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MORPHOLOGICAL GROWTH RESPONSE OF DRAPARNALDIA (CHAETOPHORACEAE; CHLOROPHYTA) IN CULTURE

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Draparnaldia Bory is a genus of branched filamentous green algae which embraces about 20 species. Its distributional pattern includes stable to ephemeral fresh water habitats including acid or alkaline conditions. It is sensitive to pollution, hence it appears to be appropriate for the typification of natural fresh water systems. For example, in the saprobic system of FJERDINGSTAD (1964) *Draparnaldia glomerata* is employed as a biological indicator of oligosaprobic waters, while *Draparnaldia plumosa* defines water of katharobic status. Based on, e.g., ultrastructural grounds *Draparnaldia* together with *Stigeoclonium*, *Fritschiella* and *Uronema* constitute the very homogeneous *Chaetophoraceae* (BAKKER & LOKHORST in press, LOKHORST et al. in press).

In its natural habitat, the alga demonstrates a conspicuous main axis consisting of barrel-shaped or cylindrical cells from which opposite, alternate or whorled fascicles of setiferous branchlets project (PRESCOTT 1951). However, when this alga is brought into culture, its phenotypic plasticity is expressed by a gradual loss in ability to produce main axes, thereby giving rise to a *Stigeoclonium*-like growth habit (e.g., CARROLL & DEASON 1969; personal observations).

Several experimental studies attempted to decipher the causes of this polymorphism in *Draparnaldia*. USPENSKAJA (1930) concluded that an increase of the nitrate level, both in natural environment and in culture, accounts for the morphological change in *Draparnaldia*. In additional studies, SUOMALAINEN (1933) reported that an increase of both light intensity and CO_2-concentration promotes main axis development, the frequency of branching and the formation of setae in this alga. SARMA (1964) pointed out that external factors involved in phenotypic plasticity appear to be of physical rather than of chemical nature. KÉRIMIAN & LARPENT (1972) concluded that a fast(er) growth favours thallus differentiation in *Draparnaldia*. JOHNSTONE (1978a) also emphasized that chemical environmental parameters alone do not account for the phenotypic variability, even though calcium plays a major role in the formation of main axis cells. In a follow-up study, JOHNSTONE (1978b) recorded that physical parameters such as daylength, temperature and light intensity interact in determining the phenotype of *Draparnaldia*. In his studies, however, the precise action of each of the whole spectrum of involved parameters could not yet be determined; only trends were detected.

