

EFFECT OF SALINITY ON PIGMENT CONCENTRATIONS OF SOME TROPICAL PHYTOPLANKTERS

P. M. A. BHATTATHIRI AND V. P. DEVASSY
National Institute of Oceanography, Panaji, Goa.

ABSTRACT

Phytoplankters grown at different salinities show varying growth rates. The maximum growth is at a salinity of about 15 ‰. In most of the cases growth at salinities 10 and 30‰ are greater than 50% of the maximum observed. The values of chlorophyll *c*/*a* (or *b*/*a*) and carotenoid/chlorophyll *a* do not vary very much with changes in salinity.

INTRODUCTION

Estuaries are characterised by marked diurnal and seasonal changes in salinity. These changes are brought about either by the tidal variations or by the influx of freshwater from rivers and land runoff caused by the monsoon system. As a result, the organisms inhabiting the estuaries have to adapt themselves to wide changes in salinity.

Investigations have been carried out earlier on phytoplankton growth rates (expressed in cell numbers) in relation to salinity changes (Braarud 1951, 1961, Jones *et al* 1963, McLachlan 1961, Nordli 1957, Smayda 1969). More recently, phytoplankton growth has been estimated from the changes in chlorophyll concentration (Thomas 1970) and photosynthetic rates (Qasim *et al* 1973). In the present study the growth rates of four tropical phytoplankton organisms have been estimated from their pigment concentrations.

MATERIALS AND METHODS

Organisms isolated earlier (see Qasim *et al* 1972) were subcultured and maintained at room temperature. From the actively growing clones, aliquots were transferred to filtered seawater of salinities ranging from 2 to 31‰. Distilled water was used for diluting the seawater. These were kept at room temperature (28-31°C) under constant illumination of 5000 lux with a dark/light cycle of 14/10 hours. Occasionally the samples were aerated. Aliquots were drawn from each set at intervals and the chlorophyll concentrations were estimated by the procedure given by Strickland and Parsons (1968). The phytoplankters investigated were *Chaetoceros lorenzianus*, *Coscinodiscus radiatus*, *Asterionella japonica* and *Tetraselmis gracilis*.

Growth rates of the organisms at different salinities were calculated from the variations in the concentration of chlorophyll *a*. Specific growth rate was

$$\text{found out from the relation } \mu = \frac{1}{(t_2 - t_1) \ln 2} \ln \frac{C_{t2}}{C_{t1}}$$

where μ is division per day, C_{t1} and C_{t2} are chlorophyll *a* concentrations at time t_1 and t_2 (days).

RESULTS AND DISCUSSION

The relative growth rates of each organism in relation to salinity have been shown in Fig. 1. For all the organisms, a sudden enhancement of growth rate, almost reaching 100%, at salinities 15-20‰ was observed. However, at salinities 10 and 30‰ the growth rates were 60% and 40% of the maximum in the case of *Asterionella*, 80% and 72% for *Chaetoceros*, 75% and 75% for

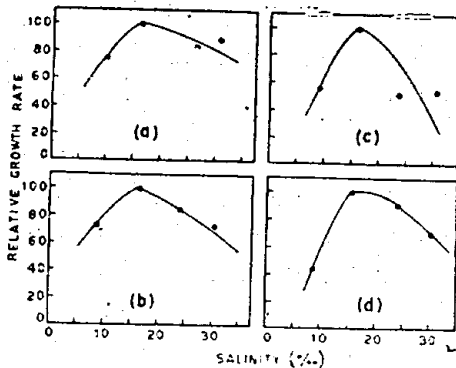


FIG. 1. Rate of growth (as a percentage of maximum) of unialgal cultures of diatoms and flagellate at different salinities. (a) *Asterionella japonica*, (b) *Chaetoceros lorenzianus*, (c) *Coscinodiscus radiatus* and (d) *Tetraselmis gracilis*.

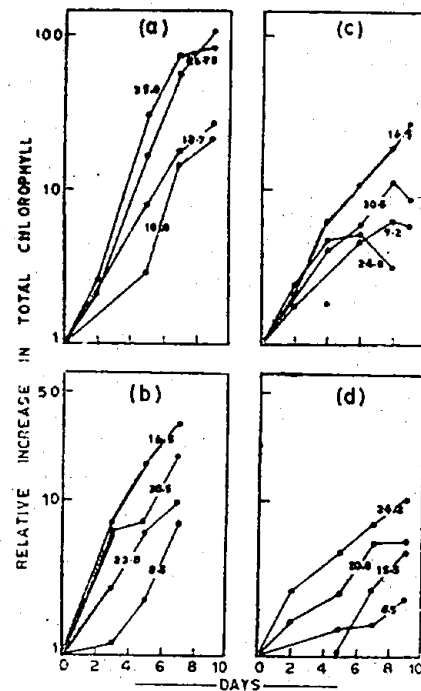


FIG. 2. Relative increase in total chlorophyll of diatom and flagellate cultures at different salinities. (a) *Asterionella japonica*, (b) *Chaetoceros lorenzianus*, (c) *Coscinodiscus radiatus* and (d) *Tetraselmis gracilis*.

