Laboratory culture of the intertidal brown alga Fucus vesiculosus

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the rate of supply of water to the region of the lower dendrograph is almost sufficient to balance the loss and little change in tension occurs. For the same reason, there is no re-expansion of the stem in the evening.

These findings are of interest in that they appear to differ from those reported elsewhere (4) after somewhat similar experiments on ring-porous and diffuse-porous hardwoods. In all these cases, saw cutting produced little, if any, change in radial fluctuation patterns from those in control trees. Unfortunately the author gives no information about the location of his dendrographs in relation to the saw cuts and, in view of the importance of this in determining the response, no strict comparison between his and the present experiments can be made.

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Oedogonium chaetophorum nomen novum

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HOFFMAN, L. R. 1969. ***Oedogonium chaetophorum*** nomen novum. Can. J. Botany, **47**: 219.
Oedogonium chaetophorum nom. nov. is proposed as a substitute for the binomial *O. setigerum* Hoffman.

It has come to my attention (Dr. Paul C. Silva, personal communication) that the binomial *Oedogonium setigerum*, used by me for a new species, has previously appeared in the literature.

Oedogonium chaetophorum nom. nov. (≡*O. setigerum* Hoffman, Can. J. Botany, 45: 405, Figs. 1–5, 15–22. 1967; non *O. setigerum* Vaupell, Iagtt. Oedogonium, p. 17, Figs. 1–15. 1859, et Ann. Sci. Nat. Bot., ser. IV, 11: 192, pls. 4, 5. 1859; nec *O. setigerum* Wolle, Bull. Torrey Botan. Club 6: 188. 1877) is therefore here proposed as a substitute.

Laboratory culture of the intertidal brown alga *Fucus vesiculosus*

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Fucus vesiculosus L. plants have been grown successfully in a recirculating culture system which provides an intertidal environment.

Fucus vesiculosus L. is the only large intertidal brown alga which has been cultured to any extent. The ease with which the early stages of the embryo development of this plant can be obtained in simple seawater culture is well known. These embryos, however, never exceed 2 to 4 mm in length and die after a few months even if they are kept under good illumination

and the seawater is changed frequently. Burrows and Lodge (1953) grew embryos of hybrids of three *Fucus* species to lengths of up to 7 mm in submerged culture with Erdschreiber-enriched seawater, but *Fucus* plants have not been grown to maturity in culture.

Isolated thallus apices of mature *Fucus* plants will undergo some growth and differentiation and small pieces of thallus lacking apices will regenerate new shoots when cultured in seawater (Moss 1964, 1967), but growth is very slow under these conditions and mature plants have not been produced.

Earlier, one of us (M.E.M.) attempted to keep mature *Fucus* plants, collected with holdfasts intact, continuously submerged in a cool, well-illuminated aquarium containing aerated pure seawater or enriched seawater. In all cases, these plants deteriorated rapidly and died in 1 to 2 weeks.

Fucus vesiculosus is an intertidal species and the occasional plant observed growing in a sublittoral position or in a tide pool usually appears unhealthy and is covered with epiphytes. It may well be that these plants require alternating periods of immersion and exposure for normal growth and development.

Recently we have developed a simple culture system which provides an intertidal environment in which it has been possible to maintain growth and development of plants of *Fucus vesiculosus* put into the system at various stages of their development. This system is easy to construct and maintain and now makes possible a wide variety of experimental studies of these plants.

Materials and Methods

(1) The Apparatus

The culture apparatus (Figs. 1, 2, and 3) consists of three vertically arranged plexiglass tanks installed in a constant-temperature room maintained at 10 °C. The *addition tank* (25-liter capacity) contains fresh medium which can be drained into the culture tank at varying rates. The *culture tank* (75-liter capacity) is equipped with a perforated plexiglass platform and a sintered glass aerator. The platform supports the plants and allows complete drainage of medium from the plants during "low-tide" periods. The *reservoir* (100-liter capacity) is fitted with a simple bubble-up type glass-wool filter. Metallic ion contamination is minimized by connecting the tanks with Tygon tubing and using a Manostat varistaltic pump.

Tidal conditions are maintained automatically in the following manner. Medium is circulated continuously by the varistaltic pump in a cycle through the culture tank and reservoir at a rate of 1 liter/min for 6 h, producing complete immersion of the plants and a "high-tide" condition. The pump is then shut off and the medium drains from the culture tank into the reservoir, producing a "low-tide" condition for the next 6 h.

