-girdle. In the shade on the steep north-side of a rock, in a vegetation of mainly *Ceramium flabelligerum* and *Rhodochorton purpureum*.
12. AUDRESSELLES, August 1955. High in the littoral belt, in the *Fucus spiralis*-girdle.
13. POINTE AUX OIES, August 1955. Midlittoral. In a vegetation of *Ulothrix flacca* and *Enteromorpha compressa*.
14. CAP GRIZ NEZ, August 1955. Midlittoral. On the north-side of a rock, in a vegetation of *Laurencia pinnatifida, Enteromorpha compressa* and *Callithamnion polyspermum*.
15. ROSCOFF, NORTH-SIDE OF ILE DE BÉGLEM, October 1955. Very much exposed, low in the littoral belt, in the *Balanus perforatus*-girdle. Vegetation characterized by *Ralfsia verrucosa, Lithophyllum* and *Corallina officinalis*.
16. ROSCOFF, NORTH-SIDE OF ILE DE BÉGLEM, October 1955. Very much exposed, very low in the littoral belt, in the *Bifurcaria rotunda*-girdle; on the steep east-side of a rock. In a vegetation characterized by *Halopteris scoparia, Lithophyllum incrustans, Corallina officinalis* and *Laurencia pinnatifida*.
17. ROSCOFF, NORTH-SIDE OF ILE DE BÉGLEM, October 1955. Very much exposed, high in the littoral belt, in the *Chthamalus stellatus*-girdle.
18. ROSCOFF, NORTH-SIDE OF ILE DE CALOT, October 1955. In the *Fucus serratus*-girdle on a steep north-side of a rock. *Balanus perforatus*. In a vegetation of mainly *Rhodymenia palmata, Lomentaria articulata, Laurencia pinnatifida, Pylaiella littoralis, Lithophyllum incrustans*.

Composition of the microvegetation

In order to form an idea of the relative abundance of the species, the following symbols are used: c = common, + = fairly common, r = rare.

Locality-number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Perforating species.																		
Entophysalis deusta (Meneghini) Drouet & Daily	c	c	c	c	c	c	+	c	r	r	r	c	+	r	r		c	r
Conchocelis phase of *Porphyra*		c		+	+	c		c	c	c	c	c	+	c	c	c		+
Entocladia sp.	+			r	+	+		r	+	r		+	c	+		+	+	
Gomontia polyrhiza (Lagerheim) Bornet et Flahault	r			r	r	c	c	r?		r	r	c		+			+?	
Plectonema terebrans Bornet et Flahault	+	c	+	+		c		c		r		c			c	r	r	+
Mastigocoleus testarum Lagerheim ex Bornet et Flahault															c		c	c
Phaeophila dendroides (Crouan) Batters															+	+		
Ostreobium queketti Bornet et Flahault															+	r		
Species growing on the shells.																		
Entophysalis deusta (Meneghini) Drouet & Daily	c	c	c	c	c	c	+	c	r	r	r	c	+	r	r			
Phormidium fragile (Meneghini) ex Gomont	+	c	c	c	c	c		c	r			r	r				c	
Pseudulvella-like plantlets	c	c	c	+	r	c		+	c	+			c				r	
Plectonema battersii Gomont	c	c	r	+	c			+	r				+					+
Young *Enteromorpha*	r		c			+				r	+	+	c	+	r			
Ralfsia verrucosa (Areschoug) J. Agardh			c	r	r	c		r	r	c		r			c	c		
Oscillatoria nigro-viridis Thwaites ex Gomont	r	+	r	r	r	r												
Ulothrix pseudoflacca Wille		+			r	c			c				+					
Young *Fucus*					r	+				+								
Rhodochorton purpureum (Lightfoot) Rosenvinge								+	+		+							
Spirulina subtilissima Kützing ex Gomont	r	r	r															
Polysiphonia urceolata (Dillwyn) Greville								+			+							
Ulothrix flacca (Dillwyn) Thuret													+					
Erythrocladia subintegra Rosenvinge							c											
Lithophyllum incrustans Philippi															c	c		c
Calothrilx scopulorum (Weber et Mohr) Agard ex Bornet et Flahault																	r	
Phormidium corium (Agardh) Gomont ex Gomont	c											c						

Morphological, systematic and ecological notes

Porphyra Agardh (*fig. 1*).

