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Environmental control of cell morphology in desmids

VIDYAVATI

Hydrobiology Laboratory, Department of Botany, Kakatiya University, Warangal 506 009, India

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Abstract. The variability of the desmids was quite interesting to note that when the conditions such as temperature and illumination were altered, there was not only an increase in the abnormal forms but the number of the adherent cells were also more. This abnormal behaviour of the species was more or less directly proportionate to the altered status of these factors in culture. It was thus quite clear that due to an increase or decrease in temperature and light intensity, quite a number of variants were produced. Sometimes the cells departed so widely from the specific characteristic that one could mistake them as belonging to different taxa. It may be that under unfavourable conditions of growth the mechanism of cell division was disturbed lowering thereby the percentage of mitosis and finally leading to the tendency of morphological aberrations. Consequently, these observations induced to study the various species of desmids under different experimental conditions to find out the range of morphological variation in cultures because the feature which more than any other, has attracted algologists to study desmids especially placoderms is their considerable morphological variability. Morphological variations under different cultural conditions have been studied and it is presumed that the cell types are capable of maintaining their narrow specificity, which is genetically controlled under favourable conditions only, but, whenever, there is a change in environmental set-up, it has resulted in upsetting the metabolic behaviour leading to abnormal forms.

Keywords. Desmids; morphology; ecology; pH; temperature; illumination.

1. Introduction

Andhra Pradesh, a South Indian State, is located at an altitude of 300–2,500 ft and with an average rain-fall 1143–1270 mm in the north and 508 mm in the south-west per year, offers very good collection spots for desmid species. The variability of the desmids has been pointed out by many earlier workers like West (1899), Ducellier (1915), Czurda (1926), Pringsheim (1930), Ondracek (1936), Lefevre (1939), Rosenberg (1944), Teiling (1956), Waris and Kallio (1957) and Nizam (1968). Recent studies of naturally occurring populations of various species of placoderm desmids have been undertaken by various investigators (Villeret 1951; Teiling 1956; Brook 1959a, b; Lind and Croasdale 1966; Brook and Hine 1966; Tyler 1971; Vidyavati and Nizam 1972; Bicudo 1975; Kirk and Cox 1975; Sathaiah 1983; Mogili and Vidyavati 1985).

2. Materials and methods

The clone dealt with here belongs to the specimen *Euastrum spinulosum*-Delp. var. *duplo-minor*, with a clone no. 260. The species was collected from rocky pan in the Osmania University Campus, and is preserved in the Department of Botany. Other two species were kindly supplied by Cambridge culture collection, UK. The clonal cultures thus raised, were the species—*Cosmarium botrytis* and *Cosmarium praemorsum.*

Clonal cultures were raised by following Pringsheim's method (Pringsheim 1946). Stock cultures were maintained in biphasic medium on a rack placed in the north window at room temperature. Liquid cultures were established in 250 cc Pyrex conical flasks containing 150 cc autoclaved Waris solution.

Ten cc of the culture was centrifuged at 2000–2500 r.p.m. and after pouring out the supernatant liquid, the sedimented cells were added to a fresh 50 cc Waris medium, contained in 100 ml Pyrex conical flasks. The cultures of *E. spinulosum* were subjected to different experimental conditions:

(i) Day light only at the north window at 21–37°C.
(ii) Alternate light and dark period of 12 hr duration at 24–37°C.
(iii) Continuously illuminated cabinet at 24–38°C.
(iv) Continuously illuminated cabinet at 17–32°C.
(v) 16 hr illumination alternated by 8 hr dark period at 16–30°C.
(vi) Continuous illumination at 18–22°C.
(vii) 16 hr light period and 8 hr dark period at 18–22°C.

The culture conditions for *C. botrytis* and *C. praemorsum* are given in the tables 2 and 3, respectively.

Among the environmental factors mostly pH, temperature and illumination conditions were studied.

3. Results

Observations were recorded every 5th day from all the samples. From each sample 50 randomly selected cells were measured for their length and breadth (tables 1–3). In the case of *E. spinulosum*, the highest percentage of the cells under all conditions were those having 43·5 μm length and 34·8 μm breadth, which is almost in close approximation with mean length (45·6 μm) and breadth (38·5 μm). These figures closely correspond with the length and breadth given for *E. spinulosum* by Krieger (1937), which

Table 1. Showing cell length and breadth under varied cultural conditions. *Euastrum spinulosum* Delp. var. *duplo-minor* W. and W.

Culture condition	Length (μm)		Breadth (μm)
Day light at 21–37°C	Range	34·8–60·9	26·1–52·2
	Mean	48·0008	40·9074
Alternate light at	Range	34·8–78·3	26·1–52·2
24–37°C	Mean	46·3942	39·1616
Constant light at	Range	34·8–113·1	26·1–52·2
24–38°C	Mean	45·2690	38·2742
Alternate light at	Range	26·1–147·9	26·1–60·9
16–30°C	Mean	45·7678	38·1988
Continuous light at	Range	26·1–174·0	17·4–52·2
17–32°C	Mean	45·1356	36·8648
Alternate light at	Range	34·8–95·7	26·1–52·2
18–22°C	Mean	46·8524	40·6640
Continuous light at	Range	26·1–121·8	17·4–52·2
18–22°C	Mean	42·2298	35·4380

Table 2. Showing cell length and breadth under varied cultural conditions. *Cosmarium botrytis* Menegh.