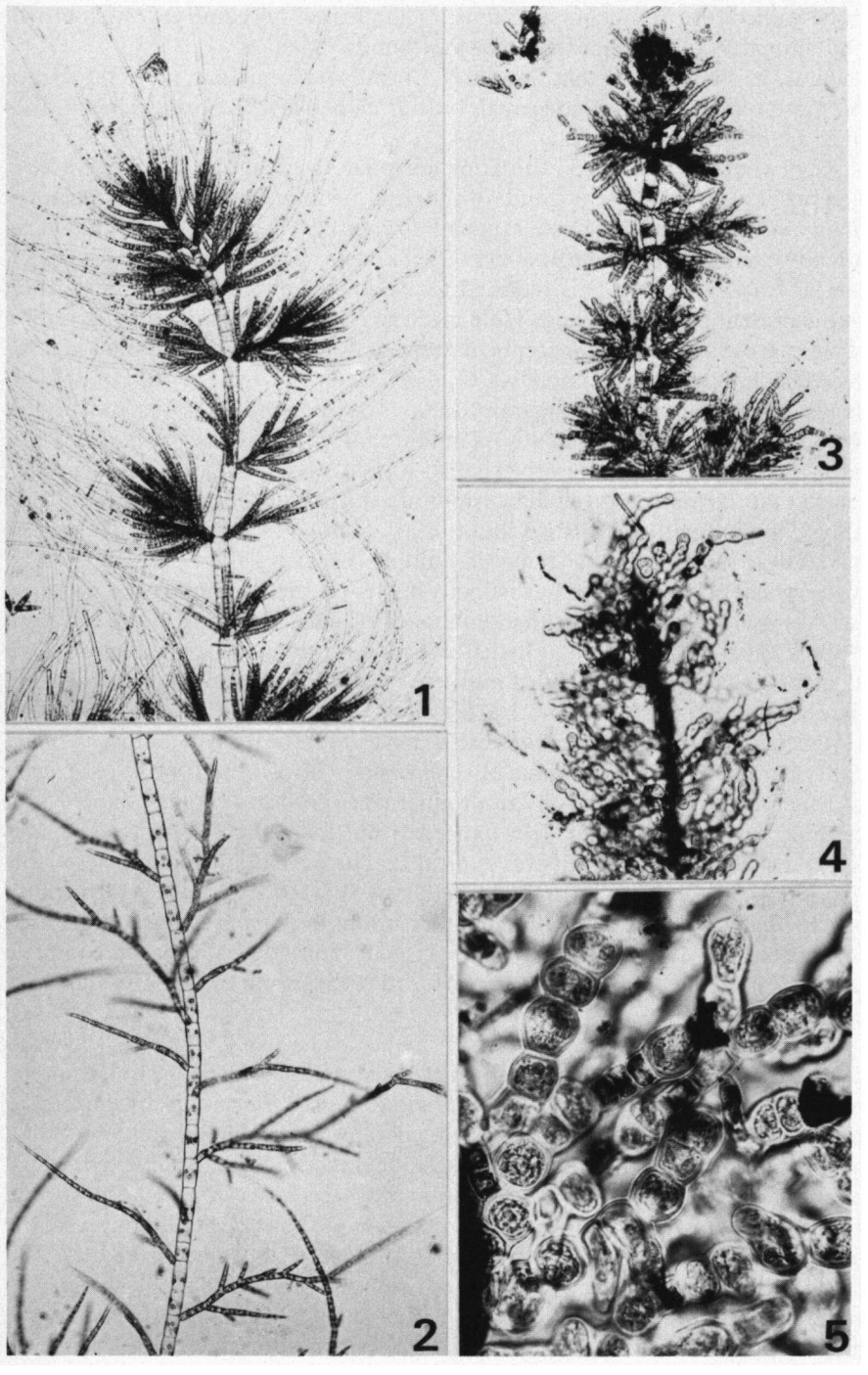
Despite the positive thallus growth response of *Draparnaldia* to some chemical parameters, all above-mentioned authors have not been able to prepare an artificial nutrient medium which is capable of maintaining typical *Draparnaldia*-phenotypes under prolonged culture conditions. VERMA & CHOWDARY (1981) were the first to succeed in developing a nutrient medium that achieved the normal morphological expression in the closely related *Draparnaldiopsis*. This genus differs from *Draparnaldia* in that the main axis has a pattern of long ("internodial") and short ("nodal") cells alternating with one another in regular succession. Branches only arise from the nodal cells.

Within the scope of our ultrastructural studies on *Draparnaldia*, we have tested VERMA & CHOWDARY'S nutrient medium for its suitability to induce normal growth of this alga in culture. In spring 1982, actively grown plants (*fig. 1*) were collected from hardly polluted eutrophic ditches and canals near the Nieuwkoopse Plassen (The Netherlands). At the laboratory, the plants were thoroughly rinsed to remove algal contaminants and then transferred to glass boxes containing VERMA & CHOWDARY'S medium, a slightly modified Woods Hole MBL medium (STEIN 1973) and pasteurized lake water, respectively. In the Woods Hole medium Tris was replaced by Hepes and Na_2SiO_3 was omitted. Cultures were kept at 4°C (8:16 h photoregime), 12°C (12:12 h) and 20°C (12:12 h). Replenishment took place every week.

The results can be summarized as follows.

- Exposure of all plants to 20°C almost immediately proved to be lethal.
- At 4° and 12°C in pasteurized lake water, the inoculated *Draparnaldia*-plants kept their typical phenotypic appearance for 7–21 days. At 4°C, the plants demonstrated a remarkable increase in production of long almost colourless setae. Afterwards, stunted plants appeared gradually showing thallus disorganisation.
- At 4° and 12°C in Woods Hole MBL medium, the differentiation in main axis and fascicles of branchlets usually started to fade away after approximately a week, giving rise to *Stigeoclonium*-like plants. In some isolates, however, the main axis was maintained; in association with the apparent loss of ability to project fascicles these plants assumed a *Cloniophora*-like growth habit (*fig. 2*). Zoospores solely germinated into *Stigeoclonium*-like plants. Despite the complete loss of natural phenotypic morphology, all isolated clones exhibited prosperous growth and luxurious reproduction (when induced) in culture.
- At 4° and 12°C in VERMA & CHOWDARY'S medium, the plants maintained their expression of typical main axis formation for at least 25 days after incubation. However, growth was extremely slow. Moreover, the compact fascicles had an impoverished appearance, and seemingly occupied the main axis randomly (*figs. 3–4*). The branchlets developed without terminate setae while their individual cells assumed a barrel-shaped appearance and gradually became