The Conchocelis phase of Porphyra growing in barnacle-shells appears to be widely distributed. In this way Porphyra can probably stand unfavourable environmental conditions. Few records could be found about Conchocelis growing in barnacle-shells: Dr. Drew observed Conchocelis growing in the chalky plates of the Lepadide Pollycipes cornucopiae, collected at Roscoff (Drew 1953, p. 84—87). Barnacles covering great areas of the coasts practically everywhere, seem to be more suitable for a rapid return of the adult Porphyra-phase than shells from the sublittoral region. My determination of the Conchocelis-phase growing in barnacle-shells

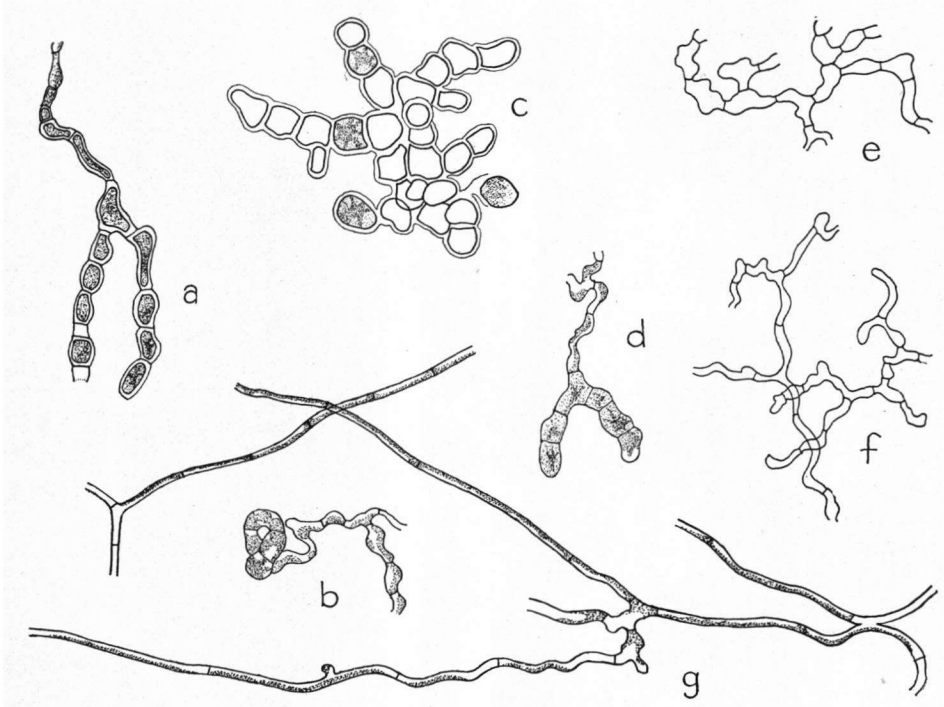


Fig. 1. *Conchocelis-phase of Porphyra.* a. "Fertile cell-row" from 16 (diam. 4—7 μ), b, d. Young fertile cell-rows from 15, c. "Fertile cell-row" from 15 (diam. 9—14 μ), e. Filaments close to the surface of the shell from 14 (1.5—4 μ), f. Filaments close to the surface of the shell from 15 (1.5—4 μ), g. Filaments deeper in the shell from 8 (diam. 1.5—3 μ).

collected in the North of France was confirmed by Dr. Drew, who also drew my attention to the presence of "plantlets" (Drew 1954) in this material, growing on the surface of the shells. The diameter of the cells of these plantlets amounts to 19—30 μ. I have tried in vain to find conchospore-formation as described by Tseng and Chang (1955). In the material from Roscoff, collected in October 1955 "fertile cell-rows" were observed. The filaments close to the surface of the shells are heavily

coiled, richly branched and forming a dense growth; the filaments deeper in the shells are straight and sparingly branched, thus forming a sparse growth.

Erythrocladia subintegra Rosenvinge 1909, p. 73—75.

A prostrate disc-like Rhodophycea, most probably Erythrocladia subintegra, was found growing on the inner side of a Mytilus-shell, collected in the Kanaal-door-Zuid-Beveland. The thallus is composed of radiately branched creeping filaments, united to a pseudo-parenchymatous disc with often bifid marginal cells. Sometimes the threads are free from each other on the margin of the disc. Each cell contains a stellate chromatophore. Monospores were not observed. Central cells isodiametric, 5—9 μ in diam., cells of the periphery 3—5 × 5—13 μ (*fig. 2a*).