Culture condition	Length (μm)		Breadth (μm)
Alternate light at 18–22°C	Range	47·5–92·5	32·5–87·25
	Mean	74·586	63·258
Alternate light at 30–32°C	Range	47·5–92·5	32·5–79·5
	Mean	72·25	61·756
Constant light at 27–29°C	Range	47·5–87·25	32·5–75·0
	Mean	70·570	60·546
Day light at 27–29°C	Range	47·5–82·50	32·750
	Mean	76·850	66·540
Refrigerator cabinet with constant light at 8–9°C	Range	47·5–77·50	32·5–70·00
	Mean	70·00	57·428

Table 3. Showing cell length and breadth under varied cultural conditions. *Cosmarium praemorsum* Breb.

Culture condition	Length (μm)		Breadth (μm)
Alternate light at 18–22°C	Range	27·25–70·00	17·50–57·25
	Mean	52·887	43·435
Alternate light at 30–32°C	Range	27·25–70·00	17·50–57·25
	Mean	50·640	42·890
Constant light at 27–29°C	Range	27·25–62·50	17·50–57·25
	Mean	48·25	42·50
Day light at 27–29°C	Range	27·25–62·50	17·50–57·50
	Mean	54·75	48·25
Refrigerator cabinet with constant light at 8–9°C	Range	27·25–57·50	17·50–55·00
	Mean	46·50	37·780

incidentally vary from 42–80 μm and 38–73 μm, respectively. This is also more or less in accord with the measurements given by various authors for this species, after the publication of Krieger's work, and gathered from different parts of the world. In *C. botrytis* the highest percentage of cells under all conditions were those having 74·50 μm length and 61·50 μm breadth; which is almost close with the mean length 72·91 μm and breadth 63·50 μm. These figures approximately correspond to the length and breadth given for *C. botrytis* Menegh; by West and West (1912). In *C. praemorsum* the highest percentage of the cells under all conditions was those having 52·75 μm length and 43·75 μm breadth which is almost close with the mean length 52·8875 μm and breadth 43·4337 μm. These figures closely correspond to the length and breadth given for *C. praemorsum* Breb. by West and West (1908).

Apart from these culture studies, some environmental factors were also considered.

During periodic collections, the author could assess an overall important role of temperature on the periodicity and growth of desmids in the natural habitats. Desmid species were found to be relatively in abundance in early summer. During this period the water temperature varied from 26–28°C, increasing gradually as the months

become hotter and reaching the range of 30–31°C in the mid-summer. Beyond these limits of temperature the desmid species in natural populations seem to be adversely affected, because they progressively diminished in number. It seems that the maximum temperature which they could tolerate in natural populations is somewhere around 38°C.

The data gathered during the periodic collection of desmid species, has clearly indicated that most of the species flourished well during the early summer months. It is presumed that for the present species the most favourable range of temperature was 18–22°C. Water temperature and prolonged periods of sunshine are considered to be favourable in the periodicity of desmids in general (Fritsch and Rich 1913; Hodgetts 1922; Rao 1955). Venkateswarlu (1983) has shown that water temperature and algal numbers showed a direct relationship and the highest peak reached at maximum temperature (33·5°C) in case of *Staurastrum tetracerum* Ralfs.

Desmids occur abundantly in acidic environments (Joshua 1886; West and West 1909; Strom 1924; Griffiths 1928; Froehne 1939), but Van Oye (1934) pointed out that the desmids increase with the rise in pH. Hutchinson *et al* (1932) found 30–40 species of desmids in South Africa at 9·0 pH. According to Rao (1955) there are few desmid species which are quite indifferent to pH variations. Venkateswarlu (1983) has observed *S. tetracerum* growing luxuriantly in alkaline water a pH range of 8·1–10·0.

For the optimum growth of these species various culture media with varied pH range were employed (5·25–8·0). The growth was estimated by optical density and cell count. The best growth was obtained in medium having pH 6·0–7·5; which corresponded more or less with those of the habitats from where the species were originally collected.

For artificial illumination, the test tubes were kept in a cabinet fitted with 40 Watts day light fluorescent tubes of 6500°K, and 15 cm distance from the light source. Desmids showed a tendency to attain a good growth under artificial illumination, where the light intensity was twice as much as the day light. Of all the illumination conditions tried, it is now well established that 16 hr light period alternated by 8 hr dark period is most suitable for the optimum growth of the desmids.

4. Discussion

The observations accumulated on the morphological variations of *E. spinulosum*, *C. botrytis* and *C. praemorsum*, under the present experimental conditions suggest that the specific definitions of the species tend to be much altered under unfavourable physical and physiological factors. The type is capable of maintaining its narrow specificity which is genetically controlled under the favourable conditions only and whenever there is a change in the environmental set-up, it results in upsetting the cell metabolism leading to the change in morphological patterns which vary according to the intensity of the various factors.

On this assumption it can be presumed that the species or varieties which are discriminated from each other on the basis of one or two differences may, at least, in some cases, belong to the same genetical stock and may not warrant placing them in two different taxa. Such types of experimental studies would certainly help in the elimination of certain taxonomic confusions, especially in Desmidiaceae, where small variations in the measurement of the cells have so often led to the creation of new species, varieties and forms.

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