Fig. 1. *Draparnaldia*-plant from natural habitat showing its typical morphological appearance, × 70. Fig. 2. *Cloniophora*-like growth habit occurring in Woods Hole MBL medium. × 110. Figs. 3–4. Gradual reduction of the typical *Draparnaldia* growth habit in VERMA & CHOWDARY'S medium. × 110. Fig. 5. Ibid. Fascicle of branchlets in detail showing ailing individual cells. × 440.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thick-walled (*fig. 5*). In course of time, all thallus cells became yellowish brown and ultimately plants appeared to be moribund.

Thus, it is concluded that VERMA & CHOWDARY's medium (1981) does not promote typical phenotypic growth in (our clones of) *Draparnaldia* as it does in *Draparnaldiopsis*.

Reviewing literature and evaluating personal observations, I doubt whether it is possible to compose a standard nutrient medium that invariably achieves main axis growth in the whole range of *Draparnaldia* species. For example, as already mentioned above, JOHNSTONE (1978a) reported that the presence of calcium (at least > 1,7 mg/l) is required for main axis differentiation. According to the present study, in Woods Hole medium containing about 10 mg/l Ca^{++}, rapidly-growing *Draparnaldia*-inoculates usually assume a healthy-looking *Stigeoclonium*-like and occasionally a *Cloniophora*-like growth habit. Possibly, as suggested by JOHNSTONE's diagram, the relatively high NO_3^--concentration in Woods Hole medium (as $NaNO_3$) is inhibitory for typical *Draparnaldia* growth habit development. On the other hand, JOHNSTONE's (1978a) experiments detected that the main axis cell dimensions are statistically correlated with nitrate only when present as $Ca(NO_3)_2$ and not as $NaNO_3$. That physical parameters have an apparent effect is shown in cultures kept at 4°C in pasteurized lake water where plants displayed a distinctly higher production of setae. JOHNSTONE (1978b) ascribed changes in the abundance of hairs to changes in daylength, while YARISH (1976) hinted at the effect of light intensity (for chaetophoralean algae in general). In the light of all these data there is no point in comparing the chemical composition of both artificial media used in this study.

It seems likely that *Draparnaldia* exists in nature in the form of a single variable entity consisting of a wide range of ecotypes (see also JOHNSTONE 1978b), each of which having evolved from an original gene pool to become adapted to a certain type of fresh water. It is expected that each of these ecotypes makes its own specific requirements for typical thallus development. In view of this hypothesis, it still has to be proved whether the VERMA & CHOWDARY's medium also induces successful cultivation in other strains of *Draparnaldiopsis* than used in their study. Moreover, a critical analysis of their figures reveals a complete lack of setae and a frequent disorder of the alternating pattern of long and short cells in the main axis.

A comparable difference in growth response as discussed here for *Draparnaldia* is also noted in algae which flourish in acid dystrophic habitats. For example, representatives of the genera *Microspora* and *Binuclearia* cannot be induced to produce zoospores when cultivated in generally applicable media. Simultaneously, these algae often exhibit an ailing appearance presumably due to the lack of specific humid acids. In the past, (most of) the here supposed ecotypes in *Draparnaldia* have been given species status (e.g. PRINTZ 1964). However, the present-day subdivision of *Draparnaldia* into species appears to be based on inadequate features, since, e.g., dense crowding of branchlets in our plants prevented to determine whether or not there is an apparent rachis throughout in individual fascicles. Moreover, several "species-distinguishing" types of fascicle

shape were encountered on one and the same plant. Despite criticism of CARROLL & DEASON (1969), for the present I am inclined to agree with FOREST's (1956) merging of the plumosa-acuta-glomerata series into a single variable entity which he called *Draparnaldia mutabilis* (Roth) Bory.

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