Gomontia polyrhiza Bornet et Flahault 1889, p. 158—159.

The thallus of Gomontia polyrhiza consists of two types of cells: first, of smaller cells, often somewhat swollen and irregular, uninucleate, with one parietal chromatophore containing usually one, sometimes two pyrenoids, 3—10 × 4—21 μ, 1—4 × as long as broad, forming freely branched filaments with branches parallel to the surface of the shell and with filaments penetrating deeper into it; and secondly, of larger inflated cells, often more or less clubshaped, with rhizoidal outgrowths turned to the shell-surface, and often connected by them with filaments of smaller cells, (13—)20—60 μ × (30—)90—200 μ, with one parietal, laminate often reticulate chromatophore containing numerous pyrenoids. According to Bornet and Flahault (1889) the large inflated cells may become sporangia filled with zoöspores. According to Kylin (1935, p. 193) Gomontia only consists of the large inflated cells, because in his cultures the zoöspores of Gomontia only grew out to such cells, one zoöspore to one inflated cell with rhizoids. He supposed the filaments composed of smaller cells to belong to another species. Bornet and Flahault (1889), however, gave detailed descriptions and figures in which they present intermediate forms of normal and inflated cells. I could sometimes clearly observe connections between the two forms of cells (*fig. 3, a—d*).

Plants growing in a Mytilus-shell collected in the Kanaal-door-Zuid-Beveland, consisted of more or less flattened cells only, provided with numerous rhizoidal outgrowths, by a few of which they were connected with each other. These cells, however, were very variable in diameter (*fig. 2, b, c*).

In the barnacles from 8 and 17, only filaments of smaller cells could be detected; so it is not absolutely certain whether they belong to Gomontia polyrhiza or not.

Entocladia sp.

Kylin (1935, p. 197—204; 1949, p. 38—41) described two species of Entocladia, perforating into the shells of molluscs, viz. E. testarum and E. tenuis. The diameter of the cells of E. testarum amounts to 5—10 μ, that of E. tenuis to 3—8 μ. The diameter of the cells in my materials is 2.5—5(—7) μ; the length of the cells is 1—6 × their dia-

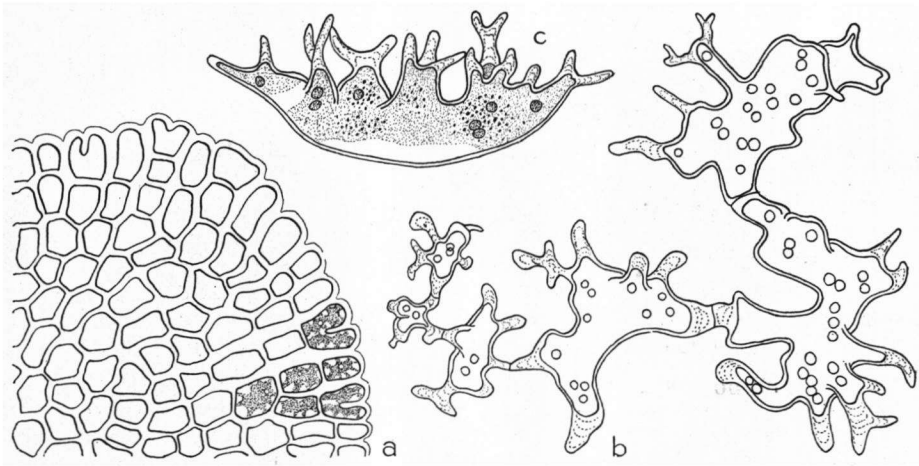


Fig. 2 a. *Erythrocladia subintegra* from 7, b, c. *Gomontia polyrhiza* in Mytilus-shell from 7.