Coscinodiscus and 60% and 72% for *Tetraselmis*. At the lowest salinity investigated (2‰) none of the phytoplankters showed any growth.

The photosynthetic rates of several organisms at varying salinities, have been investigated by Qasim *et al* (1972). It was found that *Asterionella*, *Chaetoceros* and *Coscinodiscus* showed maximum photosynthesis at salinity range 10-20‰. Similar results were observed during the present investigation, which show that maximum growth occurs at lowered salinities. Red-pigmented blue-green alga, *Phormidium persicinum* has been found to have decreased growth rate at NaCl concentration below 15‰ and above 30‰ (Pintner and Provasoli 1958). Growth of *Calothrix scopulorum* was found to be not significantly different in salinities 0.1 to 4.5‰ (w/v), though there was slightly better growth at salinities between 1 and 3.5‰ (Stewart 1964). *Nostoc entophyta* showed similar growth rates at salinity range 1.0 to 3.5‰, but had much low rates at 4.5‰ (Stewart 1964).

Braarud (1961) found that many dinoflagellates had their peak growth at salinity 20‰. Thus at salinities 10 and 30‰ the growth rates in terms of percentage of the maximum were: *Peridinium triquetrum* 64% and 92%; *Peridinium trochoideum* 61% and 81%; *Prorocentrum micans* 28% and 78%; *Amphidinium cf. operculatum* 72% and 92%; *Ceratium tripos* 39% and 56%. In the case of *Ceratium fusus*, *C. furca* and *C. lineatum*, the growth rates at salinities 15 and 30‰ were 62% and 72%, 83% and 89% and 94% and 39% respectively.

In the diatom *Detonula confervacea*, Smayda (1969) observed that the growth rate (at 12°C) was low at salinity 5‰ but showed an increase at the salinity range 5-15‰. The cell division remained more or less constant from salinity 15 to 30‰. Smayda (1969) further observed that optimal growth occurred at the salinity 15-35‰ at 2°C with illumination range of 200-600 ft C; salinity 15-30‰ at 7°C and 1200 ft C, and at salinity 20-25‰ at 12°C and 1800 ft C.

Guillard and Ryther (1962), while investigating the influence of salinity on the division rate of *Cyclotella nana*, found that the estuarine clone has very wide adaptability for the salinity range of 0.5 to 32‰ and the rate of division was two to three times a day. Similarly in *Detonula confervacea* although growth occurred at salinity 8‰, the maximum division rate was noticed when salinity was around 16‰ (Guillard and Ryther 1962). Takano (1963) reports that the relative growth rate (in cell numbers) in *Skeletonema costatum* was 0.88, 1.00, 0.88 and 0.89 at salinities 10, 20, 30 and 35‰ respectively.

Thus, the foregoing account shows that salinity is an important ecological factor controlling the abundance of many phytoplankton organisms in estuaries (Gessner and Schramm 1971). However, it has to be mentioned that

though there are large variations in the response pattern both at the inter- and intra-specific levels, most of the phytoplankters show within limits, a higher rate of growth at lowered salinity. But in most cases, it is not easy to single out the sole factor responsible for the responses observed.

The relative changes in total chlorophyll ($a+b$) or ($a+c$) values are given in Fig. 2. Values at the beginning of the experiment have been taken as unity in all cases. Thus total chlorophyll values of *Asterionella* on the 9th day were 22.8, 27.0, 107.9 and 85.3 at salinities 10, 18.7, 26.7 and 31.0‰, respectively. For *Coscinodiscus* the chlorophyll concentrations were 6.0, 27.2, 5.2 and 11 at salinities 9.2, 16.5, 24.0 and 30.5‰. In the case of *Chaetoceros* the maximum increase of 31.4 in chlorophyll was at a salinity of 16.5‰. At other salinities the increase was still lower. However, *Tetraselmis* did not show very high increase in chlorophyll with changes in salinity. The maximum change was at salinity 24.2‰

TABLE 1. Changes in phytoplankton-pigment values at different salinities.

Organisms	Salinity ‰	Chl c or b	Carotenoids
		Chl a	Chl a
<i>Asterionella japonica</i>	8.5	0.45 — 0.53	0.10 — 0.26
	16.5	0.47 — 0.63	0.18 — 0.26
	23.8	0.35 — 0.56	0.16 — 0.23
	30.5	0.17 — 0.35	0.18 — 0.27
<i>Chaetoceros lorenzianus</i>	9.2	0.60 — 0.71	0.25 — 0.44
	16.5	0.39 — 0.53	0.22 — 0.45
	24.0	0.41 — 0.54	0.30 — 0.46
	30.5	0.50 — 0.57	0.25 — 0.47
<i>Coscinodiscus radiatus</i>	10.0	0.56 — 0.71	0.24 — 0.50
	18.7	0.38 — 0.80	0.30 — 0.38
	26.7	0.24 — 0.45	0.27 — 0.40
	31.0	0.25 — 0.70	0.27 — 0.49
<i>Tetraselmis gracilis</i>	8.5	0.27 — 0.44	0.23 — 0.38
	15.5	0.29 — 0.45	0.23 — 0.40
	24.2	0.21 — 0.44	0.26 — 0.35
	30.0	0.23 — 0.38	0.25 — 0.36