Illumination over the culture tank is supplied by one Sylvania Grow-lux and one G.E. cool-white fluorescent lamp producing an intensity of 3.5–3.7 kilolux at the water surface during "high-tide" and 0.7–0.9 kilolux at the level of the platform during "low-tide". The lights are linked to a timer so that any desired photoperiod can be maintained.

Microbial contamination is minimized by the use of an ultraviolet sterilization unit which consists of a quartz glass water-jacket placed around an 8-W germicidal tube (G.E.) emitting 2537 A° ultraviolet radiation. The medium passes through this unit before reaching the culture tank.

(2) The Medium

The medium, which has been used successfully, consists of full strength natural seawater plus 25 parts per 1000 of the following enrichment mixture. This medium is similar to one used by Strand *et al.* (1966) for the culture of *Ulva* but the micronutrients are added at much lower concentration.

KNO_3	200 mg
K_2HPO_4	35 mg
$FeCl_3$	1.0 mg
$MnCl_2$	0.01 mg
Glycerophosphate disodium pentahydrate	10 mg
Ethylenediaminetetraacetic acid	10 mg
B_{12}	10 mg
Thiamin HCl	2 mg
Biotin	10 mg
Fresh seawater	750 ml
Distilled H_2O	250 ml

The pH of the medium is monitored daily and kept between 7.8 and 8.2 by addition of CO_2 when necessary. Fresh medium is added at the rate of 5% of the total volume per day.

(3) The Plants

To date, the longest time that we have attempted to keep a given group of plants in culture is 7 months. The specimens of *Fucus vesiculosus* used in this particular trial were collected at Gulliver's Cove, Digby Co., N.S., and Ketch Harbour, Halifax Co., N.S., on December 30 and 31, 1967.

The collection included sporelings with cylindrical thalli, and young plants with flattened thalli up to 12 cm in length. Some of the older specimens had developed air bladders, but none of the plants had formed any reproductive tissue at the time of collection. The holdfast of each plant (or groups of plants) was kept intact by removing, with a chisel, that portion of the rocky substratum to which the holdfast was secured. The specimens were placed in plastic bags and kept on ice (in the dark) until culturing was begun January 5, 1968. Before being cultured, the plants were rinsed several times in cold seawater, care being taken to remove as much visible foreign material as possible. While in culture the plants were given a 12-h photoperiod.