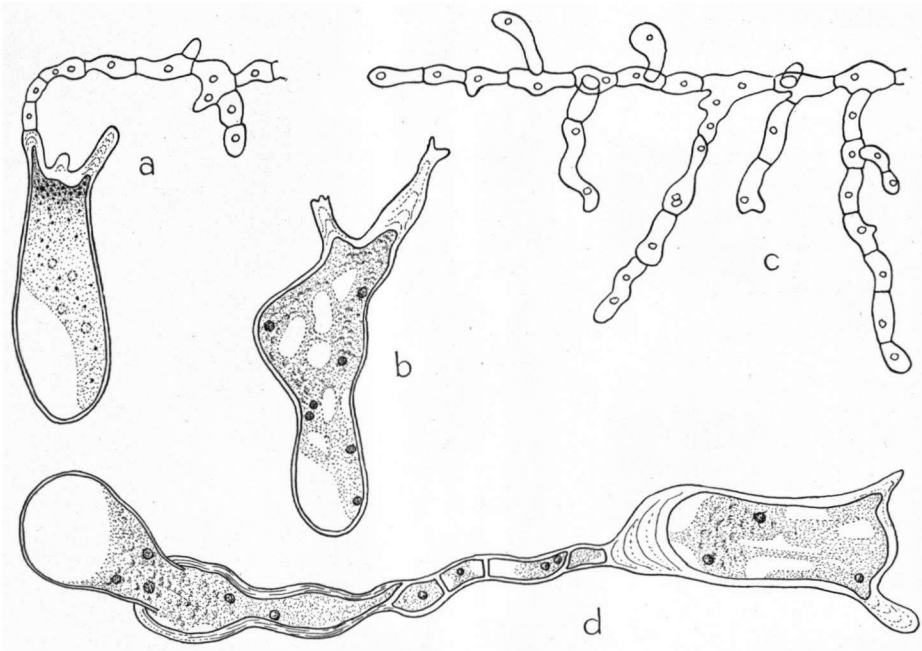


Fig. 3. *Gomontia polyrhiza* in barnacles from 6.

meter; it is, therefore, impossible to attribute my specimens to one of the two species. Furthermore, I am not certain that chalk-boring always is valuable as a taxonomic characteristic. In one case I found branches of a plantlet perforating into a shell growing among the upright and closely packed filaments of Ralfsia (*fig. 5 b*). In this respect it resembles Entocladia viridis. Phaeophila dendroides has been found growing in the cell-walls of several algae, but also among the cells of Lithothamnion and Melobesia (Hamel 1930, p. 27) and in barnacle-shells.

Phaeophila dendroides (Crouan) Batters.

P. floridearum Hauck 1885, p. 464, Hamel 1930, p. 27 — *P. engleri* Reinke 1889, p. 86, Kylin 1935.

No real morphological differences exist between P. dendroides and P. engleri. According to Reinke (1889, p. 86) P. engleri differs from P. dendroides by the fact that it bores into chalk. According to Hamel, however, (1930, p. 27) P. dendroides has been found growing among the cells of Lithothamnion and Melobesia. P. engleri, therefore, most probably is a synonym of P. dendroides (*see fig. 6, d—f*).

Pseudulvella-like plantlets (*fig. 4c, d*).

On many barnacles a disc-like Chlorophycea was found growing, the margin one cell-layer, the centre several cell-layers thick. In many specimens, however, tubular Enteromorpha-like outgrowths arose from such discs, indicating that they are Blidingia minima. Bliding (1938, p. 85—87), in his cultures of Blidingia, observed that Blidingia zoöspores gave rise to disc-like plantlets, from which afterwards the tubular Enteromorpha-like outgrowths characteristic for Blidingia minima arose. In the samples from 3, 4, 9, 10, 14 and "Pseudulvella" plantlets were observed without tubular outgrowths, in 1, 2, 5 and 6 they were seen provided with them. The first series of samples were taken from the lower littoral belt, the second series from the higher littoral belt, except 2. Perhaps Blidingia, under unfavourable conditions does not grow out to its normal form and size. Very young "Pseudulvella"-like plantlets do not show any difference from Protoderma marina.

Ostreobium queketti Bornet and Flahault (*fig. 6a—c*).

In one sample (15) Ostreobium was found growing among the filaments of Conchocelis. Ostreobium can be distinguished from that species by their lack of transverse walls and by the presence of starch grains stained dark-blue by means of chloriodide of zinc. The diameter of the thin filaments amounted to 2—6 μ, of the swollen parts to 6—15 μ.

Entophysalis deusta (Meneghini) Drouet & Daily 1956, p. 103—110 (*fig. 4 a, b*).