Table 1 shows the variation in the values of chlorophyll $c|a$ (or $b|a$) and plant carotenoids to chlorophyll a . The range in $c|a$ values for *Chaetoceros* was lowest (0.17-0.35) at salinity 30.5‰ and highest (0.47-0.63) at salinity 16.5‰. At other salinities, the values were within the above range. The ratio between plant carotenoids and chlorophyll a was always low and in the same range (0.10-0.27). For *Coscinodiscus* the $c|a$ values were highest at salinity 10‰ and lowest at 18.7‰. Carotenoid to chlorophyll a ratios varied from 0.2 to 0.6, the highest values being at the lowest salinity. In *Asterionella*, the $c|a$ values ranged from 0.25 to 0.80. In this case, the highest value was obtained at salinity 18.7‰ while at still higher salinities the values ranged from 0.24 to 0.50 and were more or less within a similar range at other salinities. The flagellate *Tetraselmis* showed variation in $b|a$ ratios from 0.2 to 0.45 and the values fall within a similar range at the salinities investigated. Carotenoid to chlorophyll a values ranged from 0.23 to 0.40.

These results show that salinity does not seem to influence the values of either chlorophyll $c|a$ (or $b|a$) or carotenoid to chlorophyll a , though there is an overall difference in growth rates. According to Yentsch and Vaccaro (1958) carotenoid to chlorophyll a ratio is a quantitative index of the physiological state of the phytoplankters. Since the values obtained were low it can be assumed that all the phytoplankters were in good physiological state.

ACKNOWLEDGEMENT

Authors are grateful to Dr N. K. Panikkar for the constant encouragement given. Thanks are to Dr S. Z. Qasim for the comments on the manuscript. The technical help of Mr C. V. G. Reddy is greatly appreciated.

REFERENCES

- BRAARUD, T. 1951. Salinity as an ecological factor in marine phytoplankton. *Physiologia Pl.*, 4: 28-34.
- BRAARUD, T. 1961. Cultivation of marine organisms as a means of understanding environmental influence on populations. In: *Oceanography*, A.A.A.S. Publs No. 67: 271-298. M. Sears (Ed.), A.A.A.S. Washington.
- GESSNER, F. AND W. SCHRAMM. 1971. Salinity — Plants. In: *Marine Ecology* Vol. 1 (pt. 2): 705-820. O. Kinne (Ed.), Wiley Interscience, London.
- GUILLARD, R.R.L. AND J. H. RYTHER. 1962. Studies on marine planktonic diatoms I. *Cyclotella nana* Hustedt, and *Detonula confervacea* (Cleve) Gran. *Can. J. Microbiol.*, 8: 229-239.
- JONES, R. F., H. L. SPEER AND K. WENDELL. 1963. Studies on the growth of the red alga *Porphyridium cruentum*. *Physiologia Pl.*, 16: 636-643.
- MCLACHLAN, J. 1961. The effect of salinity on growth and chlorophyll content in representative classes of unicellular marine algae. *Can. J. Microbiol.* 7: 399-406.
- NORDLI, E. 1957. Experimental studies on the ecology of *Ceratia*. *Oikos*, 8: 200-265.

- PINTNER, I. J. AND L. PROVASOLI. 1958. Artificial cultivation of a red-pigmented marine blue-green alga, *Phormidium persicinum*. *J. gen. Microbiol.*, **18**: 190-197.
- QASIM, S. Z., P.M.A. BHATTATHIRI AND V. P. DEVASSY. 1972. The influence of salinity on the rate of photosynthesis and abundance of some tropical phytoplankton. *Mar. Biol.*, **12**: 200-206.
- QASIM, S. Z., P.M.A. BHATTATHIRI AND V. P. DEVASSY. 1973. Growth kinetics and nutrient requirements of two tropical marine phytoplankters. *Mar. Biol.*, **21**: 299-304.
- SMAYDA, T. J. 1969. Experimental observations on the influence of temperature, light and Salinity on cell division of the marine diatom, *Detonula confervacea* (Cleve) Gran. *J. Phycol.*, **5**: 150-157.
- STEWART, W. D. P. 1964. Nitrogen fixation by Myxophyceae from marine environments. *J. gen. Microbiol.*, **36**: 415-422.
- STRICKLAND, J. D. H. AND T. R. PARSONS. 1968. A practical handbook of seawater analysis. *Bull. Fish. Res. Bd Canada*, No. **167**: 311 pp.
- TAKAMO, H. 1963. Diatom culture in artificial sea water — I. Experiments on five pelagic species. *Bull. Tokai Reg. Fish. Res. Lab.*, No. **37**: 17-25.
- THOMAS, W. H. 1970. Effect of ammonium and nitrate concentration on chlorophyll increase in natural tropical Pacific phytoplankton population, *Limnol. Oceanogr.*, **15**: 386-394.
- YENTSCH, C. S. AND R. F. VACCARO. 1958. Phytoplankton nitrogen in the oceans. *Limnol. Oceanogr.*, **3**: 443-448.