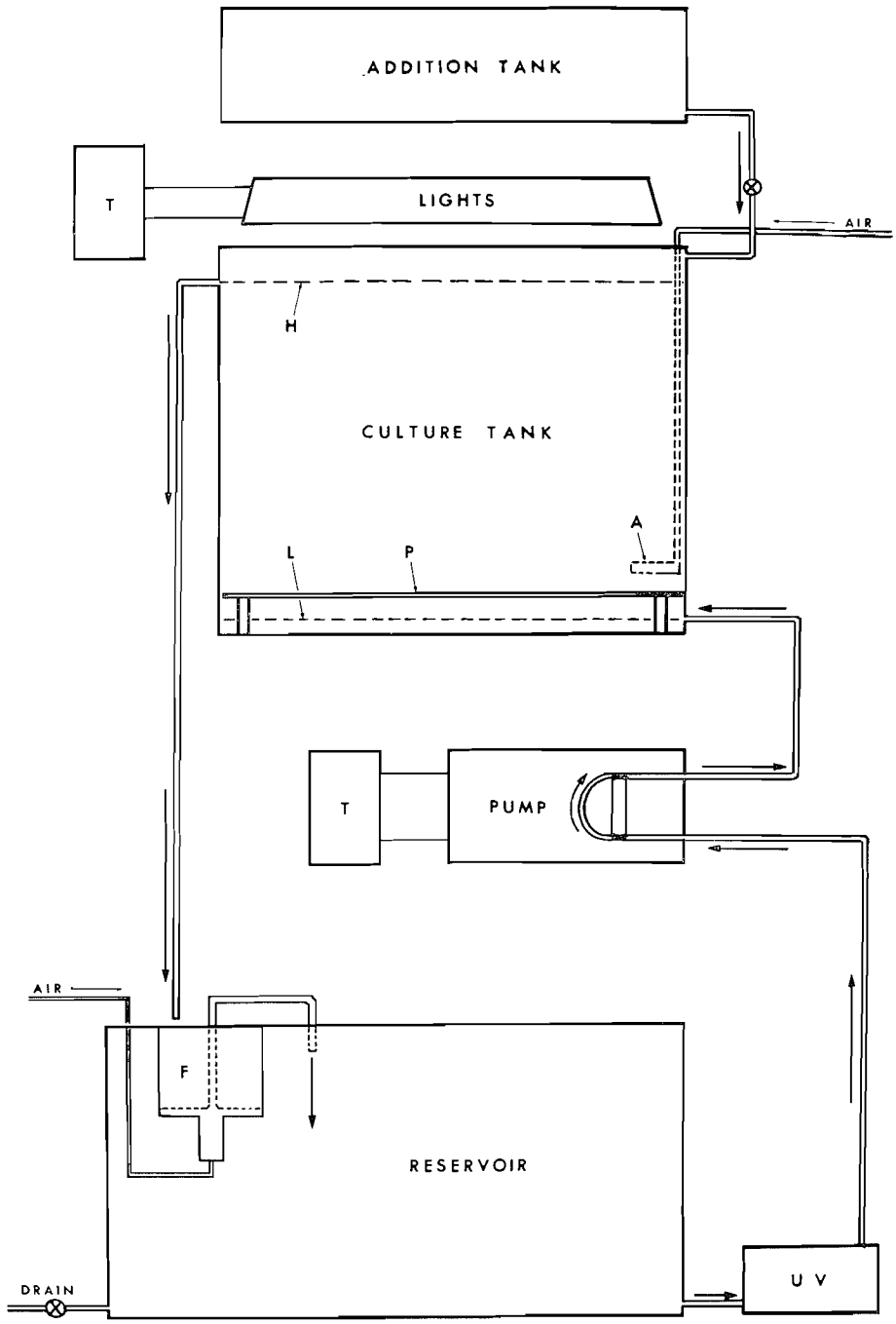

FIG. 1. Diagram of culture apparatus. A, sintered glass aerator; F, bubble-up filter; H, "high-tide" water level; L, "low-tide" water level; P, perforated plexiglass platform; T, automatic timing device. Arrows indicate direction of water flow during "high-tide" cycle.

Observations and Discussion

The specimens appeared healthy after 7 months in the culture apparatus (Figs. 4 to 7). Between 40 and 50 sporelings (these were still cylindrical and no more than 2–3 mm long at the time of collection) developed a flattened thallus 15 to 20 mm long. The more mature plants also grew and increased 20 to 30 mm in length at their apices. Several plants produced new apical dichotomies. One plant developed six receptacles (Fig. 5). These were smaller and somewhat misshaped compared to those produced on plants collected at the same location in the field, but hand sections of these receptacles showed the presence of normal antheridia which contained well-developed sperm.

The new thallus tissue produced during the culture period was lighter in color than that at the apices of freshly collected plants from the same location. This may have been due, however, to too low a light intensity in the culture tank. There was little evidence of degeneration of any parts of the plants put into the culture tank and even after 7 months they were fresh-looking and free of apparent epiphytes.

There was remarkably little fouling of the tanks or the filters by microorganisms even after months of continuous operation. The use of the ultraviolet sterilizer was probably the major factor maintaining this low level of contamination. A somewhat similar arrangement for continually sterilizing the media with ultraviolet light was used successfully by Strand *et al.* (1966) in a closed system for the culture of *Ulva*.

The low level of contamination in the present system was also perhaps a result of the antibiotic properties of the polyphenols which are secreted by healthy *Fucus* plants (Craigie and McLachlan 1964; McLachlan and Craigie 1964; Conover and Sieburth 1966). Certainly the medium in our tanks became slightly yellowish, suggesting the presence of polyphenolic materials.

The significance of the intertidal environment per se is not clear. There are few experimental data in the literature which give any clue about why plants such as *Fucus* should apparently thrive much better in such an environment than when completely submerged. A culture system such as the one described here should now make it possible to carry out some of the much-needed experimental studies on the biology both of these plants and of other intertidal algae.

Acknowledgments

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FIGS. 2, 3. Part of the culture apparatus during operation showing arrangement of *Fucus* plants in the culture tank. Fig. 2. L indicates "low-tide" water level. Fig. 3. H indicates "high-tide" water level.

FIGS. 4–7. Show specimens of *Fucus vesiculosus* L. as they appeared after 7 months in the culture system. FIG. 4. A group of plants with a common holdfast attached to a small piece of the original rocky substrate. $\times \frac{2}{3}$. Fig. 5. A portion of a mature plant showing receptacles (R) which developed during the culture period. $\times \frac{2}{3}$. Fig. 6. Specimens as they appear when supported by the plexiglass platform during "high-tide" conditions. Several developmental stages are shown. $\times \frac{1}{4}$. Fig. 7. Two groups of sporelings which have regenerated from holdfasts of mature plants. During the culture period the thalli of these plants developed from cylindrical to flattened form. The stumps (S) of the original plants can be seen. $\times \frac{2}{3}$.

PLATE I