In many shells the dominant species appeared to be Entophysalis deusta, mainly in a form resembling Hyella caespitosa Bornet et Flahault (1889, p. CLXV—CXXI); also Gloeocapsa crepidinum-like and Dermocarpa-like forms were frequently observed. Often Hyella-like filaments were seen radiating from a central group of Gloeocapsa-like cells. Aphanocapsa-like

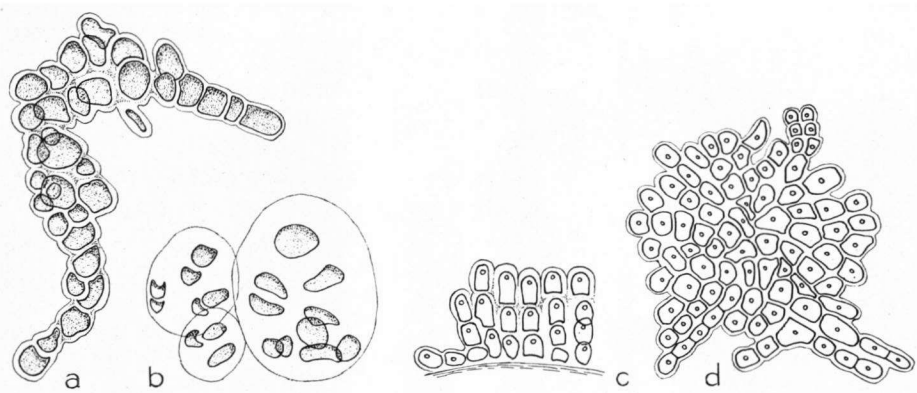


Fig. 4. a, b. *Enthophysalis deusta,* c, d. *"Pseudulvella"* from 8.

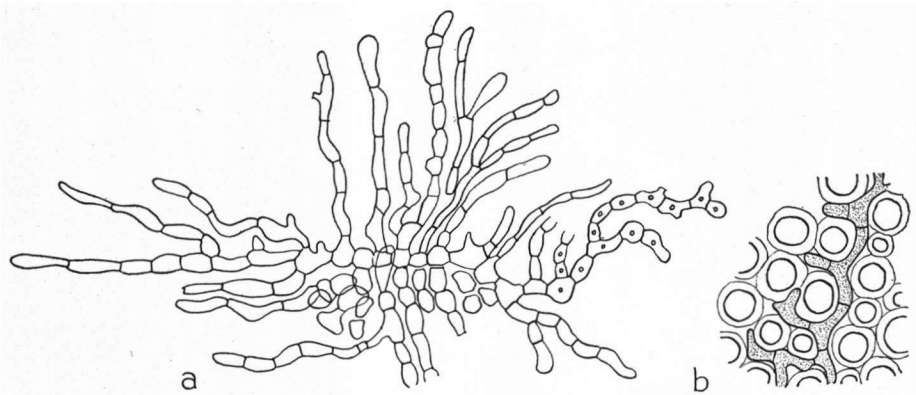


Fig. 5. *Entocladia sp.* from 6, a. Growing in the shell, b. Growing between the upright filaments of Ralfsia.

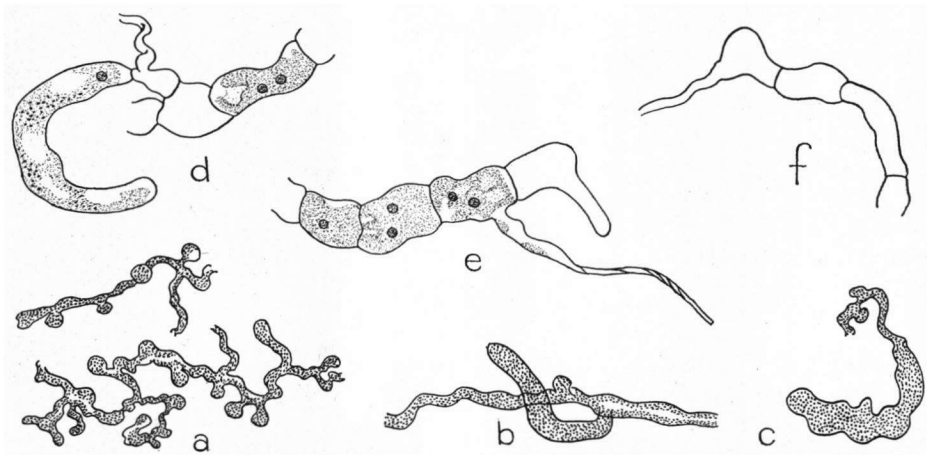


Fig. 6. a, b, c. *Ostreobium queketti* from 15, d, e, f. *Phaeophila dendroides* from 15.

colonies were also rather common; they were parasitised by Fungus threads, especially on the shells from 17. In most cases all these forms were present on the same shell, with clearly intermediate forms. This species penetrates into, as well as grows on the shells.

