

INDIAN ULVALES : CYTOTAXONOMIC CONSIDERATIONS

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Both *Ulva* and *Enteromorpha* are widespread on Indian coasts. They grow more profusely in the polluted seawater at the point of discharge of sewer. Cytosystematic studies of Ulvales, in contrast to those of other groups of green algae including the marine ones, are still meagre, owing to obvious intrinsic difficulties. In this communication, karyological characteristics, emerged from investigations in India and abroad, and their implications in cytotaxonomic delimitations of these genera of disputed systematic position are discussed.

Keywords: Cytotaxonomy; Life cycle; Morphology; Phenology; Seaweed; Ulvales.

Introduction

Extensive surveys and collections of marine algae in India are restricted to certain areas only according to the exigencies of travel and the convenience of the investigators. Port Okha and Dwarka on the Gujarat Coast, Bombay, Rameswaram and neighbouring islands and Cape Comorin in South Madras Coast have been explored more extensively¹⁻⁷. Stray collections, however, have also been made by various workers from different places on the west coast of India⁸, Laccadive and Minicoy Islands in the Arabian Sea⁹ and Andaman and Nicobar Islands in the Bay of Bengal.¹⁰ Records are also available for Malwan Harbour¹¹, Mahabalipuram¹², Visakhapatnam¹³, Gopnath¹⁴⁻¹⁷ and Porbandar.¹⁸⁻¹⁹

Ulvalean taxa are widespread in tropical waters. Both *Ulva* and *Enteromorpha* have been found to richly inhabit the shores of the mainland of India. More luxuriant growth of these green seaweeds was obvious in sewage polluted sea water especially at the point of discharge of sewer. Nearly eight taxa of *Ulva* and

sixteen of *Enteromorpha* (Table 1) have so far been recorded from the Indian waters, of which excepting *Enteromorpha intermedia* Bliding all others are marine.²⁰⁻²¹

Plants are haplobiontic or diplobiontic in life cycle, the latter being either isomorphic or heteromorphic in nature. The members of Ulvales illustrate in their organisation various patterns of cell division with resultant variation in the form of the organism. Thus the mature plants are biserial filaments (*Percursaria*), monostromatic (*Monostroma*) or distromatic (*Ulva*) membranes or hollow tubes. All, except *Prasiola*, have ulotrichalean cellular organisation including laminate, parietal chloroplasts with pyrenoids and single nucleus in each cell, and many have erect thalli that arise from a prostrate basal system.

Karyology and Systematic Considerations

The origin, evolution and inter-relationships between different groups of eukaryotic algae are in state of constant flux due to changing environmental conditions.

and gross morphological, morphogenetic, physiological, biochemical and cultural parameters have been variously used from time to time to unravel and understand the evolutionary sequences in these groups of organisms. Cytological and cytotaxonomic investigations have proved more profitable because of the stability of karyotypic characteristics. The use of cytology and cytotaxonomy for the understanding of the taxonomy and phylogeny of higher plants is obvious²²⁻²³, but unfortunately such studies have been restricted to only a negligible fraction covering very few groups of eukaryotic algae, owing to limited number of workers and the difficulties inherent in the problem. However, as in higher plants, now it has been possible to correlate the cytological features with the taxonomy and phylogeny²⁴⁻²⁷ of at least some algal classes and utilize these criteria in determining the systematic position of various taxa of controversial nature.

The organisms included in the Order Ulvales have been variously classified. Smith²⁸, Round²⁹, Bliding³⁰⁻³¹ and Bourrelly³²⁻³³ recognized them as a distinct order, while Fritsch³⁴, Papenfuss³⁵ and Fott³⁶ have included them as a family in the Order Ulotrichales. In spite of the discrepancies in the systematic position of ulvalean members on morphological grounds and their widespread distribution and abundance in nature investigations into the cytology of these algae are far less in comparison to other groups of Chlorophyceae. In addition to the inherent difficulties this is chiefly due to the fact that the active investigating centres in India are located quite far off from the sea shores. Consequently, only a very small

percentage of Indian Ulvales have been subjected to karyological investigations. Author's Centre has been the premier School having investigated more than half of the total world taxa so far studied from this angle.³⁷ However, the Banaras School of algal cytology cannot be separated from those who have suffered the exigencies of travel due to enormous distance from coastal regions as result of which only a beginning could be made here in cytotaxonomic explorations in the seventies.

Ramanathan³⁸⁻³⁹ was the first to have investigated the karyology of a Madras isolate *Enteromorpha compressa* var. *lingulata* (J. Ag.) Hauck ($n=10$, $2n=20$) and to have established cytological proof for the existence of regular isomorphic alternation of generation in this alga, also pinpointing the actual place of meiosis in the diploid sporophyte prior to the formation of zoospores. Sarma and Suryanarayana²⁰ during their local collections from river Varuna (Varanasi) came across a freshwater form of *Enteromorpha*, *E. intermedia* Bliding exhibiting two different chromosome numbers 9 and 18, presumably representing the haploid and diploid phases of the alga. Subsequently, Sarma and Chaudhary⁴⁰ made detailed investigation for the first time and reported $n=10$ chromosomes in the vegetative thalli of the green seaweed *Ulva fasciata* Delile from Visakhapatnam, east coast of India. Chaudhary⁴¹ recorded $n=10$ chromosomes and $2n(?)=18$ chromosomes⁴² in the same natural population of *Enteromorpha compressa* (L.) Grev. collected from Okha, West Coast of India (Table 2).

Table 1. Taxa of *Ulva* and *Enteromorpha* with places of their collection.

Taxa	Collection places
<i>Ulva beytensis</i> Thivy et Sharma	Beyt Island near Okha Port, Madras, Krusadai Island
<i>U. covelongensis</i>	Bombay
<i>U. fasciata</i> Delile	Trivandrum, Cape Comorin, Veraval
<i>U. lactuca</i> (L.) Le Jolls	Okha, Dwarka, Porbandar, Bombay, Diu, Krusadai Island
<i>U. lobata</i> Kg	Andaman & Nicobar Islands
<i>U. reticulata</i> Forssk	Bombay, Diu, Krusadai Island
<i>U. rigida</i> Ag.	Gopnath near Bhavnagar
<i>Enteromorpha lingulata</i> J. Ag.	Bhavnagar, Madras
<i>E. tubulosa</i> Kuetz.	Diu, Veraval
<i>E. prolifera</i> (Mull.) J. Ag.	Kuda near Bhavnagar, Visakhapatnam
<i>E. flexuosa</i> (Wulf.) J. Ag.	Hatab, Okha
<i>E. intestinalis</i> (L.) Link	Gopnath near Bhavnagar, Rameswaram, Krusadai Island
<i>E. ovata</i> Thivy & Visalakshami ex Joshi & Krishnamurthy sp. nov.	Gopnath
<i>E. compress</i> (L.) Grev.	Visakhapatnam, Mandapam Camp & Krusadai Island
<i>E. linza</i> (L.) J. Ag. var. <i>linza</i>	Gopnath
<i>E. linza</i> var. <i>bicornuta</i> Joshi & Krishnamurthy var. nov.	Mahuva at Gujarat coast
<i>E. clathrata</i> (Roth) Grev.	Dera in the Gulf of Kutch
<i>E. plumosa</i> Kuetz.	Porbandar
<i>E. gujaratensis</i> Kale	Channels of Saurashtra Salt Works, Porbandar
<i>E. hopkirkii</i> Harvey	Mandapam Camp
<i>E. complanata</i> Kuetz.	Andaman & Nicobar Islands
<i>E. polyclados</i> Kuetz.	Andaman & Nicobar Islands
* <i>E. intermedia</i> Bliding	River Varuna (Varanasi)

*Restricted to fresh water

Table 2. Chromosome numbers in Indian Ulvales.

Taxa	Chromosome number
<i>Ulva fasciata</i> Delile	10 n = 10
* <i>U. lactuca</i> (L.) Le Jolle	2n = 20
<i>Enteromorpha intermedia</i> Bliding	9 18
<i>E. compressa</i> (L.) Grev. Strain A	n = 9 n = 10
Strain B	n = 10
Strain Y	2n (?) = 18
* <i>E. compressa</i> var. <i>lingulata</i> (J. Ag.) Hauck	n = 10 2n = 20
<i>E. ramulosa</i> (Eng. Bot.) Hooker	n = 12

*Cytological evidence of the existence of isomorphic alternation of generation.

Structural variations in the chromosomes are more obvious than chromosome numerical differences. Although the same chromosome number $n=10$ has been reported for different species (Table 2) marked karyotypic differences exist between them, indicating that they are distinctly different species. Chromosomal rearrangements, thus, appear to have played more decisive role in the speciation of Indian taxa of *Ulva* and *Enteromorpha*.

The chromosomes are small and the centromeric position is not discernible in majority of the cases. The size of metaphase plate never exceeds the initial diameter of interphase nucleus. Like *Microspora amoena*, *Sphaeroplea annulina*, *Uronema terrestre* the nucleolar organizing

chromosomes in *Ulva lactuca* and *U. fasciata* lie in association with the nucleolus during prophase. Chromosomal races²⁵ have been found in *U. lactuca* and *E. compressa* similar to many Ulotrichales. On the basis of karyological investigations made in India and abroad the inclusion of *Ulva* and *Enteromorpha* under Ulortichales³⁴ was found to be justifiable. Ultrastructural studies of the persistence of nuclear envelope in *Ulva mutabilis*⁴³ also lend support to the contention of its inclusion in the Order Ulotrichales.

In general, the structure and behaviour of chromosomes resembled with those of Ulotrichales and conformed to the standard pattern of mitosis met with in typical eukaryotes. However, since the cytological

data is very meagre while considering the large number of taxa available for study, further exhaustive work needs to be accomplished in this direction to come to decisive conclusions relating to systematics and phylogeny of Ulvaes.

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