Oscillatoria nigro-viridis Thwaites ex Gomont.

The diameter of the specimens growing on the barnacle-shells varied between 5 and 8 μ, the most common diameter being 6 μ. The ends of the trichomes usually were slightly but sometimes considerably attenuate.

References

ANAND, PYARE LAL. A taxonomic study of the algae of the british chalk-cliffs. Journ. Bot. vol. LXXV, suppl. (1937), p. 1—51.

BLIDING, C. Studien über Entwicklung und Systematik in der Gattung Enteromorpha I. Botaniska Notiser (1938), p. 83—90.

BORNET, E. & FLAHAULT, CH. Sur quelques plantes vivant dans le test calcaire des Mollusques. Bull. Soc. Bot. Fr., tom. 36 (2e série, tom. XIe) (1889), p. CXLVII—CLXXVII.

—— Note sur deux nouveaux genres d'algues perforantes. Journ. Bot. tom. II (1888), p. 161—165.

CHODAT, R. Études de biologie lacustre C. Recherches sur les algues littorales; sur les algues perforantes d'eau douce. Bull. Herb. Boissier, tom. VI (1898), p. 434—450.

DREW, K. M. Studies in the Bangioideae III. The life-history of Porphyra umbilicalis (L.) Kütz. var. laciniata (Lightf.) J. Ag. A. The Conchocelis-phase in culture. Ann. Bot. N. S. vol. XVIII, no. 70 (1954), p. 183—211.

—— & RICHARDS, K. S. Studies in the Bangioideae I. The Conchocelis phase of Porphyra sp. in Pollicipes cornucopiae Leach at Roscoff. Journ. Linn. Soc. Lond., Bot., vol. LV, no. 356 (1953), p. 84—87.

DROUET, F. & DAILY, W. A. Revision of the coccoid Myxophyceae. Butler Univ. Bot. Stud., vol. XII (1956), p. 1—218.

FRÉMY, P. Les Cyanophycées des Côtes d'Europe. Saint-Lo, 1934.

HAMEL, G. Floridées de France, Bangiales. Rev. Alg. vol. I (1924), 278—292; 427—457.

—— Chlorophycées des Côtes Françaises. Rev. Alg., vol. V (1930), 1—55, 383—430.

HAUCK, F. Die Meeresalgen Deutschlands und Oesterreichs. Leipzig 1885.

KYLIN, H. Ueber einige Kalkbohrende Chlorophyceen. Kungl. Fys. Sällsk. i. Lund Förh. Ba. 5 (1935), p. 186—204.

—— Ueber die Chlorophyceengattungen Entocladia, Epicladia und Ectochaete. Botaniska Not. (1938), p. 67—76.

—— Die Chlorophyceen der Schwedischen Westküste. Lund 1949.

KOLDERUP ROSENVINGE, L. The marine algae of Denmark, Rhodophyceae I (Bangiales and Nemalionales). D. Kgl. Danske Vidensk. Selsk. Skrifter, 7 Raekke, Naturvidensk. og Mathem. Afd. VIII, 1, (1909); Rhodophyceae IV, Idem VII, 4, (1931).

LINDSTEDT, A. Die Flora der marinen Cyanophyceen der Schwedischen Westküste. Lund 1943.

SETCHELL, W. A. & GARDNER, N. L. The marine algae of the pacific coast of North America, part II, Chlorophyceae. Univ. Calif. Publ. Bot. 8 (1920), 139—374.

SMITH, G. M. Marine algae of the Montery Peninsula. Stanford Univ. Press, 1944.

TSENG, C. K. & CHANG, T. J. Studies on Porphyra II. On the Conchocelis-phase of Porphyra tenera Kjellm., and its conchospores. Act. Bot. Sin., vol. IV, no. 1, (1955), p. 45—62.

WEBER—VAN BOSSE, A. Algues in: Résultats scientifiques du Voyage aux Indes Orientales Néerlandaises. Mém. Mus. Roy. Hist. Nat. Belg., hors série, vol. VI, fasc. I.

WILLE, N. Conjugatae und Chlorophyceae in Engler & Prantl. Die natürlichen Pflanzenfamilien, Nachr. zum I Teil, 2e Abt., 1910, p. 90.